

SCHOOL LAUNCH • GEOGRAPHY K-12

GRADE 7 GEOGRAPHY: REGIONS OF THE WORLD

A year-long tour of the world's great regions, from the North European Plain and the Gotthard tunnels to the Trans-Siberian Railway, the qanats of the desert, the falls of Africa's rivers, the monsoon and the railways of India, China's Grand Canal, the port of Singapore and the locks of the Panama Canal, each region read from its land and rivers, its ports and resources and the faith and history of its peoples, and each one drawn by hand into a regional atlas the student builds and binds.

First edition

"And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;" (Acts 17:26, KJV)

COURSE GUIDE

This course takes the student around the world in eight regions: Europe; Russia and Central Asia; the Middle East and North Africa; Sub-Saharan Africa; South Asia; East Asia; Southeast Asia and Oceania; and the Americas. Every region is studied the same way. First its **land and rivers**: the plains, mountains, deserts and coasts, and the winds and rains that come with them. Then its **ports and resources**: where the harbors are, what grows and what lies underground, and which way the goods move. Then the **faith and history of its peoples**: how the land shaped where they settled, how they farmed and traded, and how the gospel reached them. Along the way the student learns to read thematic maps of population, religion, resources and trade, and draws a page of his or her own regional atlas for every unit.

Every lesson begins with **a real place and a real moment**: armies and merchants crossing the open North European Plain, Russian tsars searching for a harbor that does not freeze, the Swahili traders riding the monsoon winds, Mumbai's first train steaming out in 1853, Stamford Raffles landing at Singapore in 1819, Polynesian navigators reading the swells of the Pacific. Then the student takes it apart: what the land allowed, what it forbade, and what people did about it. Each lesson has worked examples, practice with answers, a picture study of a real painting or historic map, and a project for the hands, from a model qanat in a tray of sand to a canal lock and a Marshall Islands stick chart.

A thread runs through every unit: **technology overcoming geography**. In each region one lesson, marked ✪, shows people conquering a barrier: the Gotthard rail tunnel of 1882 and the base tunnel of 2016, the Trans-Siberian Railway, the qanats that carry water under the desert, the Uganda Railway and Kariba Dam, the railways of India, China's Grand Canal, Singapore's port at the Strait of Malacca, the Canadian Pacific Railway and the Panama Canal. The student learns that geography still sets the terms, and that the great works of engineering are the stories of people who refused to accept them.

The series verse is Acts 17:26: "*And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;*" The course teaches that God made the lands and set the peoples in them, and it follows the spread of the gospel into every region, with missionaries such as William Carey, Amy Carmichael, Matteo Ricci, Hudson Taylor and John Williams, who learned the land and the languages of the people they served. Other faiths are described accurately and respectfully, and present-day politics is kept neutral, factual and dated.

WHO IT IS FOR

Written for students in grade 7 (about ages 12–13) who read on their own, can use a ruler and a map scale, and can work with simple percentages and ratios. A parent or teacher reads along or checks in, asks questions, and helps with the larger projects. Distances are given in both kilometers and miles. Nothing needs to be bought beyond ordinary household

and school supplies: a world atlas or printed outline maps, colored pencils, a graph-paper notebook, and simple materials such as sand, straws, cardboard and string.

HOW TO USE THIS COURSE

The weekly rhythm. The year has 32 lessons in eight units, one lesson a week, with an optional ninth unit, the *Map Lab*, of map games and puzzles. Session 1 (about 45 minutes) is the warm-up, the video, the core ideas and the picture study. Session 2 (about 45 minutes) is the worked examples, the practice, the project and the map notebook. In the last week of each unit, add a third session for the unit review and the unit project.

The ★ quarter path and the ⚙ thread. Ten lessons are marked ★. Together they make a one-quarter version of the course that still visits every region and keeps the core map skills and the technology thread; use them if you have only a quarter, or as a review at the end of the year. Lessons marked ⚙ carry the thread of technology overcoming geography, one or more in every unit.

The map notebook and the atlas. Use one graph-paper composition book for the whole year. Every lesson ends with something drawn or recorded: a sketch map, a profile of a river, a climate band, a time-zone strip or a route with its distances in kilometers and miles. Date every page and give every map a title, a compass rose, a scale and a key. At the end of each unit the student turns the best of these into a clean regional atlas page; by the last unit the pages are finished and bound into an atlas of the world.

Worked examples and practice. Each lesson has three worked examples, done step by step, and ten practice questions with answers in the back of the lesson. Read the worked examples together first. Then let the student try the practice alone and check the answers afterward. When an answer is wrong, go back to the map and find out why before moving on; the *common mistakes* box names the usual slips.

Unit reviews and unit projects. Each unit ends with a short review of 8 to 12 items (60 points), including a map quiz, and a unit project that pulls the region together, such as a time-zone strip of Russia, a model qanat, a rapids-and-falls river model, a monsoon wind model, a canal lock or a stick chart. Keep the atlas pages and project notes in one folder for the year.

Where this course fits. Grade 7 belongs to the School Launch Geography series, which runs from kindergarten maps through grade 8 and on to the high school electives. It builds on the physical geography of Grade 6 and prepares for the rivers, ports and straits of Grade 8. It pairs well with the School Launch Engineering and Physics courses, which explain how tunnels, locks, dams and railways work, and with the Business and Finance courses, which explain why ports, canals and trade routes are worth so much.

SCOPE AND SEQUENCE

Unit 1: Europe (1–4)

The open North European Plain, the peninsulas and seafarers of the Mediterranean, the Alps pierced by the Gotthard tunnels of 1882 and 2016, and the Rhine flowing to Rotterdam, Europe's busiest port.

Unit 2: Russia and Central Asia (5-8)

The biggest country on earth with its eleven time zones, the Urals and Siberia; Russia's long search for ice-free harbors; the Trans-Siberian Railway from Moscow to Vladivostok; and the steppe and the Silk Road cities of Samarkand and Bukhara.

Unit 3: The Middle East and North Africa (9-12)

The Fertile Crescent where farming and cities began, the deserts and the qanats that carry water beneath them, the lands of the Bible, and where the world's oil lies and why the Strait of Hormuz matters, told factually.

Unit 4: Sub-Saharan Africa (13-16)

High plateaus and the falls that stop boats on Africa's rivers; the bands of Sahel, savanna and rain forest; the trading kingdoms of Ghana, Mali, Great Zimbabwe and the Swahili coast; and the Uganda Railway and Kariba Dam.

Unit 5: South Asia (17-20)

The Himalaya and the monsoon rains they make, the river plains of the Ganges and the Indus, India's railways from Mumbai's first train in 1853 to the hill railways, and William Carey, Amy Carmichael and the church in India.

Unit 6: East Asia (21-24)

The Yellow River and the Yangtze, the Grand Canal that links north and south China, the mountainous islands of Japan and the Korean peninsula, and Matteo Ricci and Hudson Taylor, who learned the land and the language of China.

Unit 7: Southeast Asia and Oceania (25-28)

The islands and straits of Indonesia and the Philippines, Singapore's port at the choke point of the Strait of Malacca, the island continent of Australia and New Zealand, and Polynesian navigation and the missionary John Williams in the Pacific.

Unit 8: The Americas (29-32)

Canada's Shield, the St. Lawrence and the Canadian Pacific Railway; the highlands and narrow isthmus of Mexico and Central America; the locks and Gatún Lake of the Panama Canal; and the Andes, the Amazon and the Pampas of South America.

Unit B: Bonus: Map Lab (Optional)

Map games and puzzles for any time in the year: turning a table into a population map, a countries quiz league, guessing a mystery region from five clues, and a flags and capitals

relay.

MATERIALS

- **Map notebook (a graph-paper composition book):** One for the whole year: sketch maps, river profiles, climate bands, routes and distances.
- **A world atlas, or printed outline maps of each region:** A good school atlas is ideal. Free printable outline maps work well for the atlas pages.
- **Colored pencils, a fine black pen, a ruler and a protractor:** For keys, scale bars, compass roses and measuring distances on the map.
- **A globe, if you have one:** Helpful for time zones, great-circle routes and comparing the true sizes of regions. An orange or ball marked with a pen will do.
- **Heavy paper and a binder, folder or brads:** For the regional atlas pages, which are bound together at the end of Unit 8.
- **A shallow tray or baking pan, sand or soil, and a pitcher of water:** For the qanat, the rapids-and-falls river model and the monsoon model.
- **Drinking straws, cardboard, plastic wrap, tape and modeling clay:** For the qanat tunnels, the canal and its pound lock, and small landform models.
- **A desk lamp with an ordinary bulb and two small dishes:** For the monsoon wind model, which compares how fast sand and water warm up. An adult handles the lamp.
- **Thin sticks or craft sticks, string and small shells or beads:** For the Marshall Islands stick chart in Unit 7.
- **Optional: one of the books or resources listed in a unit:** Never required. See the list in each unit.

GRADING

Grades come mostly from the map notebook, the projects and the atlas pages, because geography is learned by looking, drawing and placing things on the map. Careful, honest work that is clearly labeled earns full credit even when the drawing is plain.

- Map notebook (dated pages, titles, keys, scales and compass roses): 20%
- Practice and projects (effort, accuracy and explaining what the map shows): 30%
- Unit reviews and map quizzes (60 points each): 25%
- Unit projects and atlas pages: 25%

A 90–100, B 80–89, C 70–79, D 60–69. Below 60: redo the map or review with help.

- A map earns full marks when it has a title, a compass rose, a scale, a key, neat labels and correct placement of the main features.
- Grade the reasoning, not just the answer. Can the student explain why a city, port, railway or border lies where it does?
- Unit reviews may be done orally for a student who writes slowly; the parent writes down the answers. The map quiz should still be done on paper.

- Keep the atlas pages and project notes in one folder. Bound together at the end of the year, they make a fine record of the student's work.

A NOTE TO PARENTS

You do not need to be a geographer to teach this course. Read the lesson together, open the atlas, and keep asking three questions: "Where is it?", "Why there?" and "How did people get past the mountains, deserts or seas in the way?" Those questions are most of what a good geography teacher does, and they work just as well on the evening news or a family trip as on a map of Siberia.

The course describes every region honestly and respectfully. It begins with the land, then shows how the land shaped the history, farming, trade and faith of the people who live there. Other religions are described accurately, the history of Christianity is told where it belongs, and explorers, empires and missionaries are presented with their achievements and their real wrongs. Present-day politics is kept neutral and factual, with dates given, and nothing in the course asks you or your child to take a side in present-day public debates.

Above all, the course hopes to raise a young person who looks at a map of the world and sees not only borders and resources but nations made of one blood, each set by God in its place and each worth knowing. When the atlas is bound at the end of the year, let the student walk you through it region by region; it is the best review there is, and a fine thing to keep.

CONTENTS

Unit 1: Europe

- 1.1 The North European Plain ★
- 1.2 Mediterranean Europe
- 1.3 The Alps and the Gotthard Tunnels ⚙
- 1.4 Rivers and Ports: The Rhine and Rotterdam

Unit 2: Russia and Central Asia

- 2.1 The Biggest Country ★
- 2.2 Frozen Ports and Warm-Water Ports
- 2.3 The Trans-Siberian Railway ⚙
- 2.4 Central Asia and the Steppe

Unit 3: The Middle East and North Africa

- 3.1 The Fertile Crescent ★
- 3.2 Deserts, Oases and Water ⚙
- 3.3 The Lands of the Bible
- 3.4 Oil and Straits

Unit 4: Sub-Saharan Africa

- 4.1 Plateaus and Waterfalls ★
- 4.2 The Sahel, the Savanna and the Rain Forest
- 4.3 Great Trading Kingdoms
- 4.4 Railways and Dams ⚙

Unit 5: South Asia

- 5.1 The Himalaya and the Monsoon ★
- 5.2 The Ganges and the Indus
- 5.3 The Railways of India ⚙
- 5.4 Carey, Carmichael and the Church in India

Unit 6: East Asia

- 6.1 China's Two Great Rivers ★
- 6.2 The Grand Canal ★ ⚙
- 6.3 Japan and Korea
- 6.4 Ricci and Taylor in China

Unit 7: Southeast Asia and Oceania

- 7.1 Islands and Straits ★
- 7.2 Singapore: A Port at a Choke Point ⚙
- 7.3 Australia and New Zealand
- 7.4 The Pacific Islands

Unit 8: The Americas

- 8.1 Canada ★ ⚙
- 8.2 Mexico and Central America
- 8.3 The Panama Canal ★ ⚙
- 8.4 South America

Unit 9: Bonus: Map Lab (optional)

9.1 Thematic Map Challenge

9.2 Countries Quiz League

9.3 Mystery Region

9.4 Flags and Capitals Relay

★ quarter path · ⚙ technology overcoming geography

EUROPE

Europe is a small continent with a very long coastline, a great open plain, a wall of high mountains and some of the most useful rivers on earth. In this unit you will study it the way we will study every region this year: first the land and water, then how that land shaped the history, peoples, faith, farming and trade of those who live there. You will see why armies and merchants have crossed the North European Plain for centuries, why Mediterranean peoples took to the sea, and how the Alps divide the continent and the Rhine ties it together.

You will follow Napoleon's Grand Army across the plain in 1812 and read Charles Minard's famous map of its losses. You will sail with the Apostle Paul through a Mediterranean storm to Malta, ride under the Alps through the Gotthard tunnels of 1882 and 2016, and float down the Rhine to Rotterdam, Europe's busiest port. Along the way you will meet missionaries such as Boniface and Willibrord and see how the gospel traveled Europe's roads, rivers and sea lanes. In every lesson you will ask the question of this course: **how did the land shape the people, and how did people use God-given skill to overcome the land?**

The unit ends with the first page of your own regional atlas: a hand-drawn map of Europe's plains, mountains and rivers, with its ports and great routes. You will keep adding a page for each region all year.

BEFORE YOU BEGIN

- Can find places on a map using latitude and longitude
- Can use a map scale to measure distances and convert between kilometers and miles (1 km $\approx$ 0.621 mi)
- Can compute speed, distance and time (distance = speed $\times$ time)
- Knows the continents, the oceans and the main landform words (plain, plateau, mountain, peninsula, delta)

MASTERY CHECKLIST

- I can locate the North European Plain, the three Mediterranean peninsulas, the Alps and the Rhine on a blank map of Europe.
- I can explain why the North European Plain has been a road for armies and trade, and why its borders have so often moved.
- I can describe the Mediterranean climate, explain its causes, and name the crops that suit it.
- I can explain how the Gotthard tunnels of 1882 and 2016 overcame the barrier of the Alps, using grades, heights and lengths.
- I can explain why Rotterdam grew into Europe's busiest port at the mouth of the Rhine and Meuse.
- I can tell how the gospel spread across Europe by road, river and sea, naming at least two missionaries.

OPTIONAL BOOKS AND RESOURCES

- **Library of Congress: Maps Collection** (<https://www.loc.gov/maps/>): Free. Search for historic maps of Europe, the Rhine and the Alps to compare old and new borders for your atlas page.
- **NASA Earth Observatory** (<https://earthobservatory.nasa.gov/>): Free. Satellite images of the Alps, the Rhine delta, the Netherlands and the Mediterranean. Search “Alps,” “Rhine” or “Netherlands” to see the landforms of this unit from space.
- **Port of Rotterdam** (<https://www.portofrotterdam.com/>): Free. The port’s own site has maps of its harbors from the city to Maasvlakte 2 and yearly cargo figures. A parent may want to preview it, since much of it is written for businesses.

1.1 THE NORTH EUROPEAN PLAIN ★

OBJECTIVES

- Locate the North European Plain on a map and describe its height, rivers and soils.
- Explain how a broad, low plain has served as an open road for armies, merchants and missionaries, using Napoleon's march of 1812 and the Hanseatic League.
- Measure distances across the plain with latitude, longitude and map scale, in both kilometers and miles.

Warm-up. Lay a bath towel flat on the floor and roll a toy car or a marble from one end to the other. Now push up a tall ridge of towel across the middle and try again. Which crossing is easier? Imagine the flat towel is 2,000 miles (3,200 km) wide and the toy car is an army with wagons and cannons. What would living on the flat towel mean for the people there, both good and bad?

Watch. *The Greatest Ever Infographic - Numberphile* (Numberphile, 6:19).

<https://www.youtube.com/watch?v=3T7jMcstxY0>

With On the map: watch how Minard's famous map shows the Grand Army shrinking as it marched across the plain to Moscow and back, and trace the line of the army along with the temperature chart below it.

Note: Captions were not available to check; preview it first. It describes the huge loss of soldiers' lives in the campaign. The description says Minard made the map in 1862, but it was published in 1869.

Backup video. *The Hanseatic League: Explained (Short Animated History Documentary)* (History Matters, 3:05). <https://www.youtube.com/watch?v=r1fZAArcOJw>

With the big idea: watch how the trading towns of the Hanseatic League used the flat North European Plain, its rivers and the Baltic and North Seas to control trade, and why they later declined. Note: Captions were not available to check; preview it first.

KEY TERMS

plain

A broad area of flat or gently rolling land at a low elevation.

North European Plain

The great lowland that stretches from southwestern France through Belgium, the Netherlands, northern Germany, Denmark and Poland, and widens eastward into the East European Plain of Belarus and Russia.

loess

Fine, wind-blown dust that settled into deep, fertile soil. A belt of loess runs along the southern edge of the plain.

natural barrier

A mountain range, sea, large river, marsh or desert that makes travel and attack difficult.

invasion route

A natural path, such as a plain, valley or pass, that lets armies move easily from one land into another.

Hanseatic League

An alliance of German and Baltic trading towns, led by Lübeck, that controlled much of the sea trade of northern Europe from about the 1200s to the 1400s.

CORE IDEAS

The story. On June 24, 1812, Napoleon Bonaparte, Emperor of the French, watched his Grand Army cross the Neman River near Kaunas, in today's Lithuania, on bridges laid across boats. More than 400,000 soldiers, with horses, wagons and cannons, marched east into the Russian Empire. No mountain range stood in their way, only forests, marshes, rivers and a vast rolling plain. The Russian armies fell back, burning crops as they went. On September 7 the two armies fought a terrible battle at Borodino, and on September 14 Napoleon rode into Moscow. But the city was nearly empty, fires soon destroyed much of it, and Tsar Alexander I refused to make peace. In October the French began the long march home through hunger and an early winter. By mid-December only a small remnant of the Grand Army staggered back across the Neman.

On the map. Napoleon's road ran across the **North European Plain**, one of the great lowlands of the earth. It begins near the Pyrenees in southwestern France and sweeps northeast through Belgium, the Netherlands, northern Germany, Denmark and Poland. In the east it widens into the even larger East European Plain, which runs across Belarus and Russia to the Ural Mountains. Most of the plain lies less than 200 meters (about 650 feet) above sea level. To the north are the North Sea and the Baltic Sea; to the south rise old uplands, and beyond them the Alps and the Carpathians. The plain is narrow in the west and widens toward the east like a funnel. Its great rivers, the Rhine, Weser, Elbe, Oder and Vistula, flow north to the sea. Ice Age glaciers left sand, gravel and many lakes in the north, while along the southern edge wind-blown **loess** built deep, rich soil, where farmers grow wheat, sugar beets, potatoes and rye.

The big idea. Mountains, seas and deserts are **natural barriers**: they slow travelers and shelter the people behind them. A plain is the opposite. It is an open road, and the North European Plain has been Europe's main **invasion route** for centuries. King Charles XII of Sweden marched across it toward Moscow in 1708 and was defeated at Poltava in 1709. Napoleon came in 1812. German armies crossed it in both World Wars, and in 1944–1945 Soviet armies crossed it the other way to Berlin. Poland, in the middle of the plain between strong neighbors, was divided among Russia, Prussia and Austria in three partitions (1772, 1793 and 1795) and did not regain lasting independence until 1918. Borders on the plain have moved far more often than borders guarded by mountains, such as the Pyrenees between France and Spain. Some thinkers say geography decides a nation's fate. That goes too far, because people still make real choices, but geography sets the stage, and a country without walls of rock has often felt it must build strong armies or find allies.

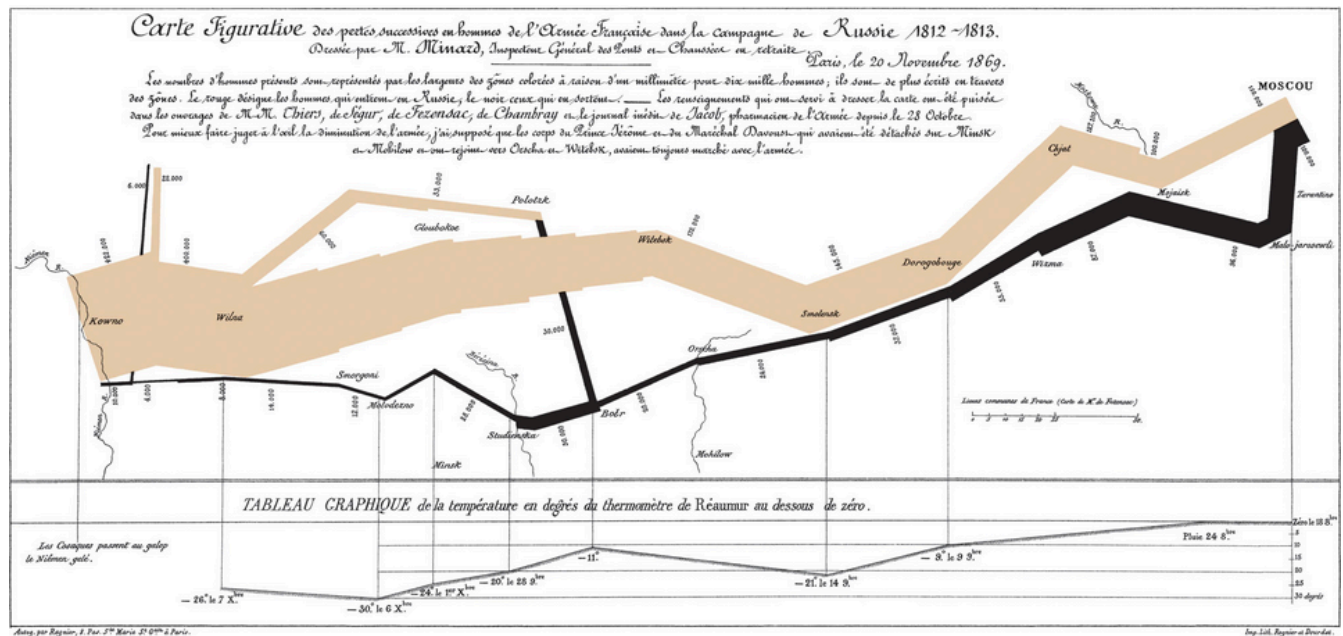
An open road for trade. What carries armies also carries merchants. The plain's northward rivers float goods to the sea, and its coasts have many harbors. From the 1200s to the 1400s the towns of the **Hanseatic League**, led by Lübeck (founded in 1143), ruled the trade of the North Sea and the Baltic. Their broad-bellied ships, called cogs, carried grain, timber, furs, wax and salted fish westward, and cloth, salt and wine eastward. The League kept trading houses in London, Bruges, Bergen and Novgorod. Polish rye floated down the Vistula to Gdańsk (Danzig) and went on by sea to the Low Countries. Today highways, fast railways and canals cross the same plain, and it is still one of the busiest trade corridors in the world.

Faith on the plain. The gospel traveled these roads too. In the 700s the English missionary Boniface preached among the Germanic tribes. At Geismar, about 723, he cut down a great oak sacred to the god Thor (Donar) to show that the old gods had no power, and in 754 he died as a martyr in Frisia. In 966 Duke Mieszko I of Poland was baptized, the date Poles remember as the beginning of Christian Poland. In 1517 Martin Luther posted his Ninety-Five Theses in Wittenberg, a town on the Elbe, and printed copies spread quickly along the plain's roads and rivers. The plain became a meeting ground of churches. As of 2026, the historic Protestant churches are strongest in northern Germany and Denmark, the Catholic Church in Poland, Belgium and much of France, and the Orthodox Church in Belarus and Russia, even where many people now rarely attend. God "hath determined ... the bounds of their habitation" (Acts 17:26), and on this plain those bounds have often been redrawn.



The North European Plain runs from France to Russia with no mountain wall across it. The red line shows Napoleon's advance in 1812.

PICTURE STUDY



Figurative Map of the Successive Losses in Men of the French Army in the Russian Campaign, 1812-1813, Charles Joseph Minard, 1869 · Lithograph map and chart, printed in color · Printed in Paris in 1869; public domain and widely reproduced

Charles Joseph Minard was a French civil engineer who spent his career building bridges, canals and railways. In retirement he invented new ways to draw numbers on maps. In this famous chart he told the whole story of Napoleon's march of 1812 in one picture. The tan band is the army marching to Moscow, and its width shows how many men were still alive and with the army. The black band is the retreat. Along the bottom, a line shows the bitter cold of the retreat, measured in degrees on the Réaumur scale used in France at the time.

The band begins at the Neman River with 422,000 men. About 100,000 reached Moscow, and only about 10,000 came back across the river. Many experts on charts have called it one of the finest pictures of numbers ever drawn.

Look closely

- Find the left end of the tan band, where the army crossed the Neman. Compare its width with the band at Moscow.
- Follow the black band home. Where does it suddenly grow thinner? (Look for the crossing of the Berezina River.)
- Find the temperature line along the bottom. How does it change as the army retreats west?
- Notice what is not on the map: there are no mountains drawn in Napoleon's way. What does that tell you about the land?

Talk about it

1. Why do you think Minard chose width to show the number of men instead of writing numbers only?
2. The army lost most of its men on the way to Moscow, before the worst cold. What besides winter do you think hurt them on such a long march across open land?
3. How does this map help you understand that a plain is an “open road” in both directions?

PROJECT: A SALT-DOUGH RELIEF MAP: PLAIN OR WALL?

You will build a raised relief map of Europe from France to Russia that shows the low North European Plain, the uplands to its south, and the high walls of the Alps and Carpathians. Then you will “march” a marble army across it to feel why the plain has been a road for armies and trade. This map will also become the base for your unit atlas page.

You will need

- 2 cups flour, 1 cup salt and about $\frac{3}{4}$ cup water (salt dough)
- A piece of stiff cardboard about 12 × 16 inches (30 × 40 cm)
- A printed outline map of Europe from France to western Russia, taped to the cardboard
- Poster paints: green, light brown, dark brown, white and blue; a small brush
- Toothpicks and small paper flags; a fine marker
- A marble or a small toy car

Steps

1. Mix the flour and salt, then add water a little at a time and knead until the dough is smooth and not sticky.
2. On the outline map, lightly pencil in the North European Plain (France to Russia), the Alps, the Carpathians and the Pyrenees, using the lesson map as a guide.
3. Spread a very thin layer of dough over the plain, only a few millimeters thick. It should be almost flat.
4. Build the uplands of central Germany a little thicker, then pile the Alps, Carpathians and Pyrenees high, pinching the dough into ridges.
5. Press a pencil tip lightly into the dough to carve the Rhine, Weser, Elbe, Oder and Vistula flowing north to the sea.
6. Let the map dry for one to two days (or bake at a very low oven temperature with a parent’s help) until hard.
7. Paint the plain green, the uplands light brown, the mountains dark brown with white peaks, and the seas and rivers blue.
8. Use flags to label Paris, Berlin, Warsaw, Kaunas, Moscow, Lübeck and Gdańsk.
9. Roll a marble from Paris toward Moscow across the plain. Then try to roll it from Berlin to Milan across the Alps. Record what happens.

Tips

- Keep the plain truly low. If everything is lumpy, the map will not show the big difference between the plain and the mountains.
- Rivers on the plain run north. Check your carved rivers against the lesson map before the dough dries.

Check your work

- My map shows the plain as a low, open belt from France to Russia.
- I labeled at least seven cities and five rivers correctly.
- I can explain, using my marble test, why the plain is called an open road.

MAP NOTEBOOK

1. Trace the outline of the North European Plain on a blank map of Europe. Shade it green, and label the North Sea, the Baltic Sea, the Alps, the Carpathians and the Ural Mountains.
2. Draw a simple timeline titled "Armies on the Plain" with Charles XII (1708-1709), Napoleon (1812), the World Wars (1914, 1941) and the Soviet march to Berlin (1945).
3. Sketch a Hanseatic cog with its single square sail and high sides, and list three goods it carried west and three it carried east.

From history. The Hanseatic League never had a king or a single government. Its member towns sent representatives to a meeting called the Hanseatic Diet, usually held in Lübeck, to agree on rules for trade and defense. Its foreign trading houses, such as the Steelyard in London and the German Wharf (Bryggen) in Bergen, Norway, were small walled towns of German merchants living under their own laws. As new nations and new ocean trade routes grew stronger, the League faded, and the last Hanseatic Diet met in 1669. Lübeck, Hamburg and Bremen kept the title "Hanseatic city" for centuries afterward.

WORKED EXAMPLES

Example 1. Kaunas (about 54.9°N , 23.9°E) and Moscow (about 55.8°N , 37.6°E) lie at nearly the same latitude. At 55°N , one degree of longitude is about 64 km. About how far is it in a straight line from the Neman crossing at Kaunas to Moscow, in kilometers and miles?

(Use the map or drawing “Kaunas and Moscow sit near the same latitude, about 55°N .” shown earlier in this lesson.)

1. Find the difference in longitude: $37.6^{\circ} - 23.9^{\circ} = 13.7^{\circ}$.
2. Multiply by the length of a degree of longitude at this latitude: $13.7 \times 64 \text{ km} \approx 877 \text{ km}$.
3. The latitudes differ by only about 0.9° , so the east-west distance is nearly the whole distance. Round to about 880 km.
4. Convert to miles ($1 \text{ km} \approx 0.621 \text{ mi}$): $880 \times 0.621 \approx 546 \text{ miles}$.

Answer: About 880 km (about 550 miles) as the crow flies. The real road was longer.

Example 2. Napoleon crossed the Neman on June 24, 1812, and entered Moscow on September 14. Using the straight-line distance of about 880 km (550 miles), what was the army’s average progress per day?

1. Count the days: June 24 to June 30 is 6 days; July has 31; August has 31; then 14 days of September. $6 + 31 + 31 + 14 = 82$ days.
2. Divide distance by days: $880 \text{ km} \div 82 \approx 10.7 \text{ km per day}$.
3. In miles: $550 \div 82 \approx 6.7 \text{ miles per day}$.
4. Think about it: soldiers can march 25 km (15 miles) or more in a day, but this army also stopped to rest, forage and fight, and the real road wound back and forth.

Answer: About 11 km (about 7 miles) of straight-line progress per day, over 82 days.

Example 3. On a map with a scale of 1:5,000,000, the distance from Berlin to Warsaw measures 10.4 cm. How far apart are the two cities in kilometers and miles? Check your answer using latitude and longitude: Berlin is at about 52.5°N, 13.4°E and Warsaw at about 52.2°N, 21.0°E; at 52°N one degree of longitude is about 68 km.

1. At 1:5,000,000, 1 cm on the map is 5,000,000 cm on the ground, which is 50 km.
2. $10.4 \text{ cm} \times 50 \text{ km} = 520 \text{ km}$.
3. Convert: $520 \times 0.621 \approx 323 \text{ miles}$.
4. Check: the longitude difference is $21.0^\circ - 13.4^\circ = 7.6^\circ$. $7.6 \times 68 \text{ km} \approx 517 \text{ km}$. The latitudes differ by only 0.3° , so the two answers agree.

Answer: About 520 km (about 320 miles), across flat land with no mountains between.

PRACTICE

1. **EASY** Name four countries crossed by the North European Plain.
2. **EASY** Name three rivers that flow north across the plain to the North Sea or the Baltic Sea.
3. **EASY** What is loess, and why do farmers value it?
4. **EASY** Who led the Hanseatic League, and what kind of ship did its merchants sail?
5. **MEDIUM** Most of the North European Plain lies below 200 meters. How many feet is 200 meters? ($1 \text{ m} \approx 3.28 \text{ ft}$)
6. **MEDIUM** Amsterdam (about 52.4°N, 4.9°E) and Berlin (about 52.5°N, 13.4°E) are at nearly the same latitude. At 52°N a degree of longitude is about 68 km. About how far apart are they, in km and miles?
7. **MEDIUM** Minard's map shows 422,000 men at the start, about 100,000 at Moscow and about 10,000 at the end. What percent of the starting army reached Moscow? What percent returned?
(Use the map or drawing "The route of 1812 across the plain." shown earlier in this lesson.)
8. **MEDIUM** On a map at a scale of 1:2,000,000, Gdańsk to Warsaw measures 14 cm. How far is it in km and miles?
9. **HARD** Poland's borders have moved many times, while the border between France and Spain has hardly moved in over 350 years. Explain the difference using geography.
10. **CHALLENGE** The rivers of the plain flow mostly north, but armies usually marched east or west. Write a short paragraph explaining how these rivers could both help and hinder an army or a merchant.

COMMON MISTAKES

- Thinking the plain is perfectly flat everywhere. It is low and gently rolling, with hills, lakes, marshes and river valleys.
- Thinking only of Germany or Poland. The plain begins in France and widens all the way across Russia to the Urals.

- Saying geography alone decides history. Geography makes some things easier and others harder, but people and nations still make real choices.

Make it a game · Road or Wall? A parent or partner names a place: the North European Plain, the Alps, the Baltic Sea, the Pyrenees, the Vistula River, the Carpathians, the English Channel. You have five seconds to call out “Road!” if it helps armies and traders move, or “Wall!” if it slows them down, and then give one reason. Some answers can be both (a river is a road along its length and a wall across it). Score a point for each good reason. Play to ten.

Scripture. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;” (Acts 17:26, KJV)

Paul spoke these words in Athens. The peoples of the plain, French, Dutch, German, Danish, Polish, Lithuanian and Russian, are all of one blood. Their borders have moved many times, but none of those changes escaped the knowledge and rule of God.

Practice answers

1. Any four of: France, Belgium, the Netherlands, Germany, Denmark, Poland, and in the east Lithuania, Belarus and Russia.
2. Any three of: the Rhine, Weser, Elbe, Oder and Vistula.
3. Loess is fine, wind-blown dust that built up into deep soil. It is soft, rich and easy to plow, so it makes some of Europe’s best farmland for wheat and sugar beets.
4. The city of Lübeck led the League. Its merchants sailed cogs, broad ships with high sides and one square sail.
5. $200 \times 3.28 \approx 656$ feet, about 650 feet.
6. $13.4^\circ - 4.9^\circ = 8.5^\circ$; $8.5 \times 68 \approx 578$ km, about 580 km (about 360 miles).
7. $100,000 \div 422,000 \approx 0.237$, about 24% reached Moscow. $10,000 \div 422,000 \approx 0.024$, about 2.4% (roughly 2%) returned.
8. 1 cm = 20 km, so $14 \times 20 = 280$ km, about 174 miles.
9. Poland lies in the middle of the open North European Plain between strong neighbors, with no mountain wall or sea on its east or west to protect it, so armies crossed easily and borders were redrawn (the partitions of 1772-1795, the changes of 1918 and 1945). France and Spain are divided by the Pyrenees, a high natural barrier that makes a clear and easily defended border.
10. Because the rivers run north, an army marching east or west had to cross one river after another, and each crossing was slow and dangerous; Napoleon’s retreating army suffered terribly crossing the Berezina in November 1812, and defenders used rivers as lines to hold. But the same rivers were highways for merchants and supply boats moving north and south, carrying grain and timber to seaports like Gdańsk. A good answer names both the barrier and the road.

1.2 MEDITERRANEAN EUROPE

OBJECTIVES

- Locate the Iberian, Italian and Balkan peninsulas and the seas and straits around them.
- Explain the Mediterranean climate of hot, dry summers and mild, rainy winters, and why olives, grapes and wheat suit it.
- Trace the Apostle Paul's voyage to Rome and explain how the sea carried trade, empires and the gospel.

Warm-up. Trace your hand on paper with your fingers spread wide. Then trace your closed fist. Lay a piece of string along each outline and compare the lengths. Which shape has more "coastline" for the same amount of "land"? Southern Europe is the spread hand: a land of long peninsulas, where almost everyone lives near the sea.

Watch. *Where was Paul shipwrecked on his way to Rome?* (Drive Thru History with Dave Stotts, 5:09). <https://www.youtube.com/watch?v=Dk-jHfF954M>

After the story: watch Dave Stotts look for the place on Malta where Paul's grain ship ran aground, and compare it with your map of Paul's voyage.

Note: Captions were not available to check; preview it first. Drive Thru History is a trusted Christian channel, and the title and description fit the lesson. Scholars disagree about exactly where on Malta the wreck happened, so the video may name a different bay from the one in your book. The exact shipwreck site is debated (St. Paul's Bay or another spot), so check it against the lesson.

Backup video. *What type of ship did Paul take to Rome?* (Drive Thru History with Dave Stotts, 4:44). <https://www.youtube.com/watch?v=TL3OaA2SpaU>

After the story: watch to see what an Alexandrian grain ship looked like and why it struggled against late-season winds on the Mediterranean. Note: Captions were not available to check; preview it first. Drive Thru History is a trusted Christian channel, and the title fits the story of Paul's grain ship.

KEY TERMS

peninsula

A piece of land almost surrounded by water but joined to a larger landmass. Southern Europe has three great ones: the Iberian, Italian and Balkan peninsulas.

Mediterranean climate

A climate of hot, dry summers and mild, rainy winters (Köppen "Cs"), found around the Mediterranean Sea and in places such as California and central Chile.

strait

A narrow channel of water joining two larger bodies of water, such as the Strait of Gibraltar between the Atlantic and the Mediterranean.

terrace

A flat step cut into a hillside and held up by a wall, so that crops can grow on steep land without the soil washing away.

Mediterranean triad

The three crops that fed the ancient Mediterranean world: wheat, olives and grapes.

CORE IDEAS

The story. About AD 60, the Apostle Paul sailed for Rome as a prisoner, guarded by a centurion named Julius. At Myra, on the coast of today's Turkey, they boarded a grain ship from Alexandria in Egypt bound for Italy. The season was late and the winds were against them. They crept to a harbor on Crete called Fair Havens, and Paul warned that going on would bring "hurt and much damage." The captain sailed anyway, and a violent northeast wind called Euroclydon caught the ship. For fourteen days it was driven across the sea, the sailors threw the cargo of wheat overboard, and all hope seemed lost. Paul told the 276 people aboard to take heart, for God had promised that no life would be lost. The ship ran aground on Malta, and every one of them reached shore (Acts 27-28). Three months later another Alexandrian ship carried Paul on by way of Syracuse and Rhegium to Puteoli, and from there he walked the road to Rome.

On the map. Paul's voyage crossed the heart of Mediterranean Europe. Three great peninsulas reach south into the sea: the **Iberian** (Spain and Portugal), cut off from France by the Pyrenees; the **Italian**, with the Apennine Mountains down its spine and the Alps across its top; and the **Balkan**, a rugged land of mountains ending in Greece and its thousands of islands. Around them lie smaller seas: the Adriatic, Ionian, Tyrrhenian and Aegean. The Mediterranean stretches about 3,800 km (2,400 miles) from west to east, and it meets the Atlantic only through the **Strait of Gibraltar**, about 14 km (9 miles) wide at its narrowest. Mountains crowd close to the shore, so flat farmland is scarce, and most rivers are short. Only a few, such as the Po in Italy and the Ebro in Spain, water wide plains.

The big idea. The region gives its name to a climate. In the **Mediterranean climate**, summers are hot, sunny and nearly rainless, and winters are mild and wet. In summer, the belt of high pressure that keeps the Sahara dry shifts north over the sea; its sinking air brings clear skies and blocks storms. In winter that belt slides south, and storms from the Atlantic bring rain. Rome lies at about 42°N, the same latitude as Chicago, yet its winters are far milder, because the warm sea and the ocean winds soften the cold. People here learned to farm with the seasons. Wheat is sown in autumn, grows through the rainy winter and is harvested before the summer drought. Olive trees, with deep roots and small, leathery leaves, survive months without rain and can live for centuries. Grapes grow on sunny slopes. Together these three crops, the **Mediterranean triad**, fed Greece and Rome, and farmers built stone **terraces** to grow them on steep hills. Spain today produces more olive oil than any other country.

A sea that joins. With poor soil and good harbors, Mediterranean peoples turned to the sea. The Phoenicians, from the coast of today's Lebanon, founded Carthage in North Africa. Greek cities planted colonies such as Syracuse in Sicily and Massalia (Marseille) in France.

The Romans ruled every shore and called it *Mare Nostrum*, “Our Sea.” Ships like Paul’s carried Egyptian wheat to feed the city of Rome. Sailing was risky in winter, so ancient ships mostly stayed in port from about November to March, which is why Paul’s ship was in such danger so late in the year. Later the merchant cities of Venice and Genoa grew rich on this trade, and sailors of Portugal and Spain carried Mediterranean seamanship out into the Atlantic.

Faith by sea. The same sea lanes carried the gospel. Paul’s journeys took him to Cyprus, Greece and finally Rome, and churches grew in the port cities first. Rome became the center of the Latin-speaking church in the West, and Constantinople, made capital by the Emperor Constantine in 330, the center of the Greek-speaking church in the East. Over centuries of distance and different languages the two drew apart and divided in 1054. That old line still shows on the map. As of 2026, the Catholic Church has the deepest roots in Portugal, Spain, Italy, Malta and Croatia, and the Orthodox Church in Greece, Serbia, Bulgaria and Cyprus. Islam came to Spain in 711 and remained there until the fall of Granada in 1492; under the Ottoman Turks it spread into the Balkans, and today many people in Albania, Bosnia and Herzegovina and Kosovo are Muslim.



Paul's voyage to Rome, about AD 60 (Acts 27-28).

PICTURE STUDY



Seaport with the Embarkation of the Queen of Sheba, Claude Lorrain (Claude Gellée), 1648 · Oil on canvas · National Gallery, London

Claude Lorrain was a French painter who spent nearly all his working life in Rome, walking the countryside and the coast to study the Mediterranean light. Here he imagined the Queen of Sheba setting out to visit King Solomon (1 Kings 10). The Bible tells us she came “with a very great train, with camels,” so Claude has borrowed the story to paint the thing he loved most: a Mediterranean harbor, glowing with sunlight off the sea.

The great English painter J. M. W. Turner admired this picture so much that he asked in his will for two of his own paintings to hang beside two by Claude, this one among them, in the National Gallery. You can still see them side by side there today.

Look closely

- Find the sun. How does the light on the water lead your eye into the painting?
- Look at the buildings on the left and right. What style are they? Do they remind you of Greek or Roman temples?
- Find the queen and her people on the steps. How small are they compared with the harbor?
- Count the ships. What does this harbor tell you about how people traveled in the Mediterranean world?

Talk about it

1. Why might a painter who lived in Rome set a Bible story in a seaport, even though the queen probably traveled by land?
2. How is this calm harbor different from the storm Paul faced in Acts 27?

3. What does the picture suggest about why Mediterranean cities grew up on the coast?

PROJECT: HILLSIDE TERRACES: SAVING SOIL FROM WINTER RAIN

Mediterranean farmers have built stone terraces on their hillsides for thousands of years. You will build two model hillsides, one smooth and one terraced, then pour a “winter storm” over each and measure how much soil washes away. Then you will plant an olive tree, a grapevine and a wheat field on your terraced model.

You will need

- Two disposable aluminum baking pans (about 9 × 13 in, or 23 × 33 cm)
- Potting soil or damp sand, enough to fill each pan halfway
- About 20 craft sticks or flat pebbles for terrace walls
- A watering can or a cup with small holes poked in the bottom
- A measuring cup and two clear jars
- Books or blocks to tilt the pans; scissors to cut a notch in each pan’s low end
- Toothpicks and green paper or cloves to make tiny olive trees, vines and wheat

Steps

1. Cut a small V-notch in the low end of each pan so water can run out. Set a clear jar under each notch.
2. Fill each pan with soil, heaped toward the high end into a slope. Tilt both pans on books to the same angle.
3. Leave the first hillside smooth.
4. On the second, press craft sticks or pebbles into the slope in rows to make three or four level steps (terraces). Flatten the soil behind each wall.
5. Make a “winter storm”: pour exactly 2 cups (about 500 mL) of water slowly over the top of each hillside.
6. Wait five minutes, then compare the two jars. How muddy is the water? How much soil settled in the bottom?
7. Record your results in a table: hillside type, water poured, how muddy, soil lost.
8. On the terraced model, plant toothpick “olive trees” on the highest, driest step, “vines” in the middle and “wheat” on the widest step. Label each crop with its season: sown, grown, harvested.

Tips

- Pour the same amount of water at the same speed on both models, or the test is not fair.
- Real terraces also keep rainwater on the hillside longer, so it soaks into the ground where roots can reach it during the dry summer.

Check your work

- I ran a fair test and recorded which hillside lost more soil.
- I can explain why terraces matter where mountains meet the sea and rain falls mostly in winter.
- I can name the three crops of the Mediterranean triad and when each grows.

MAP NOTEBOOK

1. Draw an outline map of southern Europe. Label the Iberian, Italian and Balkan peninsulas, the Pyrenees, Alps and Apennines, and the Adriatic, Aegean and Tyrrhenian Seas.
2. Draw Paul's route from Caesarea to Rome and number the stops in order: Sidon, Myra, Fair Havens, Malta, Syracuse, Rhegium, Puteoli, Rome.
3. Sketch an olive branch with its narrow leaves and fruit. Beside it, write two ways the olive tree is suited to dry summers.

From history. Malta still remembers Paul's shipwreck. A bay on the island's northeast coast is called St. Paul's Bay, and tradition places the wreck near the small St. Paul's Islands at its mouth. Every year on February 10, Maltese Christians keep the Feast of St. Paul's Shipwreck. The Acts account also notes that the people of the island "shewed us no little kindness" and built a fire for the soaked and shivering travelers (Acts 28:2).

WORKED EXAMPLES

Example 1. The Strait of Gibraltar is about 14 km wide at its narrowest. How wide is that in miles? How long would it appear on a map with a scale of 1:500,000?

1. Convert to miles: $14 \text{ km} \times 0.621 \approx 8.7 \text{ miles}$, about 9 miles.
2. At 1:500,000, 1 cm on the map stands for 500,000 cm, which is 5 km.
3. Divide: $14 \text{ km} \div 5 \text{ km per cm} = 2.8 \text{ cm}$.

Answer: About 9 miles; it would measure 2.8 cm on a 1:500,000 map. The whole gateway between the Atlantic and the Mediterranean is narrower than many large cities.

Example 2. Paul's ship was driven from the island of Clauda, south of Crete, to Malta, a straight-line distance of about 890 km (550 miles). Acts 27:27 says this took fourteen nights. What was the ship's average speed per day and per hour?

(Use the map or drawing "The fourteen-day drift from Clauda (near Fair Havens) to Malta." shown earlier in this lesson.)

1. Per day: $890 \text{ km} \div 14 \approx 64 \text{ km per day}$. In miles: $550 \div 14 \approx 39 \text{ miles per day}$.
2. Per hour: $64 \text{ km} \div 24 \text{ hours} \approx 2.7 \text{ km/h}$. In miles: $39 \div 24 \approx 1.6 \text{ mph}$.
3. This is slow, about a walking pace, which fits a ship that had lowered its sails and was drifting before the storm (Acts 27:17).

Answer: About 64 km (39 miles) a day, or about 2.7 km/h (1.6 mph).

Example 3. Rome and Chicago both lie at about 41.9°N . In January, Rome's average temperature is about 8°C (46°F), and Chicago's is about -4°C (25°F). How large is the difference? How far is each city from the equator? Why are their winters so different?

1. Difference in Celsius: $8 - (-4) = 12^\circ\text{C}$. In Fahrenheit: $46 - 25 = 21^\circ\text{F}$.
2. Each degree of latitude is about 111 km (69 miles). $41.9 \times 111 \approx 4,650 \text{ km}$; $41.9 \times 69 \approx 2,890 \text{ miles}$. Both cities are the same distance from the equator.
3. Since latitude is the same, look at other causes: Rome sits near the warm Mediterranean and receives mild air from the sea, while Chicago lies in the middle of a continent, open to cold air from the Arctic.

Answer: Rome is about 12°C (21°F) warmer in January, though both are about 4,650 km (2,890 miles) from the equator. The sea and the winds, not latitude alone, make the difference.

PRACTICE

1. **EASY** Name the three great peninsulas of southern Europe and one country on each.
2. **EASY** What are the three crops of the Mediterranean triad?
3. **EASY** In a Mediterranean climate, in which season does most of the rain fall?
4. **EASY** On which island was Paul shipwrecked, and how many people were aboard the ship?
5. **MEDIUM** A ship crosses the Strait of Gibraltar straight across its narrowest point, 14 km, at 28 km/h. How many minutes does the crossing take?
6. **MEDIUM** On a map where 1 cm = 100 km, Rome to Athens measures 10.5 cm. How far apart are they in km and in miles?
7. **MEDIUM** Madrid lies at about 40.4°N and New York City at about 40.7°N . Which is farther north, and by about how many kilometers and miles?

8. **MEDIUM** Roman ships mostly stayed in port from about November 11 to March 10. About how many days was the sea “closed”? (February has 28 days.)
(Use the map or drawing “Paul sailed late in the season and wintered on Malta.” shown earlier in this lesson.)
9. **HARD** Explain why ancient Greek cities so often sent out colonies by sea instead of expanding over land.
10. **CHALLENGE** Write a short paragraph explaining how geography helps explain why the churches of Rome and Constantinople grew apart, and where the dividing line shows on today’s map.

COMMON MISTAKES

- Thinking the Mediterranean is hot and dry all year. Its winters are mild and rainy; only the summers are dry.
- Mixing up the peninsulas. Iberia is Spain and Portugal; the Balkans are in the southeast and include Greece.
- Thinking latitude alone sets the climate. Rome and Chicago share a latitude, but the sea, winds and mountains make their climates very different.

Make it a game • Mediterranean Harbor Hop. Lay ten paper “harbors” on the floor, labeled Gibraltar, Barcelona, Marseille, Genoa, Rome, Naples, Syracuse, Malta, Athens and Crete. A partner calls out a clue, such as “the island where Paul was shipwrecked” or “the strait 14 km wide,” and you hop to the right harbor. A wrong hop sends you back to Gibraltar. After every three correct hops, name a crop or a church tradition of that place for a bonus point.

Scripture. “Wherefore, sirs, be of good cheer: for I believe God, that it shall be even as it was told me.” (Acts 27:25, KJV)

In the middle of a Mediterranean storm, with no sun or stars for many days, Paul trusted the God who made the sea. Every one of the 276 people aboard reached land safely, and the gospel went on to Rome.

Practice answers

1. Iberian (Spain or Portugal), Italian (Italy), Balkan (Greece, Albania, Bulgaria, Serbia, Croatia and others).
2. Wheat, olives and grapes.
3. In winter. Summers are hot and dry.
4. Malta (called Melita in the King James Bible). There were 276 people aboard (Acts 27:37).
5. $14 \div 28 = 0.5$ hour = 30 minutes.
6. $10.5 \times 100 = 1,050$ km; $1,050 \times 0.621 \approx 652$ miles, about 650 miles.
7. New York, by about 0.3° . $0.3 \times 111 \approx 33$ km; $0.3 \times 69 \approx 21$ miles.
8. Counting both November 11 and March 10: November 11–30 is 20 days, plus December 31, January 31, February 28 and March 1–10 is 10: $20 + 31 + 31 + 28 + 10 = 120$ days, about four months. (Counting only the days between the two dates gives 119.)

9. Greece is mountainous with little flat farmland, so a growing city soon ran short of land to feed its people. Mountains made overland travel slow, but the sea was close, calm in summer and full of islands and harbors. It was easier to sail to a new coast, such as Sicily or southern France, than to cross the mountains.
10. The two cities lay far apart at opposite ends of the Mediterranean, the West spoke Latin and the East spoke Greek, and after the Roman Empire divided, each half had its own rulers and customs. Travel by sea was slow and closed in winter, so contact was limited, and the churches drifted apart until they divided in 1054. Today the line still shows: Catholic roots in Italy, Spain, Portugal, Malta and Croatia, and Orthodox roots in Greece, Serbia, Bulgaria and Cyprus.

1.3 THE ALPS AND THE GOTTHARD TUNNELS ⚙️

OBJECTIVES

- Describe the Alps: where they lie, how high they rise, and the great rivers and passes that begin there.
- Explain how the Gotthard rail tunnel of 1882 and the Gotthard Base Tunnel of 2016 overcame the barrier of the Alps, and what each cost in labor and lives.
- Use elevations, gradients, lengths and speeds to compare a mountain railway with a base tunnel.

Warm-up. Stack books about 20 cm (8 in) high and drape a towel over them to make a mountain. Lay a string from the floor on one side, over the top, and down to the floor on the other side: that is the pass road. Now measure straight through the bottom of the mountain from foot to foot: that is a base tunnel. Which is shorter? Which would be easier for a heavy train to travel?

Watch. *Why Tunnels Don't Collapse* (Practical Engineering, 8:40).

<https://www.youtube.com/watch?v=xNDppVTUss>

Before the project: watch how engineers keep a tunnel from caving in, then think about how the Gotthard crews held up the rock under the mountains.

Note: Captions were not available to check; preview it first. This Practical Engineering video, "Why Tunnels Don't Collapse," is about tunnel engineering in general rather than the Gotthard in particular, and this channel often includes a sponsor message you can skip. This is a general tunnel engineering video, not specifically about the Gotthard tunnels or the 1880 breakthrough.

Backup video. *Brenner Base Tunnel: Game Changer for the European Mobility* (Railways Explained, 16:57). <https://www.youtube.com/watch?v=KR3kXr42AmI>

As review: watch how a new base tunnel is being bored under the Alps at the Brenner Pass, and compare it with the Gotthard Base Tunnel from the lesson. Note: Captions were not available to check; preview it first. This video is about the Brenner Base Tunnel between Austria and Italy, not the Gotthard. It runs about 17 minutes and uses metric measurements. It calls the Brenner Base Tunnel the future longest railway tunnel in the world; today that title belongs to the Gotthard Base Tunnel, which the lesson covers.

KEY TERMS

pass

A low gap or saddle through a mountain range that travelers can cross. The Gotthard Pass is about 2,106 m (6,909 ft) high.

watershed (divide)

A ridge of high land that separates rivers flowing toward different seas.

gradient (grade)

How steep a road or railway is, often given as a percent: a 2% grade rises 2 m for every 100 m of distance.

spiral tunnel

A tunnel that curls around inside a mountain so a railway can gain height in a short distance without getting too steep.

base tunnel

A tunnel dug through the bottom of a mountain range, close to the level of the valleys on each side, so trains need hardly climb at all.

portal

The entrance at each end of a tunnel.

CORE IDEAS

The story. On February 29, 1880, miners deep under the Gotthard massif in Switzerland heard the drills of another crew coming toward them through the rock. One crew had started at Göschenen on the north side, the other at Airolo on the south, and after more than seven years of blasting they broke through to each other almost perfectly in line. Their chief engineer, Louis Favre of Geneva, did not live to see it; he had collapsed and died inside the tunnel the summer before. The cost in lives was heavy. About 200 workers, most of them from northern Italy, died from rockfalls, dynamite accidents, and illness caused by dust, heat and bad air. In 1875 workers at Göschenen went on strike over these conditions, and four were killed when a local militia fired on them. When the Gotthard rail tunnel opened in 1882, it was about 15 km (9.3 miles) long, the longest railway tunnel in the world.

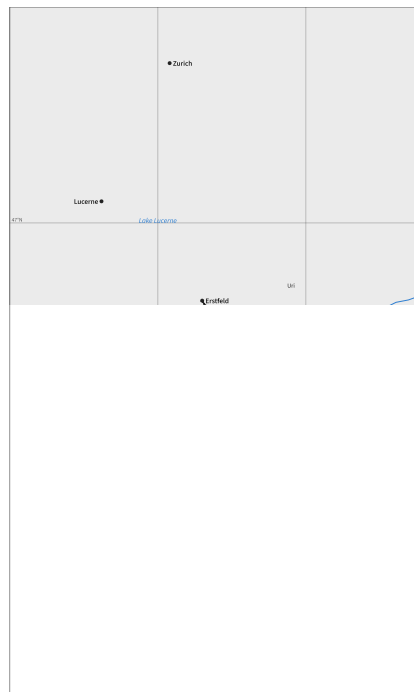
On the map. The Alps curve in a great arc about 1,200 km (750 miles) long, from the coast near Nice through France, Italy, Switzerland, Liechtenstein, Germany and Austria into Slovenia. Their highest peak, Mont Blanc, rises about 4,800 m (15,770 ft). They are a wall across the middle of Europe, separating the North European Plain and the Rhine lands from Italy and the Mediterranean. They are also Europe's water tower: snow and glaciers feed the Rhine, the Rhône, the Po and the Inn, which flows to the Danube. Around the Gotthard, rivers set off in four directions. The Reuss runs north toward the Rhine and the North Sea, and the Ticino runs south to the Po and the Adriatic. Nearby, the young Rhine heads east and the Rhône west toward the Mediterranean. The Gotthard is a **watershed** and a language line too: German is spoken in the canton of Uri on the north side and Italian in Ticino on the south.

The old road over the top. For centuries travelers crossed on foot and by mule over the Gotthard Pass, about 2,106 m (6,909 ft) high. The route opened for real trade in the early 1200s, when the people of Uri bridged the deep Schöllenen Gorge; legend says the Devil built that bridge, so it is still called the Devil's Bridge. The pass took its name from a chapel to Saint Godehard (Gotthard), an eleventh-century bishop of Hildesheim, and a hospice there sheltered travelers caught by storms. The valleys along this trade route, Uri, Schwyz and Unterwalden, swore an alliance in 1291 that the Swiss remember as the founding of their

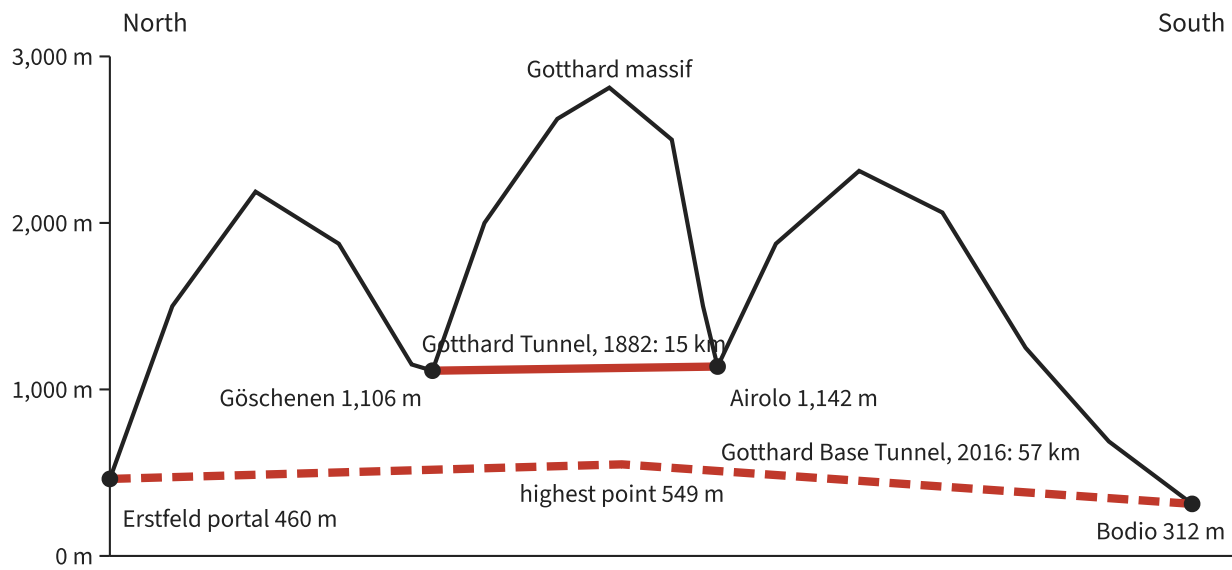
country. Mountains guarded the Swiss, and their high passes made them gatekeepers between northern and southern Europe.

Technology overcoming geography. A train's steel wheels grip the rails only on gentle slopes, so a railway cannot simply climb a mountain. The Gotthard line of 1882 rises from Erstfeld, at about 470 m, to the tunnel at Göschenen, at 1,106 m, using steep grades and **spiral tunnels** that curl inside the mountainsides. Near the village of Wassen the line loops so much that passengers see the same little church three times from different heights. Even so, heavy trains needed extra locomotives. The answer was to go under the whole climb. The **Gotthard Base Tunnel**, approved by Swiss voters in 1992, runs about 57 km (35.5 miles) from Erstfeld to Bodio, the longest railway tunnel in the world. Its crews broke through on October 15, 2010, and it opened on June 1, 2016. Its highest point is only 549 m above sea level, with up to about 2,300 m (7,500 ft) of rock overhead. It has two single-track tubes joined by cross-passages about every 325 m. Nine workers died building it.

The big idea. Mountains are barriers that divide climates, languages and peoples, but they also protect, and they reward those who master their passes. Each new technology, the bridge, the mule road, the summit tunnel, the base tunnel, has shrunk the barrier without erasing it. The Base Tunnel took 17 years of main construction and cost about 12 billion Swiss francs, and the mountain still sets the rules: heat inside the rock, hard and soft layers, and water pouring from cracks. Today freight trains carry goods from the North Sea ports toward Italy on a nearly flat line through the heart of the Alps.



The two Gotthard tunnels. The Base Tunnel runs under the whole climb.



Distance north to south about 57 km. Heights to scale; mountain outline simplified.

Cross-section of the Gotthard: the summit tunnel of 1882 and the Base Tunnel of 2016. Heights are drawn to scale; the mountain outline is simplified.

PICTURE STUDY



Landscape with Saint Jerome, Joachim Patinir, about 1516–1517 · Oil on panel · Museo del Prado, Madrid

Joachim Patinir grew up near Dinant, in the valley of the Meuse River, where sharp limestone cliffs rise above the water. He became a painter in Antwerp and was one of the first artists to make the landscape itself the main subject of a picture. Albrecht Dürer, who met him in Antwerp in 1521, called him a good landscape painter. Patinir painted what are called “world landscapes”: views from high above, showing mountains, valleys, rivers and seas all at once.

In the front of this painting sits Saint Jerome, the scholar who translated the Bible into Latin around AD 400. An old story says he pulled a thorn from a lion's paw, and the grateful lion stayed with him. Behind him, Patinir's fantastic crags tower over a world of farms, roads and harbors. The whole earth seems spread out around a man devoted to the Word of God.

Look closely

- Find Saint Jerome and the lion. What is Jerome doing?
- Look at the rocks. How are they like the cliffs and mountains you have studied? How are they different from real mountains?
- Notice the colors: brown in front, green in the middle, blue far away. How does this make the land look deep and distant?
- Find the roads, buildings and water. How do people travel through this mountain world?

Talk about it

1. Patinir painted from his imagination, but he grew up among real cliffs. Where do you see the real Meuse valley in this picture?
2. Why might a painter place a man who spent his life translating the Bible in the middle of such a huge landscape?
3. If you had to build a road or a railway through this landscape, where would you put it?

Safety first. Use only blunt wooden skewers and child-safe scissors. Keep the ramp on the floor or a low table so the toy cannot fall far.

PROJECT: GRADES, LOOPS AND TUNNELS

Engineers on the Gotthard had two problems: trains cannot climb steep slopes, and mountains are very tall. In Part A you will find the steepest grade a toy vehicle can climb. In Part B you will build a clay mountain and compare a summit tunnel with a base tunnel.

You will need

- A smooth board or stiff shelf about 100 cm (40 in) long
- A ruler or tape measure and a stack of thin books or blocks
- A battery toy train or small motorized toy car (a wind-up car also works)
- About 1 pound (450 g) of modeling clay or play dough
- Two wooden skewers, string, and a sheet of cardboard
- A pencil and a notebook for a data table

Steps

1. Part A. Lay the board flat. Place the toy at the bottom and let it run up. Record "0 cm rise, 0% grade, climbs."

2. Raise one end of the board 1 cm. Over 100 cm, that is a 1% grade. Run the toy again and record the result.
3. Keep raising the end 1 cm at a time, recording the grade each time, until the toy slips, stalls or cannot climb. That is its maximum grade.
4. Compare: the old Gotthard line was built with grades up to about 2.6%. Was your toy better or worse than a real heavy train?
5. Part B. Build a clay mountain on the cardboard about 10 cm (4 in) high and 25 cm (10 in) wide, with a valley floor at each side.
6. Push one skewer straight through the mountain near the top (the summit tunnel) and another straight through at the base (the base tunnel).
7. Use string to measure the path a train would take over the top to reach each tunnel, and then the base tunnel itself. Record both lengths.
8. With a pencil, draw a spiral path climbing around one side of your mountain. Measure it with string. How much longer is the spiral than a straight climb?

Tips

- Grade in percent = $\text{rise} \div \text{distance} \times 100$. A 3 cm rise over 100 cm is 3%.
- If your toy climbs very steep ramps, remember that rubber tires grip better than steel wheels on steel rails, which is why real trains need such gentle grades.

Check your work

- I found my toy's maximum grade and recorded it as a percent.
- I can explain why railways use spiral tunnels and loops.
- I can explain why a base tunnel is longer but easier for trains than a summit tunnel.

MAP NOTEBOOK

1. Draw a map of the Alps' arc from Nice to Slovenia. Mark Mont Blanc, the Gotthard Pass, and the Rhine, Rhône, Po and Inn rivers flowing away from the mountains.
2. Copy the Gotthard cross-section into your notebook. Label both tunnels, their portals, their opening years and their lengths in km and miles.
3. Draw the church at Wassen three times, once from each level of the loop, as a passenger would see it from the train window.

From history. Long before trains, Christian hospices helped travelers survive the Alpine passes. On the Great St. Bernard Pass between Switzerland and Italy, a hospice was founded about 1050 by Bernard of Menthon, and its monks have welcomed travelers ever since. In later centuries the monks bred large dogs to help find people lost in the snow. These St. Bernard dogs became famous, and one named Barry is said to have saved some forty lives in the early 1800s. Today Barry's preserved body can be seen in the Natural History Museum in Bern.

WORKED EXAMPLES

Example 1. The Gotthard Base Tunnel is about 57 km long and the 1882 Gotthard Tunnel is about 15 km long. How many times longer is the Base Tunnel? Give both lengths in miles.

(Use the map or drawing “The short summit tunnel and the long Base Tunnel.” shown earlier in this lesson.)

1. Divide: $57 \div 15 = 3.8$.
2. Convert: $57 \times 0.621 \approx 35.4$ miles; $15 \times 0.621 \approx 9.3$ miles.

Answer: The Base Tunnel is about 3.8 times as long: about 35.4 miles compared with about 9.3 miles.

Example 2. The highest point of the 1882 tunnel is about 1,151 m above sea level. The highest point of the Base Tunnel is 549 m. How much less must a train climb using the Base Tunnel? Give the answer in meters and feet.

(Use the map or drawing “Compare the heights of the two tunnels.” shown earlier in this lesson.)

1. Subtract: $1,151 - 549 = 602$ m.
2. Convert: $602 \times 3.28 \approx 1,975$ feet.
3. That is about 600 m that a heavy freight train no longer has to haul itself up and then brake back down.

Answer: About 600 m (about 1,975 feet) less climbing.

Example 3. A passenger train runs through the 57 km Base Tunnel at 200 km/h (about 124 mph). How many minutes does it spend inside the tunnel?

1. Time = distance $\div$ speed: $57 \text{ km} \div 200 \text{ km/h} = 0.285$ hour.
2. Convert to minutes: $0.285 \times 60 \approx 17.1$ minutes.
3. Check in miles: $35.4 \text{ miles} \div 124 \text{ mph} \approx 0.285$ hour, the same answer.

Answer: About 17 minutes to pass under the Alps.

PRACTICE

1. **EASY** Name four countries the Alps pass through.
2. **EASY** When did the first Gotthard rail tunnel open, and how long is it in km and miles?
3. **EASY** What is a base tunnel, and why is it easier for trains?

4. **MEDIUM** The steepest grades on the old Gotthard line are about 2.6%. How many meters does such a track rise in 1 km? How many feet?
5. **MEDIUM** The Gotthard Pass is about 2,106 m high. How high is that in feet?
6. **MEDIUM** Göschenen's portal is at 1,106 m and Airolo's at 1,142 m. Which is higher, and by how much in meters and feet?
(Use the map or drawing "Read the portal heights from the cross-section." shown earlier in this lesson.)
7. **MEDIUM** The 1882 tunnel was built from 1872 to 1882. Main work on the Base Tunnel began in 1999 and it opened in 2016. How many years did each take? Why might the newer, longer tunnel have taken longer?
8. **HARD** The two tubes of the Base Tunnel are joined by cross-passages about every 325 m. About how many cross-passages are there along 57 km?
9. **HARD** The Reuss and the Ticino both begin near the Gotthard. Where does each river's water end up? What does this tell you about the Gotthard?
10. **CHALLENGE** The old line must rise about 640 m from Erstfeld (about 470 m) to Göschenen (1,106 m), but the valley between them is only about 17 km long. If the steepest allowed grade is 2.6%, what is the shortest track that can make this climb? Explain why the builders used spiral tunnels and loops.

COMMON MISTAKES

- Thinking a shorter tunnel is always better. The 1882 tunnel is shorter, but trains must climb high to reach it; the longer Base Tunnel saves the climb.
- Confusing grade with angle. A 2.6% grade means 2.6 m of rise per 100 m, which is a gentle slope of only about 1.5 degrees.
- Forgetting the workers. Great engineering was done by thousands of laborers, many of whom died, and their story belongs in the history of the tunnels.

Make it a game • Grade Race. Make cards with grades from 1% to 8% and cards with distances from 1 km to 5 km. Draw one of each and race a partner to find how many meters the track rises (for example, 3% over 2 km is 60 m). Then decide whether a heavy freight train could use that grade: up to 2.6% is "Gotthard-safe," above it is "too steep, build a loop." First to ten correct answers wins.

Scripture. "Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain:" (Isaiah 40:4, KJV)

Isaiah spoke of preparing the way of the Lord, not of building railways. But his picture of high places made low and crooked ways made straight reminds us that God is greater than every mountain, and that people made in His image have been given skill to build roads, bridges and tunnels for the good of their neighbors.

Practice answers

1. Any four of: France, Italy, Switzerland, Liechtenstein, Germany, Austria, Slovenia (and Monaco at the very edge).
2. 1882; about 15 km (9.3 miles).
3. A tunnel dug through the bottom of a mountain range near valley level. Trains hardly need to climb, so they can be heavier, longer and faster, without extra locomotives.
4. 2.6% of 1,000 m = 26 m; $26 \times 3.28 \approx 85$ feet.
5. $2,106 \times 3.28 \approx 6,908$ feet, about 6,900 feet.
6. Airolo, by 36 m (about 118 feet).
7. About 10 years and 17 years. The Base Tunnel is nearly four times as long, has two tubes plus cross-passages and safety stations, and runs much deeper under the mountain, where the rock is hotter and harder to work.
8. $57,000 \text{ m} \div 325 \text{ m} \approx 175$ cross-passages.
9. The Reuss flows north into the Aare, which joins the Rhine, which reaches the North Sea. The Ticino flows south into the Po, which reaches the Adriatic Sea. The Gotthard is a watershed (divide) between rivers flowing to different seas.
10. Each km of track at 2.6% rises 26 m, so $640 \div 26 \approx 25$ km of track is needed at the very least. The valley is only about 17 km long, so the railway had to add extra length by looping back and spiraling inside the mountainsides, which is why passengers see the church at Wassen three times.

1.4 RIVERS AND PORTS: THE RHINE AND ROTTERDAM

OBJECTIVES

- Trace the Rhine from its Alpine sources to the North Sea and name the landforms and cities along its course.
- Explain why a great port grew at the Rhine–Meuse delta, and how the New Waterway made Rotterdam Europe’s busiest port.
- Calculate barge travel times, cargo loads and map distances along the Rhine, in kilometers and miles.

Warm-up. Tilt a baking tray slightly on a book and spread a thin layer of damp sand at the high end. Slowly pour a cup of water onto the sand and watch where the water goes. Look at the low end: does the sand fan out into little channels where the water slows down? You have just made a delta, the kind of land where Rotterdam stands.

Watch. *The Rhine River explained in under 3 Minutes* (FactSpark, 2:59).

<https://www.youtube.com/watch?v=IpFTi7-T-TI>

With On the map: follow the Rhine from the Swiss Alps past the castles and factories down to the busy port at its mouth, tracing the route on your map as you watch.

Note: Captions were not available to check; preview it first. It gives distances in kilometers, and the description wrongly says the river ends in southern Switzerland when it actually reaches the sea through the Netherlands. The description says the Rhine finishes "through southern Switzerland"; it actually reaches the North Sea through the Netherlands at Rotterdam.

Backup video. *Life on a Barge Along the River Rhine, 1960s - Film 95249*

(HuntleyFilmArchives, 2:34). <https://www.youtube.com/watch?v=Bvl9ZSXOhno>

After the story: watch this 1960s film of families who lived and worked on Rhine barges, and notice how the boat was both a home and a cargo carrier.

KEY TERMS

delta

Low, flat land built of sand and mud where a river slows down and splits into several channels before reaching the sea.

distributary

A channel that branches off a river and flows away from it, as the Waal and the Lek branch off the Rhine in the Netherlands.

port

A harbor town where ships load and unload cargo and passengers, with docks, cranes and warehouses.

hinterland

The inland region that a port serves, sending it exports and receiving its imports.

barge

A long, flat-bottomed boat built to carry heavy cargo on rivers and canals.

TEU

“Twenty-foot equivalent unit,” the standard size of a shipping container, about 6.1 m (20 ft) long, used to count container cargo.

CORE IDEAS

The story. In 1866 Dutch workmen began cutting a new channel through the sand dunes west of Rotterdam. The city stood on a branch of the great Rhine–Meuse delta, but the old ways to the sea wound through shallow channels that were silting up, and the new iron steamships drew too much water to use them. The engineer Pieter Caland planned a straight cut to the North Sea at the Hook of Holland, and he expected the river’s own current to scour it deep. The **New Waterway** (Nieuwe Waterweg) opened in 1872. It needed years of extra dredging before it worked as hoped, but it gave Rotterdam a direct, deep road to the ocean just as the coal mines and steel mills of Germany’s Ruhr valley, up the Rhine, were booming. Rotterdam became the Ruhr’s doorway to the world.

On the map. The Rhine runs about 1,230 km (765 miles). Its headstreams rise in the Swiss Alps; one begins at little Lake Toma near the Oberalp Pass. It flows into Lake Constance, tumbles over the Rhine Falls at Schaffhausen, and turns sharply north at Basel. From there it runs through a wide rift valley between the Black Forest and the Vosges, forming part of the border between France and Germany. Below Bingen it cuts a narrow gorge through the hills, lined with castles, vineyards and the famous Lorelei rock. Past Bonn it spreads onto the North European Plain, flows by Cologne and the Ruhr at Duisburg, and in the Netherlands splits into **distributaries**, the Waal, the Lek and the IJssel, which mingle with the Meuse (Maas) in a broad **delta**. Much of this land lies below sea level behind dikes. Alpine snowmelt in summer and rain in winter keep the Rhine’s flow fairly steady all year, a gift for shipping.

The big idea. A **port** at the mouth of a navigable river serves a whole **hinterland**. Ocean ships unload at Rotterdam, and their cargo travels on by barge, train, truck or pipeline to the Netherlands, Germany, eastern France, Switzerland and beyond. From 1962 until 2004 Rotterdam was the busiest port in the world. Ports in China and at Singapore have since grown larger, but Rotterdam remains Europe’s busiest, handling about 440 million tonnes of cargo in 2023, including about 13 million TEU of containers, as well as crude oil, fuel, iron ore, coal and grain. Its docks stretch about 40 km (25 miles) from the old city to the sea, and Maasvlakte 2, opened in 2013, was built on land made from sand pumped up from the seabed. The river is also governed by one of the oldest agreements in Europe. The Congress of Vienna in 1815 set up the Central Commission for the Navigation of the Rhine, and the Mannheim Act of 1868 promised free navigation on the river to ships of every nation.

Technology overcoming geography. A delta is a hard place for a great port: shallow water, shifting sand and storms from the sea. The Dutch answered with dredgers, dikes and canals. After a terrible North Sea flood in 1953, they built the Delta Works, and in 1997 they finished

the Maeslant Barrier across the New Waterway, two curved gates, each about 210 m (690 ft) long, that float out and swing shut when a storm surge threatens. On the river, a large Rhine barge carries about 3,000 tonnes, the load of more than 100 trucks. Since 1992 the Rhine–Main–Danube Canal has linked the North Sea to the Black Sea across the middle of Europe.

Peoples and faith. For about four centuries the Rhine was a frontier of the Roman Empire, and many of its cities, such as Cologne, Mainz, Bonn and Koblenz, began as Roman forts or towns. Christianity came early to these Roman towns. Around 695 the English monk Willibrord became the first bishop of Utrecht and carried the gospel to the Frisians of the delta. Cologne's great cathedral was begun in 1248 and finished only in 1880. In 1620 the Pilgrims, English believers who had lived in exile in Leiden, sailed from Delfshaven, now part of Rotterdam, on the first leg of the journey that brought the *Mayflower* to America. On May 14, 1940, German bombing destroyed the heart of Rotterdam; the city rebuilt its port and center, and it trades with the world again.



The Rhine from the Alps to the North Sea. Rotterdam stands where the Rhine and Meuse meet the sea.

PICTURE STUDY



View of Delft, Johannes Vermeer, about 1660–1661 · Oil on canvas · Mauritshuis, The Hague

Johannes Vermeer spent his whole life in Delft, a Dutch town a few miles from Rotterdam. Here he painted his town from across the harbor where canal boats came and went. Delft was linked by canal to its own small seaport at Delfshaven on the Maas, the same harbor from which the Pilgrims set out in 1620.

On the far shore are the town gates that led out toward Schiedam and Rotterdam, and behind them the sunlit tower of the New Church. Vermeer made the clouds and the water as important as the buildings. It is a picture of a town that lived by its waterways, in a country built on a river delta.

Look closely

- Find the boats. Where are they moored, and what do you think they carried?
- Look at the sky. How much of the painting is cloud? Where is the sunlight falling?
- Find the tall church tower lit by the sun. Why might Vermeer have made it the brightest spot?
- Look at the water. Is it moving fast like a mountain stream or lying still? What does that tell you about the land?

Talk about it

1. How does this painting show that the Dutch depended on water for trade and travel?
2. Compare this quiet harbor with a modern container port. What has changed, and what is the same?
3. Why do you think flat land and still water made canals so useful in the Netherlands?

PROJECT: DELTA AND PORT: FROM SAND TRAY TO CONTAINER YARD

In Part A you will build a river delta in a sand tray and watch how the river splits into channels. In Part B you will turn your delta into a working port and run cargo from ocean ships to river barges, the way Rotterdam serves the Rhine.

You will need

- A large plastic storage tub or a sturdy baking tray
- Damp sand (and a little fine soil or clay mixed in, if you have it)
- A pitcher of water and a cup; a towel
- Small blocks, sugar cubes or LEGO bricks as containers
- Two small boxes or lids as ships and barges; a toy truck or train if you have one
- Paper, tape and a marker for labels; a timer

Steps

1. Part A. Pile damp sand at one end of the tub to make high land, and press a river channel down the middle toward the low end, where you leave a pool of water as the sea.
2. Pour water slowly and steadily into the top of the channel. Watch where the sand settles as the water reaches the “sea.”
3. When the river begins to split, draw a quick sketch of your delta and label the main channel and its distributaries.
4. Part B. Choose the deepest channel near the sea and mark a port there. Label your channels Waal, Lek and New Waterway, and label the sea North Sea.
5. Load 20 blocks (containers) onto your ocean ship and sail it to the port.
6. Unload the containers and send them inland: a barge can carry 6, a train 4 and a truck 1. Time how long it takes to move all 20.
7. Try again using only trucks. Compare the number of trips and the time.
8. Write two sentences explaining why ports at river mouths use barges and trains to serve their hinterland.

Tips

- Pour gently; a fast flood washes the delta away instead of building it.
- Real Rotterdam is always dredging to keep its channels deep. If your channel fills with sand, scoop it out with a spoon: you are a dredger!

Check your work

- My delta shows a river splitting into at least two distributaries.
- I moved my cargo by barge, train and truck and recorded the trips and time.
- I can explain what a hinterland is and why Rotterdam’s is so large.

MAP NOTEBOOK

1. Draw the Rhine from the Alps to the sea. Label Lake Constance, the Rhine Falls, Basel, Strasbourg, the Middle Rhine gorge, Cologne, Duisburg and Rotterdam.
2. Sketch a Rhine barge and a container ship side by side, and write how many trucks' worth of cargo the barge carries.
3. Make a small timeline of Rotterdam: Erasmus (born about 1466), the Pilgrims at Delfshaven (1620), the New Waterway (1872), the bombing (1940), the Maeslant Barrier (1997), Maasvlakte 2 (2013).

From history. Erasmus of Rotterdam, born about 1466, became the most famous scholar of his age. He gathered old Greek manuscripts of the New Testament and published the Greek text with his own Latin translation, printed by Johann Froben in Basel in 1516. Martin Luther used Erasmus's Greek text when he translated the New Testament into German in 1522, and William Tyndale used it for his English New Testament of 1526. In this way a book printed on the upper Rhine helped carry the Scriptures into the languages of ordinary people across northern Europe. Rotterdam's university and its great bridge over the Maas, the Erasmus Bridge (1996), are both named for him.

WORKED EXAMPLES

Example 1. A barge travels down the Rhine from Basel to Rotterdam, about 830 km (515 miles) by river. With the current, it averages 15 km/h (about 9.3 mph) and runs day and night. How long is the trip?

1. Time = distance $\div$ speed: $830 \text{ km} \div 15 \text{ km/h} \approx 55.3 \text{ hours}$.
2. Convert: 55 hours = 2 days (48 hours) + 7 hours.
3. Check in miles: $515 \div 9.3 \approx 55.4 \text{ hours}$.

Answer: About 55 hours, a little over 2 days and 7 hours.

Example 2. A large Rhine barge carries 3,000 tonnes of cargo. A big truck carries about 25 tonnes. How many truckloads does one barge replace? If each truck is about 17 m (56 ft) long, how long a line would those trucks make, parked bumper to bumper?

1. Divide: $3,000 \div 25 = 120 \text{ truckloads}$.
2. Line of trucks: $120 \times 17 \text{ m} = 2,040 \text{ m}$, about 2 km.
3. In miles: $2.04 \times 0.621 \approx 1.3 \text{ miles}$.

Answer: 120 truckloads, a line about 2 km (1.3 miles) long, all carried by one barge with a small crew.

Example 3. Basel is at about 47.6°N, 7.6°E and Rotterdam at about 51.9°N, 4.5°E. Find the straight-line distance between them, using 111 km per degree of latitude and about 72 km per degree of longitude at this latitude. Compare it with the river distance of about 830 km.

(Use the map or drawing “Compare the straight line from Basel to Rotterdam with the river’s path.” shown earlier in this lesson.)

1. North-south: $51.9^\circ - 47.6^\circ = 4.3^\circ$; $4.3 \times 111 \approx 477$ km.
2. East-west: $7.6^\circ - 4.5^\circ = 3.1^\circ$; $3.1 \times 72 \approx 223$ km.
3. These two legs form a right triangle, so the straight-line distance is $\sqrt{(477^2 + 223^2)} = \sqrt{(227,529 + 49,729)} = \sqrt{277,258} \approx 527$ km (about 327 miles).
4. Compare: $830 \div 527 \approx 1.6$.

Answer: About 530 km (330 miles) in a straight line. The river route is about 1.6 times as long because the Rhine bends around hills and through its delta.

PRACTICE

1. **EASY** Where does the Rhine begin, and into what sea does it flow?
2. **EASY** Which river joins the Rhine in the delta where Rotterdam stands?
3. **EASY** What did the New Waterway, opened in 1872, do for Rotterdam?
4. **MEDIUM** The Rhine is about 1,230 km long. How long is that in miles?
5. **MEDIUM** Going upstream from Rotterdam to Basel (about 830 km) against the current, a barge averages 10 km/h. How long does the trip take? How much longer is it than the 55-hour trip downstream?
6. **MEDIUM** Rotterdam handled about 440 million tonnes of cargo in 2023. About how many tonnes is that per day?
7. **MEDIUM** On a map with a scale of 1:4,000,000, Cologne to Rotterdam measures 5.1 cm. How far apart are they in km and miles?
(Use the map or drawing “Cologne and Rotterdam on the Lower Rhine.” shown earlier in this lesson.)
8. **HARD** Rotterdam handled about 13 million TEU of containers in 2023. If each TEU is about 6.1 m long, how far would they stretch end to end? Compare with the distance around the equator, about 40,000 km (24,900 miles).
9. **HARD** Explain why the Rhine’s flow is steadier through the year than that of many rivers, and why that matters for shipping.
10. **CHALLENGE** Basel and Cologne are both important Rhine cities, but Rotterdam became the great seaport. Write a short paragraph explaining why, using the words “hinterland” and “delta.”

COMMON MISTAKES

- Thinking the Rhine flows south because it starts in the mountains. It begins in the Alps and flows generally north and west to the North Sea.

- Thinking a delta is a good natural harbor. Deltas are shallow and shifting; Rotterdam's channels are kept deep by engineering and constant dredging.
- Mixing up "busiest in the world" and "busiest in Europe." Rotterdam was the world's busiest port from 1962 to 2004; as of 2026 it is Europe's busiest, but several Asian ports are larger.

Make it a game · Rhine Cargo Relay. Lay eight cards in a line on the floor: Lake Toma, Lake Constance, Basel, Strasbourg, Koblenz, Cologne, Duisburg, Rotterdam. Players carry a "cargo" (a beanbag) downstream from card to card, and at each stop must name one fact about that place (Rhine Falls, rift valley, Roman fort, Ruhr, Middle Rhine gorge, New Waterway) before moving on. A wrong answer means waiting one turn at a "lock." The first to deliver the cargo to Rotterdam wins; then race back upstream, which takes two correct facts per stop, because going against the current is harder.

Scripture. "They that go down to the sea in ships, that do business in great waters; These see the works of the LORD, and his wonders in the deep." (Psalm 107:23-24, KJV)

Every day thousands of sailors, bargemen and dockworkers do "business in great waters" at the mouth of the Rhine. The river, the delta and the sea are God's works, and the trade that flows through them serves families across a whole continent.

Practice answers

1. In the Swiss Alps; it flows into the North Sea.
2. The Meuse (Maas in Dutch).
3. It gave Rotterdam a straight, deep channel to the North Sea at the Hook of Holland, so large steamships could reach the city.
4. $1,230 \times 0.621 \approx 764$ miles, about 765 miles.
5. $830 \div 10 = 83$ hours (about $3\frac{1}{2}$ days). $83 - 55 = 28$ hours longer.
6. $440,000,000 \div 365 \approx 1,205,000$ tonnes, about 1.2 million tonnes per day.
7. $1 \text{ cm} = 40 \text{ km}$, so $5.1 \times 40 = 204 \text{ km}$, about 127 miles.
8. $13,000,000 \times 6.1 \text{ m} = 79,300,000 \text{ m} = 79,300 \text{ km}$ (about 49,300 miles), almost twice around the equator.
9. The Rhine is fed both by Alpine snow and glaciers that melt in summer and by rain that falls mostly in winter in the lowlands, and Lake Constance stores water like a reservoir. So when one source is low, the other often keeps the river up. Steady, deep water means barges can sail fully loaded most of the year, though in very dry late summers low water still forces them to carry less.
10. Rotterdam stands in the delta where the Rhine and Meuse meet the North Sea, so ocean ships can reach it directly, while Basel and Cologne lie far inland where only river barges can go. Cargo must change from ocean ships to barges, trains and trucks somewhere, and the best place is at the river's mouth. From there the whole Rhine valley, the Ruhr, eastern France and Switzerland form Rotterdam's hinterland. The New Waterway and constant dredging made the delta deep enough for the largest ships.

UNIT 1 REVIEW

Answer each question. Show your work for calculations, give distances in both kilometers and miles, and use complete sentences for explanations. The review is worth 60 points.

1. (6 pts) Describe where the North European Plain lies (name at least four countries) and give two reasons it has been called an “open road.”
2. (6 pts) On a map at a scale of 1:5,000,000, Paris to Berlin measures 17.6 cm. How far apart are the two cities in kilometers and miles?
3. (6 pts) Minard’s map shows 422,000 men crossing the Neman in June 1812 and about 10,000 returning. About what percent of the army was lost? Name one missionary or event that shows how Christianity spread across the plain.
4. (6 pts) Describe the Mediterranean climate and explain what causes its dry summers. Name the three crops of the Mediterranean triad.
5. (6 pts) Using the map of Paul’s voyage and the story in Lesson 1.2, list in order the places Paul passed from Fair Havens to Rome. Why was his ship in danger so late in the year?
6. (6 pts) After wintering on Malta, Paul sailed to Syracuse, about 150 km (95 miles) away. If the ship averaged 8 km/h (5 mph), about how many hours did the crossing take?
7. (6 pts) The Gotthard Base Tunnel is about 57 km long and the 1882 tunnel about 15 km. Give both lengths in miles. How many minutes does a train at 200 km/h take to pass through the Base Tunnel?
8. (6 pts) Explain why railways need gentle grades, how the builders of the 1882 line climbed the Gotthard, and why a base tunnel is better for heavy trains.
9. (6 pts) List these Rhine places in order from source to sea: Cologne, Lake Constance, Rotterdam, Basel, the Middle Rhine gorge, Lake Toma. What is a delta, and why did Rotterdam need the New Waterway?
10. (6 pts) A Rhine barge carries 3,000 tonnes. A truck carries 25 tonnes. How many truckloads does the barge replace? Going downstream from Basel to Rotterdam (about 830 km, or 515 miles) at 15 km/h, how many hours does the barge take?

UNIT PROJECT: MY REGIONAL ATLAS: EUROPE

Make the first page of your regional atlas: a large hand-drawn map of Europe showing its plains, mountains and rivers. Shade the North European Plain, the Iberian, Italian and Balkan peninsulas, the Alps, Pyrenees, Apennines and Carpathians. Draw the Rhine, Rhône, Po, Elbe, Vistula and Danube, and mark at least ten cities and ports, including Rotterdam, Lübeck, Gdańsk, Rome, Athens and Moscow. Add symbols for Napoleon’s route of 1812, Paul’s voyage to Malta and Rome, and the Gotthard tunnels, with a small key.

Beside the map, add a fact panel: the Mediterranean climate in one sentence, one number for each lesson (for example, the 57 km Base Tunnel or Rotterdam’s 440 million tonnes in 2023), one missionary and where he worked, and a paragraph explaining one way the land

shaped Europe's history and one way technology overcame it. Photograph or attach your salt-dough relief map from Lesson 1.1.

- **Accuracy:** Landforms, rivers, cities and routes are placed correctly and labeled clearly, and the key matches the symbols.
- **Geography and history:** The fact panel correctly explains the plain, the Mediterranean climate, the Alps and the Rhine, with correct numbers in both km and miles.
- **Explanation:** The paragraph clearly shows how the land shaped Europe's history and how technology overcame a barrier, using a real example.
- **Care:** The atlas page is neat, colorful, readable and ready to be bound with the pages to come.

Answer key

1. It stretches from southwestern France through Belgium, the Netherlands, northern Germany, Denmark and Poland, and widens into the East European Plain of Belarus and Russia. It is an open road because it is low and mostly flat with no mountain wall across it, so armies could march across it (Charles XII, Napoleon, the World Wars), and because its rivers and coasts made it easy for merchants such as the Hanseatic League to trade.
2. $1 \text{ cm} = 50 \text{ km}$, so $17.6 \times 50 = 880 \text{ km}$; $880 \times 0.621 \approx 547 \text{ miles}$ (about 550 miles).
3. Lost: $412,000 \div 422,000 \approx 0.976$, about 98%. Faith: Boniface preaching among the Germanic tribes and cutting down the oak at Geismar (about 723); the baptism of Mieszko I of Poland (966); or Luther's Ninety-Five Theses at Wittenberg (1517).
4. Hot, dry summers and mild, rainy winters. In summer the belt of high pressure that keeps the Sahara dry moves north over the sea; its sinking air brings clear skies and blocks storms. In winter it moves south and Atlantic storms bring rain. The triad is wheat, olives and grapes.
5. Fair Havens (Crete), Clauda, the shipwreck on Malta, Syracuse, Rhegium, Puteoli, then by road to Rome (Acts 28:15 also names Appii forum and The three taverns on that road; accept these). Ancient ships mostly stayed in port from about November to March because winter storms made the Mediterranean dangerous, and Paul's ship sailed after the safe season had passed.
6. $150 \div 8 \approx 18.8 \text{ hours}$, about 19 hours ($95 \div 5 = 19 \text{ hours}$).
7. $57 \text{ km} \approx 35.4 \text{ miles}$; $15 \text{ km} \approx 9.3 \text{ miles}$. Time: $57 \div 200 = 0.285 \text{ hour} \times 60 \approx 17 \text{ minutes}$.
8. Steel wheels grip steel rails only on gentle slopes (about 2.6% at most on the old Gotthard line), so trains cannot climb steep mountains directly. The 1882 builders lengthened the track with loops and spiral tunnels (as at Wassen) to climb to a summit tunnel at about 1,100 m. A base tunnel runs through the bottom of the range at about 549 m at its highest, so trains barely climb at all and can be heavier, longer and faster without extra locomotives.
9. Lake Toma, Lake Constance, Basel, the Middle Rhine gorge, Cologne, Rotterdam. A delta is low, flat land of sand and mud where a river slows and splits into channels before reaching the sea. The delta's old channels were shallow and silting up, so Rotterdam needed the straight, deep New Waterway (opened 1872) to let large steamships reach the sea.
10. $3,000 \div 25 = 120 \text{ truckloads}$. $830 \div 15 \approx 55 \text{ hours}$ (about 2 days and 7 hours).

RUSSIA AND CENTRAL ASIA

East of Europe the land opens into the largest country on earth. Russia stretches about 9,000 km (5,600 mi) from the Baltic Sea to the Pacific, across eleven time zones, over the low Ural Mountains and the endless forests and frozen rivers of Siberia. South of it lie the grasslands of the steppe and the deserts and mountains of Central Asia, where oasis cities like Samarkand and Bukhara grew rich on the Silk Road. In this unit you will study these lands the way geographers do: first the land, rivers and climate, then how they shaped the history, peoples, faith, farming and trade of the people God placed there (Acts 17:26).

You will cross the Urals with Yermak's Cossacks in 1582 and follow the fur traders to the Pacific. You will stand with Peter the Great at the mouth of the Neva and learn why Russia has fought for centuries to reach a harbor that does not freeze. You will ride the Trans-Siberian Railway, built between 1891 and 1916, and see how engineers bridged Siberia's rivers and passed Lake Baikal. Finally you will travel with a Spanish ambassador to Timur's Samarkand and meet the nomads of the steppe, the scholars of the Silk Road and the Christians of the Church of the East who carried the gospel along the caravan routes.

Along the way you will build a time-zone strip of Russia, test which harbors freeze, make a scale model of the Trans-Siberian, build a model yurt and finish an atlas page of Russia's rivers, railways and ports.

BEFORE YOU BEGIN

- Can read latitude and longitude on a map grid
- Knows that the earth turns once in 24 hours and why the sun rises in the east
- Can multiply and divide to convert units and to find speed, time and distance
- Has completed Unit 1 (Europe), including the North European Plain

MASTERY CHECKLIST

- I can locate the Urals, Siberia, the Volga, Ob, Yenisei, Lena and Amur, Lake Baikal, and the tundra, taiga and steppe belts on a map of Russia.
- I can explain why Russia has eleven time zones and find the time in one Russian city from the time in another.
- I can explain why some harbors freeze and others do not, and tell how the search for warm-water ports shaped Russian history.
- I can trace the Trans-Siberian Railway, describe the barriers its builders overcame, and calculate journey times and speeds along it.
- I can describe the steppe, deserts, rivers and oasis cities of Central Asia and explain how nomads and oasis farmers lived.
- I can tell how Christianity came to Russia and traveled the Silk Road, and describe the other faiths of the region accurately.

OPTIONAL BOOKS AND RESOURCES

- **Prokudin-Gorsky Photograph Collection, Library of Congress**
(<https://www.loc.gov/pictures/collection/prok/>): Free. Early color photographs of the Russian Empire taken between about 1905 and 1915, including Samarkand, Bukhara, the Urals, Russian rivers and railways. Excellent for atlas pages and for comparing with this unit's paintings.
- **NASA Earth Observatory** (<https://earthobservatory.nasa.gov/>): Free. Search for "Aral Sea," "Lake Baikal" and "Lena River" to see satellite images of the shrinking Aral Sea, Baikal's winter ice and the great Siberian rivers in flood.

2.1 THE BIGGEST COUNTRY ★

OBJECTIVES

- Locate the Ural Mountains, the West Siberian Plain, the great Siberian rivers and Lake Baikal, and describe Russia's belts of tundra, taiga and steppe.
- Explain why Russia has eleven time zones and calculate the time in one Russian city from the time in another.
- Tell how Yermak's Cossacks and the fur traders who followed them crossed Siberia by river, and how Christianity and other faiths spread among Russia's peoples.

Warm-up. Darken the room and shine a flashlight on a globe or an orange (the flashlight is the sun). Stick a small piece of tape near Moscow and another near the Pacific coast of Russia. Turn the globe slowly from west to east, the way the earth turns. Which piece of tape comes into the light first? If the sun rises at the Pacific tape first, will its clocks be ahead of Moscow's or behind?

Watch. *Why did Russia conquer Siberia? (Short Animated Documentary)* (History Matters, 3:09). <https://www.youtube.com/watch?v=EkTXXeqjT8U>

After the story: watch this short animation on why Russia pushed east across Siberia after Yermak, and look for the fur trade and the rivers they followed.

Note: Captions were not available to check; preview it first. It is a short animated history from a generally even-handed channel.

Backup video. *Russia's Brutal Conquest of Siberia* (Kings and Generals, 23:42).

<https://www.youtube.com/watch?v=swxok155gQA>

As review: watch for Yermak's crossing of the Urals and how the Cossacks followed Siberia's rivers all the way to the Pacific. Note: Captions were not available to check; preview it first. The title is "Russia's Brutal Conquest of Siberia" by Kings and Generals, so expect battle scenes and talk of harsh treatment of native peoples. This channel often includes a sponsor message you can skip.

KEY TERMS

time zone

A region that keeps the same clock time. The earth turns 15° of longitude each hour, so time zones are about 15° wide, but their borders bend to follow countries and provinces.

Ural Mountains

A low, old mountain chain about 2,500 km (1,550 mi) long that runs north to south through Russia and is the traditional boundary between Europe and Asia.

Siberia

The huge Asian part of Russia east of the Urals, stretching to the Pacific; about three-quarters of Russia's land.

taiga

The great northern forest of pine, spruce, fir and larch that covers much of Siberia; the largest forest belt on earth.

permafrost

Ground that stays frozen all year round, for two years or more. Only a thin top layer thaws in summer.

portage

A place where travelers carry or drag their boats over land from one river to the next.

CORE IDEAS

The story. In 1582 a band of a few hundred Cossacks led by a river raider named Yermak Timofeyevich rowed and dragged their boats over the Ural Mountains. They had been hired by the Stroganovs, a rich merchant family who held salt works and fur lands on the western side of the Urals. On the far side lay the Khanate of Sibir, a Muslim Tatar kingdom ruled by Khan Kuchum. In the autumn of 1582, after a hard battle on the Irtysh River, Yermak's men took Kuchum's capital, Qashliq. Yermak himself drowned in the Irtysh a few years later, but the door was open. Fur traders, Cossacks and soldiers poured east, building small log forts as they went. In 1639 a party under Ivan Moskvitin reached the Pacific at the Sea of Okhotsk. In less than sixty years, Russians had crossed the width of Asia.

On the map. Russia is the largest country on earth: about 17.1 million km² (6.6 million sq mi), more than one-tenth of all the land in the world and about 1.7 times the size of the United States. It stretches about 9,000 km (5,600 mi) from the Baltic Sea to the Bering Strait. The **Ural Mountains** run north to south through it like a seam. They are old and worn down; the highest peak, Mount Narodnaya, is only 1,895 m (6,217 ft), lower than the tallest Appalachians. West of the Urals lies European Russia, a continuation of the North European Plain, with Moscow and the Volga, Europe's longest river, flowing south to the Caspian Sea. East of the Urals is **Siberia**: the flat, marshy West Siberian Plain, the Central Siberian Plateau, then mountains toward the Pacific. Three giant rivers, the Ob, the Yenisei and the Lena, flow north across it to the Arctic Ocean. In the south lies Lake Baikal, the deepest lake in the world at 1,642 m (5,387 ft), holding about one-fifth of the world's unfrozen fresh surface water.

How the land works. Most of Russia lies north of 50°N, and it is far from any warm ocean, so it has a *continental* climate: short warm summers and long, bitter winters. Towns in eastern Siberia such as Verkhoyansk and Oymyakon have recorded about -68 °C (-90 °F), the coldest temperatures ever recorded in any town on earth. Permafrost lies under roughly two-thirds of the country. From north to south the land falls into belts. Along the Arctic coast is treeless **tundra**, moss and low shrubs over frozen ground. South of it is the **taiga**, the endless forest. South of that, in a narrower band, come the grassy steppes with deep black soil. Because the best farmland and the mildest weather are in the west and south, roughly three out of four Russians live west of the Urals. The north-flowing rivers bring a special problem: in spring their southern stretches thaw first, and the melting water runs into ice that is still frozen farther north, so ice jams and great floods are common.

The big idea: eleven time zones. The earth turns 360° in 24 hours, which is 15° of longitude every hour. A country that spans many degrees of longitude cannot keep one clock time, because the sun rises hours earlier in its east than in its west. Russia reaches from about 20°E at Kaliningrad to about 170°W at the tip of Chukotka, a span of roughly 170°, or more than 11 hours of the sun's travel. As of 2026, Russia keeps **eleven time zones**, from UTC+2 in Kaliningrad to UTC+12 in Kamchatka. Moscow is UTC+3. When it is noon in Moscow, it is already 7:00 p.m. in Vladivostok. Time-zone lines bend around Russia's regions so that most provinces keep one time.

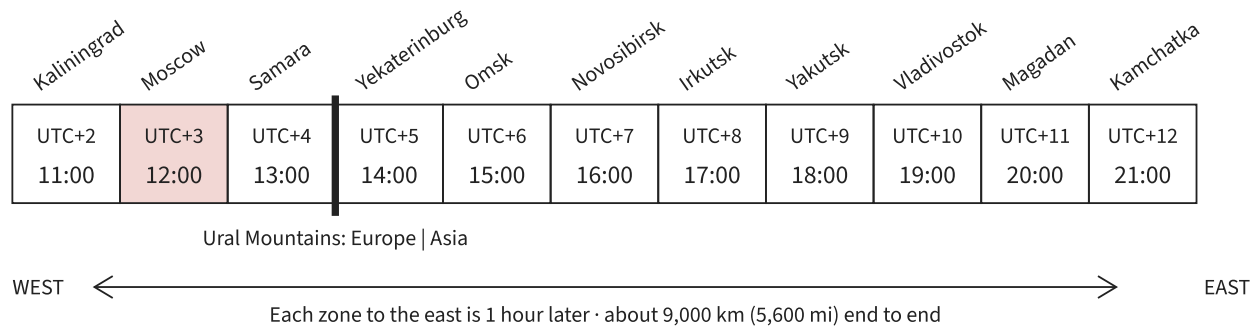
How the rivers built an empire. Why could Yermak's successors cross Asia so fast? The answer is the rivers. The tributaries of the Ob, the Yenisei and the Lena reach out east and west until their headwaters nearly touch. Traders paddled up one river, carried their boats over a short **portage**, and floated down the next. They were after furs, especially sable, so valuable that Russians called it "soft gold." The Siberian peoples, such as the Khanty, the Evenks, the Yakuts (Sakha) and the Buryats, were made to pay a tax in furs called *yasak*. Some resisted for years; many suffered from new diseases and harsh treatment. These were real wrongs, and they belong in the story alongside the courage of the travelers.

Peoples and faith. Russia is home to nearly two hundred peoples. In 988 Prince Vladimir of Kiev was baptized and brought his people into the Orthodox Christian faith he had received from Constantinople. Orthodoxy spread north and east with the Russians; monks founded monasteries in the northern forests, and Tobolsk in Siberia received its first bishop in 1620. Islam is the faith of the Tatars, the Bashkirs and many peoples of the Caucasus, and Buddhism that of the Buryats, Kalmyks and Tuvans. Under Soviet rule (1917–1991), the government taught atheism, closed most churches, mosques and temples, and imprisoned or killed many believers. Since 1991 many churches have reopened, and most Russians who name a religion today call themselves Orthodox Christians.



Russia's plains, mountains and great rivers. The Urals divide European Russia from Siberia.

When it is 12:00 noon in Moscow



Russia's eleven time zones, as of 2026. Each box east is one hour later.

PICTURE STUDY



The Conquest of Siberia by Yermak, Vasily Surikov, 1895 · Oil on canvas · State Russian Museum, St. Petersburg

Vasily Surikov was born in 1848 in Krasnoyarsk, a Siberian town on the Yenisei River, and he came from a Cossack family. More than three hundred years after Yermak's battle on the Irtysh, he painted it on an enormous canvas, traveling through Siberia to sketch the faces, clothing and boats of its peoples so that the scene would look real. The painting shows the moment Russia stepped across the Urals into Asia.

Look closely

- Find Yermak. How did the painter make him stand out from the crowd of Cossacks?
- Look at the banners above the boats. What do they tell you about the faith the Cossacks carried with them?
- Look at Khan Kuchum's warriors on the bank. What weapons do they have, and what weapons do the Cossacks have?

- Find the river and the far bank. How does the land itself shape the way this battle is fought?

Talk about it

1. The Cossacks traveled by boat. What does this painting tell you about how rivers opened Siberia?
2. This picture celebrates a victory for one side. How might the Siberian Tatars have remembered the same day?
3. Why do you think Surikov, a Siberian himself, wanted to paint this story?

PROJECT: A TIME-ZONE STRIP OF RUSSIA

You will make a long folding strip that shows all eleven of Russia's time zones from west to east, with a city, a clock and a picture of the land in each one. When it is finished, you can use it to answer any "What time is it in Irkutsk?" question in seconds, and it will become the first page of your Russia atlas.

You will need

- A strip of paper about 1 m (about 3 ft) long and 15 cm (6 in) tall: adding-machine tape, or several sheets taped end to end
- Ruler, pencil, colored pencils or markers
- Eleven small paper circles for clock faces (trace a bottle cap or a coin)
- Glue stick
- An atlas or the map in this lesson

Steps

1. Divide the strip into eleven equal boxes about 9 cm (3.5 in) wide. Write WEST at the left end and EAST at the right end.
2. Label the boxes from left to right: UTC+2, UTC+3, UTC+4 and so on to UTC+12.
3. Write one city in each box: Kaliningrad (+2), Moscow (+3), Samara (+4), Yekaterinburg (+5), Omsk (+6), Novosibirsk (+7), Irkutsk (+8), Yakutsk (+9), Vladivostok (+10), Magadan (+11), Petropavlovsk-Kamchatsky (+12).
4. Draw hands on each clock face to show the time when it is 12:00 noon in Moscow. Kaliningrad is 11:00; each box to the east is one hour later. Glue the clocks in place.
5. Draw a thick line between the Samara box and the Yekaterinburg box and label it "Ural Mountains: Europe | Asia." (The Urals run close to this zone border, though a few regions west of the mountains also keep Yekaterinburg time.)
6. In the bottom of each box, draw a tiny picture of the land there: forest, tundra, steppe, a river, Lake Baikal (Irkutsk box), volcanoes (Kamchatka box).
7. Fold the strip like an accordion along the box lines so that it fits in your atlas. Unfold it to show someone how far the sun travels across Russia.

Tips

- Russia's time-zone borders are not straight lines on the map. Your strip shows the order of the zones, not their exact shapes.
- Check with a parent or an up-to-date world clock before finishing. Countries sometimes change their time zones; this strip shows them as of 2026.

Check your work

- My strip has eleven zones labeled UTC+2 to UTC+12, in order from west to east.
- Every clock is correct for noon in Moscow (11:00 in Kaliningrad through 21:00, or 9:00 p.m., in Kamchatka).
- I marked the Urals and drew the land in each zone.

MAP NOTEBOOK

1. Trace an outline of Russia. Draw and label the Urals, the Volga, the Ob, the Yenisei, the Lena, the Amur and Lake Baikal. Use arrows to show which way each river flows.
2. Draw a north-to-south cross-section of Siberia from the Arctic Ocean to the Mongolian border and label the tundra, taiga and steppe belts. Add a layer of permafrost under the northern part.
3. Draw Yermak's route from the western side of the Urals to Qashliq on the Irtysh, and then a dotted line of the fur traders' rivers to the Sea of Okhotsk. Write 1582 and 1639 at the ends.

From history. In 1648 a Cossack named Semyon Dezhnev sailed from the mouth of the Kolyma River around the far northeastern tip of Asia and into the Pacific, passing through the strait between Asia and America. His report lay forgotten in the archives at Yakutsk until the 1700s, so the strait is named for Vitus Bering, the Danish captain in Russian service who sailed through it in 1728. Today the cape at the tip of Asia is called Cape Dezhnev in his honor.

WORKED EXAMPLES

Example 1. It is 12:00 noon in Moscow (UTC+3). What time is it in Petropavlovsk-Kamchatsky (UTC+12) and in Kaliningrad (UTC+2)?

(Use the map or drawing "Count the boxes east or west of Moscow to find the time difference." shown earlier in this lesson.)

1. Find the difference between the zones. Kamchatka: $12 - 3 = 9$ hours ahead of Moscow. Kaliningrad: $2 - 3 = -1$, so 1 hour behind.
2. Add 9 hours to noon: $12:00 + 9 \text{ h} = 21:00$, which is 9:00 p.m.
3. Subtract 1 hour from noon: $12:00 - 1 \text{ h} = 11:00 \text{ a.m.}$

Answer: 9:00 p.m. in Petropavlovsk-Kamchatsky and 11:00 a.m. in Kaliningrad.

Example 2. Russia stretches from about 20°E (Kaliningrad) to about 170°W (Cape Dezhnev in Chukotka). How many degrees of longitude is that, and how many hours does the sun take to cross it? Does that fit eleven time zones?

1. A longitude of 170°W is the same as $360^\circ - 170^\circ = 190^\circ$ measured eastward from Greenwich.
2. Span: $190^\circ - 20^\circ = 170^\circ$ of longitude.
3. The earth turns 15° per hour, so $170^\circ \div 15^\circ \text{ per hour} \approx 11.3$ hours.
4. About 11 hours of the sun's travel fits about eleven one-hour zones.

Answer: About 170° of longitude, which the sun crosses in a little over 11 hours. That matches Russia's eleven time zones.

Example 3. St. Petersburg (about 30°E) and Magadan (about 151°E) both lie close to 60°N. How far apart are they if you travel due east along the 60th parallel? At 60°N, one degree of longitude is about 55.7 km (34.6 mi).

1. Degrees of longitude between them: $151^\circ - 30^\circ = 121^\circ$.
2. Distance in kilometers: $121 \times 55.7 \text{ km} \approx 6,740 \text{ km}$.
3. Distance in miles: $121 \times 34.6 \text{ mi} \approx 4,190 \text{ mi}$.
4. Why is a degree so short here? At the equator a degree of longitude is about 111.3 km, but the meridians come together toward the poles. At 60°N the parallel is only half as long as the equator, so each degree is about half as long: $111.3 \div 2 \approx 55.7 \text{ km}$.

Answer: About 6,700 km (about 4,200 mi) along the 60th parallel.

PRACTICE

1. **EASY** How many time zones does Russia have as of 2026, and what are the zones at its western and eastern ends?
2. **EASY** Which mountain range is the traditional boundary between Europe and Asia in Russia? Name its highest peak and give its height in meters and feet.
3. **EASY** Name the three great Siberian rivers that flow north into the Arctic Ocean, from west to east.
4. **MEDIUM** It is 8:00 a.m. in Moscow (UTC+3). What time is it in Vladivostok (UTC+10)?
5. **MEDIUM** A family in Yekaterinburg (UTC+5) sits down to supper at 6:00 p.m. What time is it for their cousins in Kaliningrad (UTC+2)?
6. **MEDIUM** Russia covers about 17.1 million km² (6.6 million sq mi) and the United States about 9.8 million km² (3.8 million sq mi). About how many times larger is Russia? Check your answer with both units.

7. **MEDIUM** Lake Baikal is 1,642 m deep. Convert this to feet ($1 \text{ m} \approx 3.281 \text{ ft}$). Is it deeper or shallower than one mile (5,280 ft)?
8. **HARD** Explain why the Ob, Yenisei and Lena often flood in spring. Use the words *south*, *north* and *ice jam*.
9. **HARD** Look at the map of Russia. (a) Which city shown lies north of the Arctic Circle (about 66.5°N)? (b) Which city shown lies farthest east?
(Use the map or drawing “Use the latitude and longitude grid to compare the cities.” shown earlier in this lesson.)
10. **CHALLENGE** In a short paragraph, explain how Russians crossed from the Urals to the Pacific in fewer than sixty years (1582 to 1639). Include the land, the goal of the travelers, and what it cost the Siberian peoples.

COMMON MISTAKES

- Thinking the Urals are a great wall like the Alps. They are low and worn, with passes that Yermak’s men crossed by boat and on foot. They divide the continents on the map more than they block travel.
- Picturing all of Siberia as frozen tundra. Most of Siberia is taiga forest, and its southern edge has steppe grassland and farms.
- Assuming each time zone is exactly 15° wide with straight borders. Zones are about 15° wide, but their borders follow regions and provinces.

Make it a game • What Time Is It in Irkutsk? Lay your time-zone strip on the table. A parent calls out a time and a city, such as “It is 9:00 a.m. in Omsk!” and then names a second city. The first player to give the right time in the second city scores a point. A bonus point goes to anyone who can also name the river or lake that city stands near (Omsk: the Irtysh; Novosibirsk: the Ob; Krasnoyarsk: the Yenisei; Irkutsk: the Angara, near Lake Baikal; Yakutsk: the Lena). Play to ten.

Scripture. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;” (Acts 17:26, KJV)

Russia’s nearly two hundred peoples, from the Russians of Moscow to the Yakuts of the Lena and the Buryats of Lake Baikal, are all of “one blood.” God set them in very different lands, from forest to tundra to steppe, and every one of those peoples matters to Him.

Practice answers

1. Eleven, from UTC+2 (Kaliningrad) in the west to UTC+12 (Kamchatka and Chukotka) in the east.
2. The Ural Mountains. The highest peak is Mount Narodnaya, 1,895 m (6,217 ft).
3. The Ob, the Yenisei and the Lena.
4. $10 - 3 = 7$ hours ahead, so 3:00 p.m.
5. Kaliningrad is 3 hours behind, so 3:00 p.m.
6. $17.1 \div 9.8 \approx 1.7$, and $6.6 \div 3.8 \approx 1.7$. Russia is about 1.7 times the size of the United States.

7. $1,642 \times 3.281 \approx 5,387$ ft. That is a little more than one mile deep.
8. These rivers flow from the south to the north. In spring the southern (upper) parts thaw first, while the northern parts near the Arctic are still frozen. The meltwater flows north into the frozen stretch, piles up behind the ice in an ice jam, and spills over the banks.
9. (a) Murmansk, at about 69°N . (b) Petropavlovsk-Kamchatsky, at about 158.7°E .
10. Siberia is laced with great rivers whose tributaries come close to one another, so traders could paddle up one river, carry their boats across a short portage and float down the next. They were driven by the fur trade, especially sable, the “soft gold” of Siberia, and they built small log forts along the rivers. The native peoples were few and spread over a vast land; they were forced to pay a fur tax (yasak), some fought back, and many suffered from war and new diseases.

2.2 FROZEN PORTS AND WARM-WATER PORTS

OBJECTIVES

- Locate Russia's main seaports (Arkhangelsk, St. Petersburg, Murmansk, Kaliningrad, Sevastopol, Novorossiysk and Vladivostok) and the seas and straits they open onto.
- Explain why some harbors freeze and others stay open, using latitude, continental winds, saltiness and ocean currents.
- Describe how the search for ice-free harbors shaped Russian history from Peter the Great to the founding of Murmansk, and weigh how far that idea explains Russia's past.

Warm-up. Put two small cups in the freezer: one of plain tap water and one of tap water with a big spoonful of salt stirred in. Before you close the door, predict which will freeze first and write your guess down. (You will check them at the end of the lesson.) While you wait, look at a globe and run your finger along all of Russia's coastline. How much of it touches the Arctic Ocean?

Watch. *27th May 1703: The foundation of St Petersburg by Tsar Peter the Great* (HistoryPod, 2:44). <https://www.youtube.com/watch?v=hq-COZdZpmo>

After the story: watch how Peter the Great laid the first stone of St. Petersburg at the mouth of the Neva in 1703 to give Russia its door to the Baltic Sea.

Note: Captions were not available to check; preview it first. It may mention that many workers died while building the city on the marshes.

Backup video. *Ten Minute History - Peter the Great and the Russian Empire (Short Documentary)* (History Matters, 9:59). <https://www.youtube.com/watch?v=3tBNr2gjAA0>

As review: watch for Peter's trip to Western shipyards, his war with Sweden, and why he wanted ports on the sea. Note: Captions were not available to check; preview it first. It is a 10-minute general history of Peter's reign, so only part of it is about ports and the navy.

KEY TERMS

warm-water port

A harbor whose water does not freeze in winter, so ships can use it all year. Also called an ice-free port.

icebreaker

A ship with a strong, sloping bow and powerful engines that rides up onto sea ice and breaks it under its weight, opening a channel for other ships.

strait

A narrow passage of water connecting two larger bodies of water, such as the Bosphorus between the Black Sea and the Sea of Marmara.

brackish water

Water that is saltier than river water but less salty than the ocean, like most of the Baltic Sea. It freezes more easily than ocean water.

ocean current

A steady, river-like flow of water in the ocean. Warm currents carry heat from the tropics toward the poles.

choke point

A narrow place on a trade route, such as a strait, where ships must pass and which can be closed or controlled by whoever holds its shores.

CORE IDEAS

The story. In 1697 a very tall young man calling himself “Peter Mikhailov” worked as a ship’s carpenter in the shipyards of Zaandam and Amsterdam in Holland, and then, in 1698, at Deptford in England. He was really Peter I, the tsar of Russia, traveling in disguise to learn how to build a navy. He came home determined to give Russia a door to the sea. In 1700 he went to war with Sweden, which then ruled the shores of the Baltic. In May 1703, at the marshy mouth of the Neva River on the Gulf of Finland, Peter’s men began a fortress of earth and logs, the Peter and Paul Fortress. Around it rose a city, St. Petersburg, and in 1712 Peter made it his capital. It was built at a terrible cost: tens of thousands of conscripted peasants and Swedish prisoners of war labored in the swamps, and a great many died of cold, hunger and disease. When the war ended in 1721, Russia held the coast. Peter had his port.

The problem. Russia is the largest country on earth and has one of the longest coastlines, yet for most of its history it has struggled to reach the open sea. Look at the map. Most of Russia’s coast faces the Arctic Ocean, which is frozen much of the year. Before Peter, Russia’s only seaport was Arkhangelsk, founded in 1584 on the White Sea, where English and Dutch merchants came to trade, but its harbor is locked in ice for roughly half the year. The warm Black Sea to the south was ruled by the Ottoman Empire and its ally the Crimean Khanate. The Baltic was a Swedish lake.

How it works: why harbors freeze. Four things decide whether a harbor freezes. The first is **latitude**: the farther from the equator, the colder the winter. The second is **the continent**: in winter the land of Asia becomes intensely cold, and winds blow that cold air out over the coasts. This is why Vladivostok, at 43°N, the same latitude as Marseille in France, has a harbor that freezes over in winter. The third is **salt**. Ocean water must be chilled to about -1.9°C (28.6°F) before it freezes, but the Gulf of Finland is brackish, made almost fresh by the Neva and other rivers, so it freezes nearly as easily as a pond. The fourth is **ocean currents**. The warm North Atlantic Current, the far end of the Gulf Stream, flows past Norway and around into the Barents Sea. Because of it, Murmansk, at 69°N and north of the Arctic Circle, has a harbor that stays open all winter.

The big idea: the search for warm water. After Peter, Russian rulers kept pushing toward ice-free coasts. Catherine the Great annexed Crimea in 1783 and founded the naval port of Sevastopol; Odessa followed in 1794. In the Far East, Russia founded Vladivostok in 1860 (the name means “Ruler of the East”) and in 1898 leased Port Arthur in Manchuria, a harbor

that stayed open in winter, but lost it to Japan in the war of 1904–1905. During the First World War, Russia's allies needed a northern port that would not freeze, so in 1916 Russia founded Murmansk on the Kola Peninsula and rushed a railway to it. After 1945 Russia also gained Kaliningrad (once the German city of Königsberg) on the Baltic. Yet even warm-water ports have a catch: they open onto **choke points**. Ships from Sevastopol must pass the Bosphorus and the Dardanelles, held by Turkey; Baltic ships must pass the Danish straits; Vladivostok's ships must pass straits beside Japan. Many writers argue that the search for warm water explains much of Russian history; others answer that Russia's rulers also acted for security, trade, religion and pride. It is an idea to weigh, not a rule. As of 2026, Russia's fleets are based near Murmansk, Kaliningrad, Vladivostok and Kamchatka and on the Black Sea. Russia has controlled Crimea since 2014; Ukraine and most other countries regard it as part of Ukraine, and its ports have been at the center of the conflict between the two countries.

Technology overcoming geography. If a port freezes, you can break the ice. In 1899 the *Yermak*, built in England to the design of the Russian admiral Stepan Makarov, became one of the first icebreakers strong enough for polar seas. In 1959 the Soviet Union put into service the *Lenin*, the world's first nuclear-powered surface ship, an icebreaker that could stay at sea for months without refueling. Today icebreakers keep St. Petersburg and other ports open through the winter and lead ships along the Northern Sea Route across the top of Russia.

Ports and the gospel. Russian ports carried missionaries as well as furs. In 1824 a young Orthodox priest, Ioann Veniaminov, arrived at Unalaska in the Aleutian Islands of Russian America (Alaska). He built a church with his own hands, paddled between the islands in skin kayaks, made an alphabet for the Aleut language and translated the Gospel of Matthew into it. Later, as a bishop, he served Kamchatka and Alaska, and in 1868 he became Metropolitan of Moscow. The Orthodox Church honors him as Saint Innocent, Apostle to the Americas.



Russia's western ports. Only Murmansk, warmed by Atlantic water, stays ice-free without help this far north.

PICTURE STUDY



Peter I, Valentin Serov, 1907 · Tempera on cardboard · State Tretyakov Gallery, Moscow

Valentin Serov was one of the finest Russian portrait painters of his time. In 1907, about two hundred years after Peter the Great built St. Petersburg, Serov painted the tsar striding along the shore of his new city in a cold wind off the sea. Serov studied Peter's portraits, clothes and letters, and he imagined a man always in a hurry, whose followers could hardly keep up.

Look closely

- Compare Peter's size and stride with the people behind him. What does Serov want you to feel about him?
- Find signs of the wind. Which way is it blowing, and what does it tell you about the weather of the Gulf of Finland?
- Look at the land and water in the distance. What can you see of the young city and its harbor?
- Look at the colors of the sky and sea. Is this a warm-water port?

Talk about it

1. Why did Peter choose a cold, marshy river mouth for his new capital?
2. Serov shows Peter's energy but also people struggling behind him. How does that fit what you know about the cost of building St. Petersburg?
3. If you painted the founding of a port, what would you put in the picture?

PROJECT: WHICH HARBORS FREEZE? A FREEZING RACE

You will make three model "harbors" with different amounts of salt, freeze them side by side and record which one ices over first. Then you will use your results to explain why the Gulf of Finland freezes while the open ocean off Murmansk does not.

You will need

- Three identical clear plastic cups
- Measuring cup and measuring spoons
- Table salt
- Masking tape and a marker for labels
- A freezer and a clock or timer
- A kitchen thermometer (optional)
- Your map notebook for a data table

Steps

1. Label the cups RIVER (Neva), BRACKISH (Gulf of Finland) and OCEAN (Barents Sea).
2. Pour 1 cup (about 240 mL) of tap water into each.
3. Leave RIVER plain. Stir 1/4 teaspoon of salt into BRACKISH. Stir 1 1/2 teaspoons of salt into OCEAN; that is close to the saltiness of real seawater.
4. If you have a thermometer, record the starting temperature of each cup.
5. Set all three cups side by side in the freezer at the same time.
6. Check every 20 minutes. Record whether each cup has no ice, a thin skin of ice, slush, or solid ice.
7. When all three have some ice, take them out and compare. Press the ice gently with a spoon: which ice is hardest?

8. Write two sentences: which harbor froze first, and how this explains the ice in St. Petersburg's harbor.

Tips

- Keep the cups the same size and in the same part of the freezer, so salt is the only thing you change.
- Saltier water freezes at a lower temperature. Real seawater freezes at about -1.9°C (28.6°F); fresh water at 0°C (32°F).
- For an extra test, set a fourth OCEAN cup inside a small bowl of warm water in the freezer. This is your "North Atlantic Current." How much longer does it take to freeze?

Check your work

- I kept a data table with times and observations for all three cups.
- I can explain why brackish and fresh water freeze before ocean water.
- I can name the four things that decide whether a harbor freezes.

MAP NOTEBOOK

1. Draw a map of Russia's coasts and mark each major port. Color the ports that freeze in winter blue and the ports that stay open red. Add a red arrow for the warm North Atlantic Current flowing around Norway to Murmansk.
2. Draw the Black Sea, the Bosphorus, the Sea of Marmara and the Dardanelles as a chain of water from Sevastopol to the Mediterranean. Label the choke points.
3. Sketch an icebreaker from the side. Show its sloping bow riding up onto the ice and label the ice, the bow and the channel it opens behind it.

From history. Murmansk was founded in 1916, during the First World War, under the name Romanov-on-Murman, in honor of the ruling family; it was renamed Murmansk in 1917. Workers raced to finish a railway more than 1,000 km (over 600 mi) long through forest and swamp to connect it with Petrograd (St. Petersburg), so that British and French supplies could reach Russia through a port that never froze. In the Second World War, Allied convoys again brought tanks, aircraft and food to Murmansk and Arkhangelsk through icy, dangerous Arctic seas.

WORKED EXAMPLES

Example 1. Murmansk lies at about 69.0°N and Vladivostok at about 43.1°N . How far apart are these latitudes, in kilometers and miles? (One degree of latitude is about 111 km or 69 mi.) Which harbor freezes?



Find Murmansk and Vladivostok and compare their latitudes.

1. Difference in latitude: $69.0^{\circ} - 43.1^{\circ} = 25.9^{\circ}$.
2. In kilometers: $25.9 \times 111 \text{ km} \approx 2,870 \text{ km}$.
3. In miles: $25.9 \times 69 \text{ mi} \approx 1,790 \text{ mi}$.
4. Murmansk, far to the north, stays ice-free because warm Atlantic water reaches it. Vladivostok, almost 2,900 km farther south, freezes because bitter winter winds blow out from the frozen interior of Asia.

Answer: About 26° of latitude, or roughly 2,900 km (1,800 mi). Vladivostok's harbor freezes in winter; Murmansk's does not.

Example 2. Suppose a Dutch merchant ship needs 2 months for a round trip from Amsterdam to Arkhangelsk, and the White Sea is open for about 6 months a year. How many round trips can it make each year? How many could it make if the port were open all year?

1. Open season: $6 \text{ months} \div 2 \text{ months per trip} = 3 \text{ round trips}$.
2. Year-round port: $12 \text{ months} \div 2 \text{ months per trip} = 6 \text{ round trips}$.
3. The frozen harbor cuts the ship's trade in half, and every cargo must be hurried in or out before the ice returns.

Answer: 3 round trips a year at Arkhangelsk, compared with 6 at an ice-free port.

Example 3. A ship leaving Sevastopol for the Mediterranean must pass the Bosphorus, about 31 km (19 mi) long, and the Dardanelles, about 61 km (38 mi) long. At 18 km/h (about 11 mph), how many hours does it spend inside these two straits?

(Use the map or drawing “Trace the route from Sevastopol to the Bosphorus.” shown earlier in this lesson.)

1. Total length of the two straits: $31 \text{ km} + 61 \text{ km} = 92 \text{ km}$ ($19 \text{ mi} + 38 \text{ mi} = 57 \text{ mi}$).
2. Time = distance $\div$ speed = $92 \text{ km} \div 18 \text{ km/h} \approx 5.1 \text{ hours}$.
3. Check in miles: $57 \text{ mi} \div 11 \text{ mph} \approx 5.2 \text{ hours}$.
4. During those hours the ship passes within sight of Turkish shores; at the narrowest point of the Bosphorus, the water is only about 700 m (less than half a mile) wide.

Answer: About 5 hours, through two choke points controlled by Turkey.

PRACTICE

1. **EASY** What city did Peter the Great found in 1703? On what river and what sea does it stand?
2. **EASY** Before Peter, what was Russia’s only seaport, and on what sea was it?
3. **EASY** Murmansk is north of the Arctic Circle. Why does its harbor stay open in winter?
4. **MEDIUM** Seawater freezes at about -1.9°C . Convert this to degrees Fahrenheit using $^\circ\text{F} = ^\circ\text{C} \times 9/5 + 32$.
5. **MEDIUM** Look at the map of Russia’s western ports. Which two straits must a ship from Sevastopol pass to reach the Mediterranean, and which country holds their shores?
(Use the map or drawing “Follow the water from Sevastopol to Istanbul.” shown earlier in this lesson.)
6. **MEDIUM** Vladivostok (43.1°N) and Marseille, France (43.3°N), lie at almost the same latitude. Marseille’s harbor never freezes, but Vladivostok’s does. Give the main reason.
7. **MEDIUM** A northern port is open for about 30 weeks a year, and a ship needs 6 weeks for each round trip. How many round trips can it make in a season? How many in 52 weeks if the port never froze?
8. **HARD** St. Petersburg is at about 59.9°N and Murmansk at about 69.0°N . How far north of St. Petersburg is Murmansk, in kilometers and miles? Which one needs icebreakers in winter?
9. **HARD** Explain why the Gulf of Finland freezes more easily than the open ocean.
10. **CHALLENGE** Some writers say the search for warm-water ports explains Russian history. Write a paragraph weighing this idea. Give at least two pieces of evidence for it and one reason to be careful.

COMMON MISTAKES

- Thinking that a harbor farther south is always warmer. Vladivostok, at 43°N, freezes, while Murmansk, at 69°N, stays open, because of continental winds and ocean currents.
- Forgetting that a warm-water port is only useful if its ships can reach the open ocean. The Black Sea and Baltic ports depend on straits controlled by other countries.
- Thinking that salt water cannot freeze. It can; it just needs to be colder, about $-1.9\text{ }^{\circ}\text{C}$ ($28.6\text{ }^{\circ}\text{F}$) for ordinary seawater.

Make it a game · Open or Frozen? A parent names a port and a month, such as “Arkhangelsk in January!” or “Murmansk in February!” Players hold up a red card for open water or a blue card for ice, then give one reason: latitude, continental winds, saltiness, a warm current, or an icebreaker. A correct card scores one point and a correct reason a second. Include Sevastopol, Novorossiysk, Vladivostok, St. Petersburg and Kaliningrad, in summer and winter.

Scripture. “By the breath of God frost is given: and the breadth of the waters is straitened.” (Job 37:10, KJV)

Elihu marvels that God binds wide waters in ice. The frozen White Sea and the iced-in Gulf of Finland are part of the world God made; people can study the frost, learn its patterns and, by wise work, build ships that break it.

Practice answers

1. St. Petersburg, at the mouth of the Neva River on the Gulf of Finland, an arm of the Baltic Sea.
2. Arkhangelsk, founded in 1584 on the White Sea.
3. The warm North Atlantic Current, the far end of the Gulf Stream, carries warm water around Norway into the Barents Sea.
4. $-1.9 \times 9/5 = -3.42$; $-3.42 + 32 \approx 28.6\text{ }^{\circ}\text{F}$.
5. The Bosphorus and the Dardanelles (with the Sea of Marmara between them). Turkey holds both shores; passage is governed by the Montreux Convention of 1936.
6. Vladivostok is on the east coast of the huge Asian continent. In winter the interior of Asia becomes extremely cold and winds blow that frozen air out over the coast. Marseille is warmed by the Mediterranean Sea and by mild winds from the Atlantic.
7. $30 \div 6 = 5$ round trips. With a year-round port: $52 \div 6 \approx 8.7$, so 8 complete round trips.
8. $69.0 - 59.9 = 9.1^{\circ}$; $9.1 \times 111 \approx 1,010\text{ km}$, and $9.1 \times 69 \approx 630\text{ mi}$. St. Petersburg, though about 1,000 km farther south, needs icebreakers; Murmansk stays open.
9. Its water is brackish: the Neva and other rivers pour in so much fresh water that it is far less salty than the ocean, so it freezes at nearly $0\text{ }^{\circ}\text{C}$ ($32\text{ }^{\circ}\text{F}$). It is also shallow and lies beside a cold continent, so winter air chills it quickly.
10. For: Peter the Great fought Sweden for twenty-one years to win the Baltic coast and built St. Petersburg there; Catherine the Great took Crimea and founded Sevastopol; Russia leased ice-free Port Arthur in 1898 and founded Murmansk in 1916. Be careful: rulers also acted for

security against invasion, for trade, for religion (such as protecting Orthodox Christians in the Ottoman Empire) and for prestige, and even warm-water ports still depended on straits held by others. The idea explains a real pattern but not everything.

2.3 THE TRANS-SIBERIAN RAILWAY ⚙

OBJECTIVES

- Trace the route of the Trans-Siberian Railway from Moscow to Vladivostok and name its great river crossings, Lake Baikal and the Amur.
- Explain the barriers Siberia set against the builders (distance, permafrost, wide rivers, Lake Baikal's cliffs, short summers) and how each was overcome between 1891 and 1916.
- Calculate journey times, average speeds and scale distances for a trip along the line, using both kilometers and miles.

Warm-up. Lay a piece of string across a map or globe from Moscow to Vladivostok, following the southern edge of Siberia. Now guess: if a horse-drawn sledge could cover about 100 km (60 mi) a day, how many days would it take to cross? Write your guess. (The real answer is in the first worked example, and the railway changed it from months to days.)

Watch. *Trans-Siberian Railway: The Queen of Railways* (Railways Explained, 14:56).

<https://www.youtube.com/watch?v=VazUuBxeb74>

After the story: watch how the line was built across Siberia from 1891, and look for the Lake Baikal crossing and the big river bridges.

Note: Captions were not available to check; preview it first. It runs about 15 minutes and probably uses metric measurements.

KEY TERMS

Trans-Siberian Railway

The railway across Russia from Moscow to Vladivostok on the Pacific, about 9,289 km (5,772 mi) long; begun in 1891 and completed on an all-Russian route in 1916.

track gauge

The distance between the two rails. Russian railways use a broad gauge of about 1,520 mm (just under 5 ft), wider than the 1,435 mm (4 ft 8.5 in) used in most of Europe and North America.

train ferry

A ship that carries railway cars on rails laid across its deck, so a train can cross water where there is no bridge.

single track

A railway with only one line of rails, so trains going opposite ways must wait for each other at passing places. The Trans-Siberian was first built single-track.

Chinese Eastern Railway

A shortcut line through Manchuria in China, built by Russia and opened in the early 1900s, that linked the Trans-Siberian with Vladivostok before the all-Russian Amur line

was finished.

CORE IDEAS

The story. On a spring day in 1891, at the Pacific port of Vladivostok, Tsarevich Nicholas, the heir to the Russian throne, filled a wheelbarrow with earth and tipped it onto the first embankment of a new railway. He also helped lay the first stone of the station. His father, Tsar Alexander III, had ordered that a continuous railway be built across all of Siberia. At that moment the line from Moscow already reached the Urals, and between the Urals and the Pacific lay some 7,000 km (over 4,000 mi) of forest, marsh, rivers and mountains. A journey across Siberia by cart, sledge and riverboat could take months. Sergei Witte, a railway manager who became finance minister in 1892, pushed the project with all his strength, believing that a railway would bind the empire together and open Siberia to settlers and trade.

The barriers. Siberia put almost every obstacle in the builders' way. The distances were immense, and rails, tools and engines had to be brought from far away. The summers, the only good building season, are short, and in winter the ground freezes like iron. In the north and east, **permafrost** lies under the surface; when the top layer thaws, the ground turns to bog and heaves, twisting the track. The great rivers, the Ob, the Irtysh, the Yenisei and the Amur, are each hundreds of meters wide, frozen half the year and flooded in spring. Most fearsome of all was Lake Baikal, more than 600 km (nearly 400 mi) long, whose southern shore drops in rocky cliffs straight into the water. Workers came from everywhere: Russian peasants and soldiers, convicts and exiles, and hired laborers from China, Korea and other lands, often toiling in harsh conditions.

How they built it. To go faster, the work was split into sections built at the same time from several starting points, from Chelyabinsk eastward, from Vladivostok northward and at points in between. The line was laid single-track, with light rails and wooden bridges at first, to be strengthened later. Great iron bridges crossed the big rivers. The town where the Ob bridge was built, founded in 1893, grew into Novosibirsk, today Russia's third-largest city. At Lake Baikal the builders first used a **train ferry**: the icebreaker *Baikal*, built in England, shipped in pieces and assembled on the lakeshore, began carrying whole railway cars across the water in 1900. Meanwhile engineers blasted a line along the cliffs of the southern shore, the Circum-Baikal Railway, with dozens of tunnels; it opened in 1904–1905. For the last stretch, Russia built a shortcut, the Chinese Eastern Railway, straight across Manchuria to Vladivostok. But after its defeat by Japan in 1905, Russia wanted a route entirely on its own soil. The Amur Railway was pushed along the north bank of the Amur, and in 1916, when the great bridge over the Amur at Khabarovsk opened, the all-Russian line was complete.

On the map. The main line runs about 9,289 km (5,772 mi) from Moscow to Vladivostok, and its clocks move ahead seven hours along the way (Moscow is UTC+3, Vladivostok UTC+10). It stays near Siberia's southern edge, where the land is less frozen, the soil is better and the rivers can be bridged far from the Arctic. Follow it on the map: Moscow, across the Volga, over the Urals to Yekaterinburg, along the West Siberian Plain through Omsk and Novosibirsk, across the Yenisei at Krasnoyarsk, to Irkutsk near Lake Baikal,

around the lake to Ulan-Ude and Chita, then a long curve along the Amur to Khabarovsk, and south to Vladivostok. Its kilometer posts count from Moscow; the post at Vladivostok station reads 9,288.

Technology overcoming geography. Before the railway, Siberia was more than a month's hard travel from Moscow; afterward, the trip took about a week or two. Millions of peasant families moved east to farm Siberia's southern steppes in the years before 1914, and cities grew up at the bridges and junctions. The line was doubled, strengthened and finally fully electrified in 2002, and a second line north of Lake Baikal, the Baikal-Amur Mainline, was built mostly in the 1970s and 1980s. Today the Moscow-Vladivostok passenger train takes about six to seven days, and long freight trains carry coal, timber, oil and containers between the Pacific and Europe. The railway also has a dark chapter: in Soviet times prisoners were carried along it to labor camps in Siberia and the Far East. Like all great works, it served both good and evil purposes, depending on the people who used it.

The big idea. Siberia's size, cold and rivers did not change. What changed was how much time and money it cost to cross them. A railway does not conquer geography once and for all; it must be maintained against frost heave, floods and wear every year. But by turning months into days, the Trans-Siberian bound the Pacific coast to Moscow and made the biggest country on earth something that one nation could hold together.



The Trans-Siberian Railway and the Chinese Eastern Railway shortcut through Manchuria.

PICTURE STUDY



Vladimirka, Isaac Levitan, 1892 · Oil on canvas · State Tretyakov Gallery, Moscow

Isaac Levitan was one of Russia's greatest landscape painters. In 1892 he painted the *Vladimirka*, the old road east from Moscow through Vladimir. For generations, convicts and exiles in chains had walked this road on the first part of their long march to Siberia, often a journey of many months. Levitan painted no prisoners at all, only the road, worn into many ruts, stretching away under a heavy sky. He gave the painting to Pavel Tretyakov for his gallery, where it still hangs.

Levitan painted it in the very years the Trans-Siberian Railway was begun. The picture shows the old way of crossing Russia, on foot, just before the railway changed it forever.

Look closely

- Follow the road with your eyes. Where does it lead, and where does it end?
- Count the tracks and ruts worn into the road. What do they tell you about how many people have traveled it?
- Find the tiny signs of people: a figure, a church, a roadside marker. How big are they compared with the land?
- Look at the sky. What mood does it give the painting?

Talk about it

1. Why do you think Levitan left the prisoners out of the painting? What do you feel when you look at the empty road?
2. How would a march to Siberia on this road compare with a journey on the Trans-Siberian Railway a few decades later?
3. What does this painting tell you about the size of Russia?

PROJECT: THE TRANS-SIBERIAN RIBBON: A SCALE RAILWAY

You will make a scale model of the whole Trans-Siberian line as a ribbon you can stretch across a room, marking the stations at their real distances from Moscow. Then you will run a toy train along it and time the journey.

You will need

- A strip of paper, ribbon or adding-machine tape at least 1 m (about 3.5 ft) long
- Meter stick or tape measure
- Markers in two colors and small sticky notes
- A toy train, toy car or a coin to be your train
- A stopwatch or phone timer

Steps

1. Use the scale 1 cm = 100 km. The line is 9,289 km long, so your ribbon line will be about 92.9 cm. Draw it along the strip and mark 0 at the left end (Moscow).
2. Mark each station at its distance from Moscow (rounded): Yekaterinburg about 1,800 km (18 cm), Omsk about 2,700 km (27 cm), Novosibirsk about 3,300 km (33 cm), Krasnoyarsk about 4,100 km (41 cm), Irkutsk about 5,200 km (52 cm), Chita about 6,200 km (62 cm), Khabarovsk about 8,500 km (85 cm), Vladivostok 9,289 km (92.9 cm).
3. In a second color, draw the obstacles: the Urals, the Ob at Novosibirsk, the Yenisei at Krasnoyarsk, Lake Baikal past Irkutsk, and the Amur Bridge at Khabarovsk.
4. Write the year each obstacle was overcome on a sticky note beside it: Baikal train ferry 1900, Circum-Baikal line 1904–1905, Amur Bridge 1916.
5. Mark the time zones along the top: Moscow UTC+3 at the start and Vladivostok UTC+10 at the end, with the clocks moving ahead from UTC+3 to UTC+5 between Kirov and Perm, just west of the Urals.
6. Run your train along the ribbon in about 70 seconds while a partner times it. Each 10 seconds stands for about one day of the modern journey. Call out each station as you pass it.
7. Add the ribbon to your Russia atlas, folded or rolled, with a title and the scale written clearly.

Tips

- Station distances are rounded to the nearest 100 km; your ribbon only needs to be correct to the nearest centimeter.
- The real line curves a great deal. Your ribbon straightens it out, the way a railway timetable does.

Check your work

- My ribbon uses the scale 1 cm = 100 km and is about 93 cm long.

- All eight stations and five obstacles are marked in the right order.
- I can tell how each obstacle was overcome and in what year.

MAP NOTEBOOK

1. Draw the route of the Trans-Siberian on an outline map of Russia, with the Chinese Eastern Railway as a dashed shortcut through Manchuria. Label the Ob, the Yenisei, Lake Baikal and the Amur where the railway crosses or passes them.
2. Draw a cross-section of a railway built on permafrost: the rails, the ties, a thick embankment of gravel, the thawing top layer and the frozen ground below. Label each layer.
3. Draw the icebreaker ferry *Baikal* carrying railway cars across the lake. Add the cliffs of the southern shore, with a tunnel mouth for the Circum-Baikal line.

From history. The icebreaker *Baikal* was built by Armstrong Whitworth on the River Tyne in England, taken apart, sent to Siberia in thousands of numbered pieces and put back together at the lakeshore village of Listvyanka. It carried trains across Lake Baikal from 1900, joined by a smaller ship, the *Angara*. When ice grew too thick in the winter of 1904, during the war with Japan, temporary rails were laid across the frozen lake and railway cars were hauled over the ice. The *Angara* still survives today as a museum ship in Irkutsk.

WORKED EXAMPLES

Example 1. In the warm-up, a horse-drawn sledge covers about 100 km (60 mi) a day. How many days would it need to travel the 9,289 km (5,772 mi) from Moscow to Vladivostok, with no days of rest? Compare this with a modern train that takes about 7 days.

1. Sledge: $9,289 \text{ km} \div 100 \text{ km per day} \approx 93 \text{ days}$.
2. Check in miles: $5,772 \text{ mi} \div 60 \text{ mi per day} \approx 96 \text{ days}$. Both give about three months.
3. Compare: $93 \text{ days} \div 7 \text{ days} \approx 13$. The train is about 13 times faster, even before counting the rest stops, storms and spring mud that slowed every sledge or cart.

Answer: About 93 days, or three months, by sledge without stopping, compared with about 7 days by train.

Example 2. A train leaves Moscow and reaches Vladivostok after 144 hours of travel. What was its average speed in km/h and mph? Why is the average so much slower than the train's top speed?

(Use the map or drawing "The whole line, about 9,289 km (5,772 mi)." shown earlier in this lesson.)

1. 144 hours = 6 days.
2. Average speed = $9,289 \text{ km} \div 144 \text{ h} \approx 64.5 \text{ km/h}$.
3. In miles: $5,772 \text{ mi} \div 144 \text{ h} \approx 40.1 \text{ mph}$.
4. The average includes many stops at stations, slow running on curves and grades, and waits, so it is far below the train's top speed.

Answer: About 65 km/h (about 40 mph) on average.

Example 3. A traveler's train leaves Moscow (UTC+3) at 11:00 p.m. on a Monday, Moscow time. It arrives in Vladivostok (UTC+10) exactly 144 hours later. What day and local time is it in Vladivostok when the traveler steps off?

1. 144 hours = 6 days exactly. Six days after 11:00 p.m. Monday, Moscow time, is 11:00 p.m. Sunday, Moscow time.
2. Vladivostok is $10 - 3 = 7$ hours ahead of Moscow.
3. 11:00 p.m. Sunday + 7 hours = 6:00 a.m. Monday, Vladivostok time.

Answer: 6:00 a.m. on Monday, local time in Vladivostok, a week after leaving by the calendar though only 6 days of travel.

PRACTICE

1. **EASY** Between which two cities does the Trans-Siberian Railway run, and how long is it in kilometers and miles?
2. **EASY** In what year did building begin at Vladivostok, and in what year was the all-Russian route completed? What structure finished it?
3. **EASY** Which lake was the hardest single obstacle on the route? Name the two ways the builders crossed it.
4. **MEDIUM** On a map with a scale of 1 cm = 100 km, how long would the Trans-Siberian line be? How long on a map where 1 inch = 500 miles?
5. **MEDIUM** Novosibirsk is about 3,300 km from Moscow by rail. If a train averages 65 km/h, about how many hours does it take to get there? About how many days?
6. **MEDIUM** Look at the railway map. Which three great rivers does the main line cross between the Urals and Lake Baikal, from west to east? (Use the cities as clues: Omsk, Novosibirsk, Krasnoyarsk.)

(Use the map or drawing "Each of these cities stands on a great river." shown earlier in this lesson.)

7. **MEDIUM** Russian railways use a gauge of about 1,520 mm; most European railways use 1,435 mm. How much wider is the Russian gauge in millimeters? Why is a difference in gauge a problem at the border?
8. **HARD** Explain why permafrost makes railway building difficult, and name one way builders protect the track.
9. **HARD** Why did Russia build the Amur Railway along its own bank of the Amur after already having the Chinese Eastern Railway shortcut through Manchuria?
10. **CHALLENGE** Write a paragraph explaining how the Trans-Siberian Railway “overcame” Siberia’s geography, and one way geography still costs the railway today.

COMMON MISTAKES

- Thinking the railway was finished in a single push from Moscow. It was built in many sections at once, and for years trains used a ferry on Lake Baikal and a shortcut through China.
- Mixing up the year building began (1891) with the year the all-Russian route was completed (1916).
- Forgetting the time zones when working out arrival times. A train from Moscow to Vladivostok gains 7 hours on the clock.

Make it a game · All Aboard to Vladivostok. Lay out your Trans-Siberian ribbon. Each player starts a token in Moscow. On your turn, roll a die and move that many “days” of 500 km each (5 cm on the ribbon). Before you may pass an obstacle (the Urals, the Ob, the Yenisei, Lake Baikal, the Amur), you must answer a question about it from this lesson; a wrong answer means you wait one turn. Landing exactly on a station earns a bonus if you can name the river it stands beside. First to Vladivostok wins.

Scripture. “Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain:” (Isaiah 40:4, KJV)

Isaiah is speaking of preparing the way for the Lord, not of trains. But his picture of a highway made level through hard country helps us admire what railway builders do with embankments, bridges and tunnels, and reminds us that every road should finally lead people toward the One who made the land.

Practice answers

1. From Moscow to Vladivostok, about 9,289 km (5,772 mi).
2. Building began in 1891; the all-Russian route was completed in 1916 with the opening of the bridge over the Amur River at Khabarovsk.
3. Lake Baikal. First by train ferry (the icebreaker *Baikal*, from 1900), then by the Circum-Baikal Railway along the cliffs of the southern shore, with dozens of tunnels (opened 1904-1905).
4. $9,289 \div 100 \approx 92.9$ cm. $5,772 \div 500 \approx 11.5$ inches.
5. $3,300 \div 65 \approx 51$ hours, a little over 2 days.
6. The Irtysh (at Omsk), the Ob (at Novosibirsk) and the Yenisei (at Krasnoyarsk).

7. $1,520 - 1,435 = 85$ mm (about 3.3 in). Trains cannot run straight from one system onto the other, so freight must be moved to new cars or the cars must have their wheel sets changed at the border.
8. In summer the top layer of permafrost thaws into soggy ground while the ice below stays frozen, so water cannot drain away. The ground sinks, heaves and shifts, twisting the rails. Builders raise the track on thick embankments of gravel and rock that keep the ground below cold and let water drain, and they repair the line every year.
9. The shortcut ran through Chinese territory. After Russia lost the war with Japan in 1904–1905, its hold on Manchuria was weaker and the shortcut felt unsafe, so Russia wanted a line wholly on its own soil to reach Vladivostok. It was finished in 1916.
10. Before the railway, crossing Siberia took months by cart, sledge and riverboat. The railway bridged the great rivers, crossed Lake Baikal first by ferry and then around its cliffs, and followed Siberia's southern edge, turning the trip into about a week. It brought millions of settlers and tied the Pacific coast to Moscow. But geography still costs: permafrost heaves the track, spring floods threaten bridges, winter cold strains engines and rails, and the huge distance means fuel, crews and maintenance over thousands of kilometers.

2.4 CENTRAL ASIA AND THE STEPPE

OBJECTIVES

- Locate the five countries of Central Asia, the Kazakh Steppe, the Kyzylkum and Karakum deserts, the Tian Shan and Pamir mountains, the Amu Darya and Syr Darya, and the Silk Road cities of Samarkand, Bukhara, Khiva and Merv.
- Explain how a dry, landlocked land far from the ocean produced two ways of life, the herders of the steppe and the farmers and merchants of the oases.
- Describe the faiths that traveled the Silk Road, including the Christians of the Church of the East and the coming of Islam, and how Russia came to rule Central Asia and how the region became independent in 1991.

Warm-up. Pour a thin layer of sand or dry rice on a baking sheet to be a desert. With a spoon, make a tiny “river” of water trickle in from one side. Where does the sand turn dark and wet? Put three dried beans there as a town. Now ask: if you were a traveler crossing the dry sand, where would you have to stop? That is the secret of every Silk Road city.

Watch. *Central Asia Map Explained: Countries and Borders* (Outline Map, 5:45).

<https://www.youtube.com/watch?v=MRKpJ6uG40A>

With On the map: watch as the five Central Asian countries are traced, and find Kazakhstan, Uzbekistan, the deserts and the Aral Sea region on your own map.

Note: Captions were not available to check; preview it first. It comes from a small map-drawing channel whose narration may be computer-generated.

Backup video. *How the Mongols Lived in the Steppe* (Kings and Generals, 15:18).

<https://www.youtube.com/watch?v=AS95dkiWkfk>

After the story: watch how the Mongols lived on the open steppe with their horses, herds and felt tents. Note: Captions were not available to check; preview it first. The channel covers wars; this one is about daily life.

KEY TERMS

steppe

A vast, dry, mostly treeless grassland. The Eurasian steppe stretches from Hungary and Ukraine across Kazakhstan to Mongolia.

oasis

A green, watered place in a desert, fed by a river, spring or well, where crops can grow and towns can stand.

nomad

A person who moves with herds of animals from pasture to pasture through the seasons instead of living in one place.

caravanserai

A walled inn on a trade route, with rooms around a courtyard where merchants, camels and goods could rest safely for the night.

landlocked

Having no coastline on the open ocean. Kazakhstan is the largest landlocked country in the world.

Silk Road

The network of overland trade routes that linked China with Central Asia, Persia, the Middle East and Europe for well over a thousand years.

CORE IDEAS

The story. In May 1403 a Spanish knight named Ruy González de Clavijo sailed from Puerto de Santa María, near Cádiz, as ambassador of King Henry III of Castile. His destination was the court of Timur, also called Tamerlane, a conqueror who had built an empire from Persia to the borders of India. The journey took more than a year, by sea to Constantinople and across the Black Sea, then by horse over Persia and the deserts beyond the Amu Darya. In September 1404 Clavijo reached Samarkand and was amazed. He wrote of orchards all around the city, of markets full of silk, furs, spices and melons, of craftsmen brought from many conquered lands, and of a great mosque rising under Timur's orders. Timur feasted him, then set out on a campaign toward China and died on the way in February 1405.

On the map. Central Asia today is five countries: Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan. In the north, the **Kazakh Steppe**, a sea of grass, rolls south of Russia. In the middle lie deserts, the Kyzylkum ("red sand") and the Karakum ("black sand"). In the southeast rise high mountains, the Tian Shan and the Pamirs, where Ismoil Somoni Peak in Tajikistan reaches 7,495 m (24,590 ft). Snowmelt from these mountains feeds two great rivers, the Amu Darya (the ancient Oxus) and the Syr Darya (the Jaxartes), which flow northwest across the deserts toward the Aral Sea. To the west lies the Caspian Sea, the largest inland body of water on earth. The whole region is far from any ocean: Kazakhstan, about 2.7 million km² (1.05 million sq mi), is the largest landlocked country in the world, and Uzbekistan is one of only two countries on earth that are doubly landlocked, surrounded entirely by other landlocked countries.

How the land shaped life. Moist ocean air rarely reaches so far inland, and the mountains to the south block it, so most of Central Asia gets little rain and has hot summers and cold winters. That dry land gave rise to two ways of life. On the steppe, peoples such as the Kazakhs and the Kyrgyz were **nomads**, moving their horses, sheep and camels with the seasons and living in felt tents called yurts that could be packed onto animals in an hour. Along the rivers and mountain streams, the Uzbeks and the Tajiks built **oasis** cities and dug canals to water fields of wheat, rice, cotton, melons and fruit. The Fergana Valley, ringed by mountains, is the richest farmland of all. Water is precious here. In the Soviet era, so much water was taken from the Amu Darya and Syr Darya to irrigate cotton that the Aral Sea, once one of the four largest lakes in the world, shrank to a small fraction of its size and split apart; a dam built in 2005 has helped part of the northern sea partly recover.

The Silk Road cities. A caravan of Bactrian camels covered perhaps 30 to 40 km (20 to 25 mi) a day, so traders needed a place to stop every night and a city every week or two. The oases became those cities: Merv, Bukhara, Samarkand, Khiva, and Kashgar beyond the mountains. Walled caravanserais stood about a day's journey apart. Silk, paper, horses, glass, spices, cotton cloth and silver passed through, and so did ideas. By a well-known tradition, Samarkand learned to make paper from Chinese craftsmen captured after the Battle of Talas in 751. Scholars flourished here. Al-Khwarizmi, from Khwarazm near Khiva, wrote the book that gave us the word *algebra*; Ibn Sina (Avicenna), born near Bukhara around 980, wrote a book of medicine studied in Europe for centuries; and Timur's grandson Ulugh Beg built an observatory at Samarkand in the 1420s. The Registan, Samarkand's great square, is framed by three blue-tiled madrasas, or religious schools.

Faith along the road. Many faiths traveled the Silk Road. Zoroastrians, Buddhists and Manichaeans all had followers here. So did Christians. Missionaries of the Church of the East, whose leaders sat in Mesopotamia, carried the gospel east along the caravan routes, and by the Middle Ages Samarkand had a metropolitan, a senior bishop. Gravestones carved with crosses and Syriac letters from the 1200s and 1300s have been found in the Chüy Valley near Bishkek and Tokmok in Kyrgyzstan. Arab armies reached Bukhara and Samarkand in the early 700s, and over the following centuries most of Central Asia became Muslim; Bukhara became a famous center of Islamic learning. Today most Central Asians are Sunni Muslims, and there are Orthodox Christian communities, many of Russian descent, as well as smaller Protestant and Catholic churches.

Russia and Central Asia. In the 1800s the Russian Empire pushed south across the steppe. It took Tashkent in 1865 and Samarkand in 1868, made Bukhara and Khiva protectorates, and crushed Turkmen resistance at Geok Tepe in 1881, where thousands were killed. Under Soviet rule, the forced collectivization of herds caused a famine in Kazakhstan in 1930-1933 in which more than a million people died. In 1957 the Soviet Union launched Sputnik, the first artificial satellite, from Baikonur on the Kazakh steppe, and in 1961 Yuri Gagarin flew from there into space. When the Soviet Union broke up in 1991, all five countries became independent. As of 2026, Russia still leases the Baikonur Cosmodrome from Kazakhstan.



Central Asia: steppe, deserts, mountains and the Silk Road oasis cities.

PICTURE STUDY



The Doors of Tamerlane, Vasily Vereshchagin, 1872 · Oil on canvas · State Tretyakov Gallery, Moscow

Vasily Vereshchagin was a Russian painter who traveled with the Russian army in Turkestan in 1867–1868 and was among the defenders when the citadel of Samarkand was besieged in 1868. He filled sketchbooks with the people, buildings and crafts of Central Asia. Back in his studio he painted this imagined scene from Timur's time: two guards standing watch before the great carved doors of the conqueror's palace.

Look closely

- Look closely at the doors. What shapes and patterns do you see carved into them? Are there any pictures of people or animals?
- Study the guards' robes, weapons and shields. What do they tell you about the wealth and power of Timur's court?
- Notice what the painter does not show: we cannot see what lies behind the doors. Why might he have chosen this?
- Find the colors. Which ones remind you of the tile and silk of the Silk Road cities?

Talk about it

1. Clavijo walked through doors like these to meet Timur in 1404. What do you think he felt?
2. Islamic art in Central Asia often uses geometric patterns, flowers and writing rather than pictures of people. How does that show in these doors?
3. Vereshchagin came to Central Asia with a conquering army. How might that have shaped what he chose to paint?

Safety first. Bamboo skewers are sharp. Have an adult snip off the points before you begin, and use scissors carefully when cutting cardboard.

PROJECT: BUILD A MODEL YURT

The yurt is one of the cleverest homes ever made for a hard land: light enough to pack on a camel, strong against steppe winds, warm in winter and cool in summer. You will build a model with the same three parts as a real one: a folding lattice wall, roof poles and a round crown at the top. The crown of a yurt, called a *tunduk* in Kyrgyz, is so beloved that it appears on the flag of Kyrgyzstan.

You will need

- A strip of thin cardboard about 60 cm (24 in) long and 8 cm (3 in) tall, or several craft-stick lattices glued in a criss-cross
- 12 to 16 bamboo skewers with the points cut off (roof poles)
- A small cardboard ring about 6 cm (2.5 in) across (the crown); a jar lid traced and cut out works well
- Felt, an old wool sock or flannel cloth for the cover
- Glue, tape, string or yarn, scissors, a pencil
- A dinner plate or round piece of cardboard for the floor

Steps

1. Draw a criss-cross diamond lattice along the cardboard strip and cut out some of the diamonds, or glue craft sticks in an X pattern. This is the wall, called the *kerege* in Kazakh.

2. Stand the wall in a circle on the floor plate and tape the ends together, leaving a gap for a door.
3. Tie a piece of string or yarn tightly around the top of the wall. In a real yurt, a woven band holds the wall in against the push of the roof.
4. Poke or glue the roof poles around the edge of the crown ring, like spokes of a wheel. Rest their lower ends on top of the wall and tape each one in place. The crown should sit above the middle like the hub of an umbrella.
5. Cut the felt to wrap the wall and drape over the roof, leaving the crown open. Tie it on with yarn.
6. Add a small door of cardboard facing south, the way many steppe families set their doors.
7. Write a label card: who lived in yurts, why it suits the steppe, and the three parts of the frame.

Tips

- The crown opening lets smoke out from the stove and light in. Herders could tell the time by where the sunlight fell inside.
- If the roof sags, use more poles or tie the band around the wall tighter: the band is what keeps a real yurt from spreading apart.

Check your work

- My yurt has a lattice wall, roof poles and an open crown, with a felt cover.
- I can explain why a portable home suits the nomads of the steppe.
- I can tell how the yurt's crown appears on the flag of Kyrgyzstan.

MAP NOTEBOOK

1. Draw a map of Central Asia. Shade the steppe yellow-green, the Kyzylkum and Karakum deserts tan, and the Tian Shan and Pamirs brown. Draw the Amu Darya and Syr Darya in blue flowing into the Aral Sea.
2. Mark the Silk Road route from Merv through Bukhara and Samarkand to Kashgar. Draw a small caravanserai every 30 to 40 km (20 to 25 mi) between Bukhara and Samarkand, using your map scale.
3. Draw a T-chart titled "Two Ways of Life" with the columns Steppe Nomads and Oasis Farmers. List homes, animals or crops, food, and how each depends on water.

From history. Ulugh Beg, who ruled Samarkand in the early 1400s, was a better astronomer than king. His observatory held a huge curved instrument set into a trench in the hill, which let his astronomers measure the positions of the sun and stars with remarkable accuracy; they measured the length of the year to within about a minute. After Ulugh Beg was murdered in 1449, the observatory was destroyed and forgotten. In 1908 the archaeologist Vasily Vyatkin found its remains, and today visitors can walk down the stone curve of the great instrument.

WORKED EXAMPLES

Example 1. Bukhara and Samarkand are about 220 km (135 mi) apart in a straight line. A camel caravan travels about 30 km (19 mi) a day. How many days does the journey take, and about how many caravanserais would a traveler stay in along the way?

(Use the map or drawing “Find Bukhara and Samarkand on the Silk Road.” shown earlier in this lesson.)

1. Days of travel: $220 \text{ km} \div 30 \text{ km per day} \approx 7.3$ days. A caravan cannot stop a third of the way between two inns, so plan for 8 days.
2. Check in miles: $135 \text{ mi} \div 19 \text{ mi per day} \approx 7.1$ days.
3. A caravan sleeps at a caravanserai at the end of each day except the last, when it reaches the city. Eight days of travel means about 7 nights on the road.

Answer: About 7 to 8 days, staying at about 7 caravanserais. Real roads curve around hills and water, so the true journey was a little longer.

Example 2. Ismoil Somoni Peak in the Pamirs is 7,495 m high. Convert its height to feet ($1 \text{ m} \approx 3.281 \text{ ft}$). How many times higher is it than Mount Narodnaya in the Urals (1,895 m)?

1. Feet: $7,495 \times 3.281 \approx 24,591 \text{ ft}$, about 24,590 ft.
2. Compare: $7,495 \div 1,895 \approx 3.96$.
3. The Pamirs are young, high mountains; the Urals are old and worn low.

Answer: About 24,590 ft, roughly 4 times as high as Mount Narodnaya.

Example 3. Samarkand (39.7°N) and Philadelphia (40.0°N) lie at almost the same latitude. Samarkand gets about 350 mm (14 in) of rain and snow a year; Philadelphia gets about 1,100 mm (43 in). How many times wetter is Philadelphia? Explain the difference.

1. Ratio: $1,100 \text{ mm} \div 350 \text{ mm} \approx 3.1$. Check: $43 \text{ in} \div 14 \text{ in} \approx 3.1$.
2. Same latitude means about the same length of day and angle of sunlight, so latitude does not explain it.
3. Philadelphia is near the Atlantic, and moist air from the ocean and the Gulf of Mexico brings rain in every season. Samarkand lies thousands of kilometers from any ocean, with high mountains to the south that block moist winds, so little rain reaches it.

Answer: Philadelphia is about 3 times wetter, because it is near the ocean while Samarkand lies deep inside a continent, behind mountains.

PRACTICE

1. **EASY** Name the five countries of Central Asia.
2. **EASY** Name the two great rivers that flow toward the Aral Sea, and give their ancient Greek names.
3. **EASY** What was a caravanserai, and why were they built about a day's journey apart?
4. **MEDIUM** Kazakhstan covers about 2.7 million km² (1.05 million sq mi). Texas covers about 696,000 km² (269,000 sq mi). About how many Texases would fit in Kazakhstan?
5. **MEDIUM** Look at the map of Central Asia. (a) Of Samarkand, Bukhara and Khiva, which lies farthest west? (b) Which desert lies between the Amu Darya and the Syr Darya? *(Use the map or drawing "Use the longitude lines to compare the cities." shown earlier in this lesson.)*
6. **MEDIUM** Uzbekistan keeps UTC+5 and Moscow UTC+3. When it is 12:00 noon in Samarkand, what time is it in Moscow?
7. **MEDIUM** Samarkand and Tashkent are about 270 km (165 mi) apart. How many days would a caravan need at 30 km (about 19 mi) a day?
8. **HARD** Explain how the land of Central Asia produced two different ways of life. Name one people for each.
9. **HARD** Give two physical reasons why most of Central Asia is so dry.
10. **CHALLENGE** Write a paragraph explaining how the Silk Road carried faith as well as goods. Include Christianity and Islam, with at least one piece of real evidence.

COMMON MISTAKES

- Thinking the Silk Road was one paved road. It was a web of caravan tracks joining oasis to oasis, and most traders traveled only one stretch before selling to the next merchant.
- Believing Central Asia was always Muslim. Before the 700s it was home to Zoroastrians, Buddhists, Manichaeans and Christians of the Church of the East, and Christian communities survived for centuries after.
- Forgetting that the Aral Sea shrank mainly because people diverted its rivers for irrigation. It is a story of how water is used, not of rainfall alone.

Make it a game • Caravan Trader. Write the oasis cities Merv, Bukhara, Samarkand, Kokand and Kashgar on cards and lay them in a line. Each player starts in Merv with three goods cards (glass, silver, horses) and must reach Kashgar. On each turn, move one city and answer a question about Central Asia from this lesson. A right answer lets you trade one card for a city's special good (Samarkand: paper; Bukhara: cotton cloth; Kashgar: silk). A wrong answer means a sandstorm: lose a turn. The first trader to reach Kashgar holding silk and paper wins.

Scripture. "Parthians, and Medes, and Elamites, and the dwellers in Mesopotamia, and in Judæa, and Cappadocia, in Pontus, and Asia," (Acts 2:9, KJV)

On the day of Pentecost, Parthians heard the gospel in their own language. The Parthian Empire reached as far east as Merv on the Silk Road. From the first days of the church, the

good news was heard by peoples from the edge of Central Asia, and later missionaries carried it along the caravan routes.

Practice answers

1. Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan.
2. The Amu Darya (the Oxus) and the Syr Darya (the Jaxartes).
3. A walled inn with rooms around a courtyard where merchants, animals and goods could rest safely. They were spaced about a day's caravan travel apart, about 30 to 40 km (20 to 25 mi), so that travelers always had a safe place to stop at nightfall.
4. $2,700,000 \div 696,000 \approx 3.9$, and $1,050,000 \div 269,000 \approx 3.9$. About 4 Texases.
5. (a) Khiva, at about 60.4°E . (b) The Kyzylkum ("red sand").
6. Moscow is 2 hours behind, so 10:00 a.m.
7. $270 \div 30 = 9$ days ($165 \div 19 \approx 8.7$, so about 9 days).
8. The dry grasslands of the steppe have too little water for farming but enough grass for herds, so peoples such as the Kazakhs and Kyrgyz lived as nomads, moving their horses, sheep and camels with the seasons and living in portable yurts. Along rivers and mountain streams, water allowed irrigation, so peoples such as the Uzbeks and Tajiks built oasis cities and farmed wheat, cotton, fruit and melons.
9. It lies very far from any ocean, so moist sea air seldom reaches it; and high mountains to the south (the Pamirs, Hindu Kush and Himalaya) block moist winds, putting much of the region in a rain shadow.
10. Merchants and missionaries traveled the same caravan routes. Christians of the Church of the East carried the gospel east from Mesopotamia; by the Middle Ages Samarkand had a metropolitan bishop, and gravestones with crosses and Syriac writing from the 1200s and 1300s have been found in the Chüy Valley of Kyrgyzstan. Buddhists and Zoroastrians also had followers along the road. Arab armies reached Bukhara and Samarkand in the early 700s, and over the following centuries Islam became the main faith; Bukhara grew into a famous center of Islamic learning.

UNIT 2 REVIEW

Answer each question. Show your work for calculations, give distances in both kilometers and miles where asked, and use complete sentences for explanations. You may use your time-zone strip but not your notes. The review is worth 60 points.

1. (6 pts) Name the mountain range that divides European Russia from Siberia, and the three great Siberian rivers that flow north into the Arctic Ocean. Why do these rivers often flood in spring?
2. (6 pts) It is 9:00 a.m. in Moscow (UTC+3). What time is it in Irkutsk (UTC+8) and in Kaliningrad (UTC+2)?
3. (6 pts) Russia stretches from about 20°E to about 170°W. Show that this span fits about eleven time zones.
4. (6 pts) Name three belts of land from north to south across Siberia and describe each in a few words. Which belt covers most of Siberia?
5. (6 pts) Murmansk (69°N) stays ice-free all winter, but Vladivostok (43°N) and St. Petersburg (60°N) freeze. Explain why, naming at least two of the four causes you learned.
6. (6 pts) Who founded St. Petersburg, in what year, and why? Name one other Russian port founded to reach warmer or more open water and the year it was founded.
7. (6 pts) Look at a map of the Black Sea. Which two straits must a ship from Sevastopol pass to reach the Mediterranean? Why does this make Sevastopol's warm water less useful than it seems?
8. (6 pts) The Trans-Siberian Railway is about 9,289 km (5,772 mi) long. A train takes 156 hours from Moscow to Vladivostok. What is its average speed in km/h and mph? Round to the nearest whole number.
9. (6 pts) Describe how the builders overcame Lake Baikal and the Amur River, with the year for each.
10. (6 pts) Bukhara and Samarkand are about 220 km (135 mi) apart. A caravan travels 30 km (about 19 mi) a day. How many days does it take? Then explain why the Silk Road cities stand where they do, and name two faiths that traveled the Silk Road.

UNIT PROJECT: ATLAS PAGE: RUSSIA'S RIVERS, RAILWAYS AND PORTS

Make a large hand-drawn map of Russia and Central Asia for your regional atlas. Draw and label the Urals, the Volga, Ob, Yenisei, Lena and Amur, Lake Baikal, the Caspian and Aral seas, and the tundra, taiga, steppe and desert belts in colors with a key. Draw the Trans-Siberian Railway from Moscow to Vladivostok with at least six stations, and mark the ports of Arkhangelsk, Murmansk, St. Petersburg, Kaliningrad, Sevastopol and Vladivostok, coloring ice-free ports differently from those that freeze. Add Samarkand, Bukhara and the Silk Road route.

Attach your time-zone strip of Russia beneath the map, add a scale bar in kilometers and miles, and write a paragraph explaining one way the land shaped Russia's history and one

way technology overcame it.

- **Accuracy:** Rivers, mountains, cities, ports, the railway and the Silk Road are placed correctly and labeled clearly; the scale bar is correct.
- **Time-zone strip:** All eleven zones are in order from UTC+2 to UTC+12 with correct cities and clock times.
- **Explanation:** The paragraph clearly connects a feature of the land (such as frozen ports or long rivers) to history, and explains how a technology (such as the railway or icebreakers) overcame it.
- **Care:** The map is neat, colorful and easy to read, with a title, key, compass rose and scale.

Answer key

1. The Ural Mountains; the Ob, the Yenisei and the Lena. Their southern (upper) stretches thaw first while the northern stretches near the Arctic are still frozen, so meltwater piles up behind ice jams and spills over the banks.
2. Irkutsk is 5 hours ahead: 2:00 p.m. Kaliningrad is 1 hour behind: 8:00 a.m.
3. $170^{\circ}\text{W} = 190^{\circ}$ east of Greenwich. $\text{Span} = 190^{\circ} - 20^{\circ} = 170^{\circ}$. The earth turns 15° per hour, so $170 \div 15 \approx 11.3$ hours, which fits about eleven one-hour zones.
4. Tundra: treeless moss and low shrubs over permafrost along the Arctic coast. Taiga: vast northern forest of pine, spruce, fir and larch. Steppe: dry grassland with deep black soil in the south. The taiga covers most of Siberia.
5. Murmansk is warmed by the North Atlantic Current, the far end of the Gulf Stream. Vladivostok lies on the east coast of Asia, where bitter winter winds blow out from the frozen interior. St. Petersburg is on the Gulf of Finland, whose brackish, nearly fresh water freezes easily, and it is far north beside a cold continent. (Causes: latitude, continental winds, saltiness, ocean currents.)
6. Peter the Great founded it in 1703 at the mouth of the Neva on the Gulf of Finland, to give Russia a seaport on the Baltic open to Europe; before this its main seaport was ice-bound Arkhangelsk. Other examples: Sevastopol (1783), Odessa (1794), Vladivostok (1860), Murmansk (1916).
7. The Bosphorus and the Dardanelles. They are narrow choke points held by Turkey (passage is governed by the Montreux Convention of 1936), so Russia's Black Sea ships depend on another country's straits to reach the open ocean.
8. $9,289 \div 156 \approx 60$ km/h; $5,772 \div 156 \approx 37$ mph.
9. Lake Baikal: first by train ferry, the icebreaker *Baikal*, from 1900; then by the Circum-Baikal Railway along the cliffs of the southern shore, with dozens of tunnels, opened 1904–1905. The Amur: the Amur Railway was built along Russia's side of the river, and the bridge at Khabarovsk, opened in 1916, completed the all-Russian route.
10. $220 \div 30 \approx 7.3$, so about 8 days ($135 \div 19 \approx 7.1$). The cities stand at oases watered by rivers from the mountains, such as the Zeravshan (Samarkand and Bukhara) and the Amu Darya (Khiva), the only places in the dry land where crops could grow and caravans could rest and trade. Faiths: Christianity (the Church of the East, which had a metropolitan in Samarkand), Islam, Buddhism and Zoroastrianism (any two).

THE MIDDLE EAST AND NORTH AFRICA

From the Atlantic coast of Morocco to the mountains of Iran stretches a land of deserts, a few great rivers, and narrow seas. Rain is scarce, so water decides almost everything: where people farm, where cities stand, and which roads caravans and armies follow. Along the Tigris and Euphrates, in the curve of good land called the **Fertile Crescent**, people built some of the first cities and wrote some of the first books. In the deserts beyond, they learned to find water underground and to carry it for miles in hand-dug tunnels. And beneath the sands around the Persian Gulf lies nearly half of the world's known oil, which must pass through a few narrow straits to reach the rest of the world.

This is also the land of the Bible. Abraham set out from Ur, Israel's kings ruled from the hill city of Jerusalem, and Jesus taught beside the Sea of Galilee, died and rose again in Jerusalem. From there the gospel spread to Mesopotamia, Egypt and North Africa, home of Augustine and the desert monks, long before Islam arose in Arabia in the 600s. Today most people of the region are Muslims, with ancient Christian and Jewish communities as well. As Paul told the Athenians, God "hath made of one blood all nations of men" and "determined ... the bounds of their habitation" (Acts 17:26). In this unit you will study each place as it really is: physical setting first, then how its geography shaped the history, faith, farming and trade of its peoples, with current events described neutrally and factually.

BEFORE YOU BEGIN

- Can read latitude and longitude and use a map scale in kilometers and miles
- Knows what a rain shadow is and why some places are dry (Grade 6 physical geography)
- Can multiply and divide with large numbers and convert meters to feet and kilometers to miles
- Knows the basic Bible narrative from Abraham to the early church

MASTERY CHECKLIST

- I can locate the Tigris, Euphrates, Nile and Jordan Rivers, the Sahara and Arabian Deserts, the Persian Gulf, the Red Sea and the Strait of Hormuz.
- I can explain how river floods, irrigation and salt shaped farming and the first cities of Mesopotamia.
- I can explain how a qanat carries groundwater by gravity and why it saves water in the desert.
- I can describe the land of the Bible from the coast to the Dead Sea and explain why the Dead Sea is so low and so salty.
- I can explain how oil is trapped underground and why the Strait of Hormuz is a choke point, in a factual and neutral way.
- I can calculate distances, elevation differences, slopes and flows in both metric and U.S. units.

OPTIONAL BOOKS AND RESOURCES

- **Library of Congress digital collections** (<https://www.loc.gov/>): Free. Search “David Roberts Holy Land” to see Roberts’s lithographs of Jerusalem, Petra and Egypt, and search for old maps of Persia and Arabia for your atlas page (Lessons 3.3 and 3.4).
- **UNESCO World Heritage List** (<https://whc.unesco.org/en/list/>): Free. Search “The Persian Qanat” and “Aflaj Irrigation Systems of Oman” for photographs, maps and descriptions of real qanats and their shafts (Lesson 3.2).
- **U.S. Energy Information Administration** (<https://www.eia.gov/>): Free. A parent can search “World Oil Transit Chokepoints” for current, factual data and maps on the Strait of Hormuz, the Bab-el-Mandeb and the Suez Canal (Lesson 3.4).

3.1 THE FERTILE CRESCENT ★

OBJECTIVES

- Locate the Fertile Crescent, the Tigris and Euphrates Rivers, and the Syrian Desert, Taurus and Zagros Mountains that frame them.
- Explain how river floods, silt, canals and salt shaped farming and the first cities of Mesopotamia, such as Ur and Babylon.
- Use map scale, latitude and route distances in kilometers and miles to explain why travelers like Abraham followed the curve of good land instead of crossing the desert.

Warm-up. Open an atlas or a world map to the Middle East. Put your finger on the southeast corner of the Mediterranean Sea. Trace a curve north along the coast, then east across the top of Syria, then down the Tigris and Euphrates to the Persian Gulf. What shape did your finger draw? Now put a bowl upside down in the middle of that curve. If the bowl were a dry desert, where would you want to live, and where would you walk if you had to travel from one end of the curve to the other?

Watch. *Mesopotamia and the Fertile Crescent - A Short History* (World History Encyclopedia, 7:53). <https://www.youtube.com/watch?v=vPVfhc9QiNY>

After the story: watch where Mesopotamia lies between the Tigris and Euphrates and what Sumer gave the world, such as writing, cities and the wheel, and listen for Ur.

Note: Captions were not available to check; preview it first. It has a section on the "Length of Human Occupation" (about 2:23) that may give very early dates, and it uses BCE instead of BC. The video likely uses BCE dates, while the lesson may use BC.

Backup video. *Ancient Mesopotamia 101 | National Geographic* (National Geographic, 4:10). <https://www.youtube.com/watch?v=xVf5kZA0HtQ>

As review: watch this short overview of Mesopotamia between the Tigris and Euphrates. Note: Captions were not available to check; preview it first.

KEY TERMS

Fertile Crescent

The curved band of well-watered farmland that runs from the eastern Mediterranean coast north through Syria and down the Tigris and Euphrates Rivers to the Persian Gulf.

Mesopotamia

A Greek name meaning "between the rivers": the land along and between the Tigris and Euphrates, mostly in modern Iraq.

silt

Fine, fertile mud carried by a river and dropped when floodwater spreads out and slows down.

irrigation

Bringing water to fields through canals, ditches or machines when rain alone is not enough.

salinization

The slow buildup of salt in soil when irrigation water evaporates in a hot, dry climate and leaves its salt behind.

surplus

More food than the farmers themselves need, which can feed craftsmen, priests, soldiers and traders in cities.

CORE IDEAS

The story. In 1916 James Henry Breasted, a professor at the University of Chicago, published a schoolbook called *Ancient Times*. Looking at a map of the Near East, he noticed a curved strip of good farmland wrapped around the edge of a great desert, like a new moon. He called it the **Fertile Crescent**, and the name stuck. A few years later, from 1922 to 1934, the British archaeologist Leonard Woolley dug at Ur in southern Iraq for the British Museum and the University of Pennsylvania. Under the sand he found streets, houses, a great stepped temple tower called a ziggurat, and royal tombs full of gold, shell and blue lapis lazuli. Ur is the city the Bible calls “Ur of the Chaldees,” from which Abraham’s family set out (Genesis 11:31).

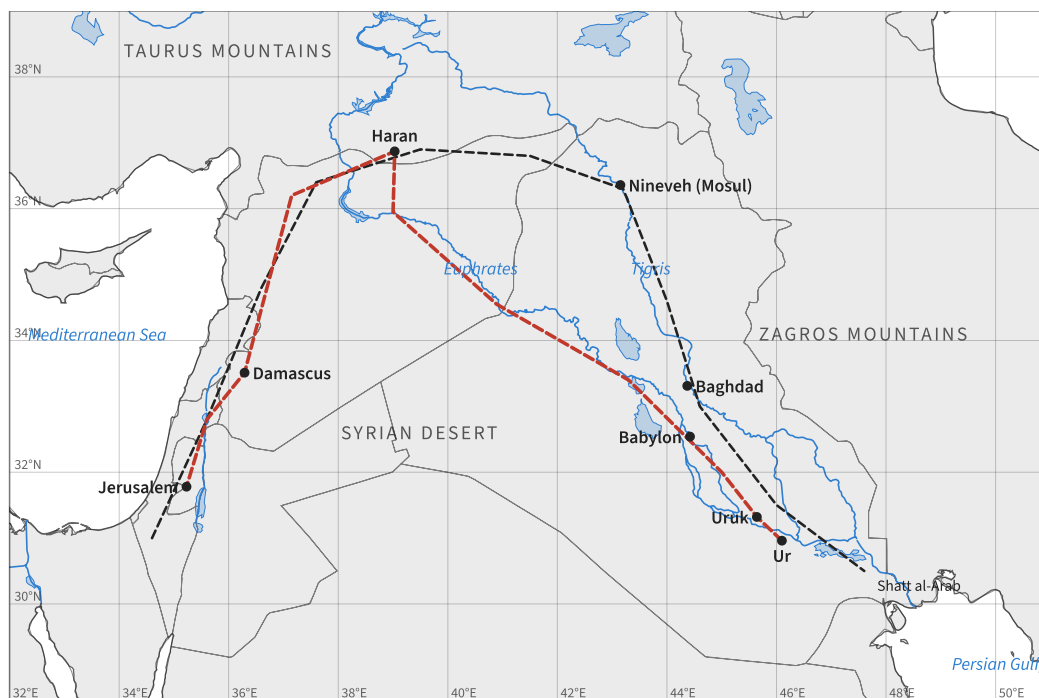
On the map. The crescent has a desert on its inside and mountains on its outside. The Syrian Desert fills the middle. To the north rise the Taurus Mountains of Turkey, and to the east the long ridges of the Zagros Mountains of Iran. Snow and rain on these highlands feed two great rivers. The **Euphrates**, about 2,800 km (1,740 mi) long, is the longest river of western Asia; the **Tigris**, about 1,850 km (1,150 mi) long, runs east of it and closer to the mountains. Both rise in the highlands of eastern Turkey, flow southeast through Syria and Iraq, and meet near Al-Qurnah to form the Shatt al-Arab, which flows about 200 km (120 mi) to the Persian Gulf. In the north, enough rain falls for wheat to grow without help. In the south, Baghdad gets only about 150 mm (6 in) of rain a year, far too little, so every field there depends on the rivers.

How they farmed. The rivers were both a gift and a danger. Each spring, from about April to June, melting snow in the mountains sent floods rushing down. The floods spread rich **silt** over the plain, but they came just when the grain was ripening, and they could wash away fields and villages. So the people of Mesopotamia learned to control the water. They built levees (earth banks) to hold the rivers in, dug canals to lead water to fields in the dry months, and lifted water with the shaduf, a pole with a bucket on one end and a weight on the other. Irrigation had a hidden cost. In the hot sun, water evaporates and leaves its salt behind. Over centuries, **salinization** spoiled many fields in the south. Clay tablets suggest farmers there grew more barley and less wheat over time, likely because barley can stand more salt.

The big idea. Water plus fertile soil made a **surplus** of grain, and a surplus made cities possible. Ur, Uruk, Babylon and Nineveh grew where farmers could feed many people who were not farmers. Geography shaped what those cities made and traded. The plain had clay

and reeds but very little stone, timber or metal, so the people wrote on clay tablets with reed pens in wedge-shaped cuneiform, built with mud brick, and traded grain and cloth for cedar from Lebanon, copper and tin, and lapis lazuli from the mountains of Afghanistan. Yet the same open plain had no natural walls. Armies could march in from the mountains or the desert, and kingdom after kingdom rose and fell: Sumer, Akkad, Babylon under Hammurabi, Assyria, the Neo-Babylonian Empire of Nebuchadnezzar and Persia.

Faith and history. The Bible names the Euphrates and the Hiddekel, the Tigris, among the rivers of Eden (Genesis 2:14). Abraham traveled from Ur to Haran and then south to Canaan, following the crescent where there was water and pasture rather than crossing the desert. Jonah was sent to Nineveh, and Daniel served kings in Babylon. Christianity reached Mesopotamia very early. The Church of the East, which worshiped in Syriac, sent missionaries along the trade roads as far as India and China. Christians, today called Assyrians and Chaldeans, have lived in northern Iraq ever since, though their numbers have fallen sharply since 2003 as many fled war and persecution. As of 2026, most people in Iraq are Muslims, Shia and Sunni, both Arabs and Kurds. Large dams upstream in Turkey and Syria now hold back river water, so how the two rivers are shared remains an important question for the nations along them.



The Fertile Crescent curves around the Syrian Desert. Abraham's traditional route followed the good land.

PICTURE STUDY



The Standard of Ur (the "Peace" side), Unknown Sumerian craftsmen, about 2600 BC · Wooden box (restored) inlaid with shell, red limestone and lapis lazuli set in bitumen · British Museum, London

Leonard Woolley's team found this object in the Royal Cemetery at Ur in 1927–1928. It is a hollow wooden box about the size of a large shoebox laid on its side, and no one knows for sure what it was used for. Woolley thought it was carried on a pole like a banner, so he called it a "standard." One long side shows a war, with chariots and soldiers. The other side, which we study here, shows peace and plenty.

Look carefully and you will see the whole economy of a river city: farmers bringing animals, men carrying sacks and fish, and at the top a feast with music. The blue stone is lapis lazuli. It did not come from Mesopotamia at all, but from mines in the mountains of northeastern Afghanistan, about 2,400 km (1,500 mi) away in a straight line.

Look closely

- Find the three rows, called registers. Which row shows the most important people, and how can you tell?
- Find the cattle, sheep and goats. Where would a farmer on a dry plain find grass and water for them?
- Find the men carrying heavy bundles on their backs and a man carrying fish. What do these tell you about where the food came from?
- Find the lyre player. Why might a city with a food surplus have time for music?

Talk about it

1. Which things in this picture came from the river plain, and which had to be traded from far away?
2. How does this picture show the idea of a surplus?

3. Why do you think people who lived without much stone or timber made such careful work out of tiny pieces of shell and stone?

PROJECT: A RIVER PLAIN FARM IN A TRAY

You will build a small model of the Mesopotamian plain with two rivers, levees and canals, flood it to see where the silt goes, and then run a slow test that shows how irrigation in a hot, dry land can leave salt behind.

You will need

- A large baking pan or plastic storage tub lid
- Garden soil or sand, plus a cup of fine potting soil or clay dust for “silt”
- A pitcher of water and a small cup
- Craft sticks or a spoon for digging canals
- Table salt, a dark-colored saucer and a measuring spoon
- Labels made from paper and toothpicks

Steps

1. Fill the pan with damp soil about 3 cm (1 in) deep. Prop one end up on a book so it slopes gently. The high end is the mountains of Turkey; the low end is the Persian Gulf.
2. Draw two rivers with your finger from the high end to the low end. Make the right-hand river (the Tigris) run closer to the edge, the “Zagros side.” Let the rivers meet near the low end and continue as one channel, the Shatt al-Arab.
3. Mix a spoonful of fine soil into a cup of water. Pour it slowly into the top of both rivers to make a spring flood. Watch where the water spills over and where the fine mud settles.
4. Now build levees by pushing up low banks along the rivers. Dig three small canals from the rivers to square “fields.” Flood again and see whether you can steer the water to the fields instead of everywhere.
5. Salt test: stir 1 teaspoon of salt into half a cup of warm water. Pour a thin layer onto the dark saucer and set it in a sunny window. Check it each day for several days and draw what you see.
6. Label your model: Tigris, Euphrates, Shatt al-Arab, Ur, Babylon, levee, canal, field.

Tips

- Pour slowly. A real spring flood came over weeks, not seconds.
- River water carries only a tiny bit of salt, much less than your test, but over thousands of years of irrigation the same thing happens in real fields.

Check your work

- I can show where silt settles when a flood spreads out.
- I can explain how levees and canals let farmers control a river.

- I can explain why irrigation in a hot, dry place can leave salt in the soil.

MAP NOTEBOOK

1. Draw a map of the Fertile Crescent. Shade the crescent green, the Syrian Desert tan and the Taurus and Zagros Mountains brown. Label the Tigris, Euphrates, Shatt al-Arab, Persian Gulf and Mediterranean Sea.
2. Draw a cross-section of a Mesopotamian river: the river channel, a levee on each side, a canal leading away and a field. Add arrows for the spring flood.
3. Make a two-column chart titled “What the Plain Had / What the Plain Lacked.” Put clay, reeds, water, grain and dates on one side; stone, timber, copper, tin and lapis lazuli on the other.

From history. For centuries no one could read the wedge-shaped writing of Mesopotamia. The key came from a cliff in western Iran. In the 1830s and 1840s a British officer, Henry Rawlinson, climbed the rock face at Behistun, sometimes on ladders and ropes, to copy a long inscription of the Persian king Darius I carved in three languages written in cuneiform. Working from the Old Persian part, scholars cracked the other scripts, and by the late 1850s they could read Babylonian. Soon the clay tablets from the river cities, and names known from the Bible such as Nebuchadnezzar and Sennacherib, could be read in their own words.

WORKED EXAMPLES

Example 1. On a map with the scale 1 cm = 100 km, the straight line from Baghdad to Basra measures 4.5 cm. How far apart are the two cities in kilometers and in miles?

1. Multiply the map distance by the scale: $4.5 \text{ cm} \times 100 \text{ km per cm} = 450 \text{ km}$.
2. Convert to miles. One kilometer is about 0.621 mile: $450 \times 0.621 \approx 279 \text{ miles}$.
3. Round sensibly: about 450 km, or about 280 miles.

Answer: About 450 km (about 280 mi).

Example 2. A Sumerian farmer’s field is 100 m long and 50 m wide. He opens a canal and floods it to a depth of 10 cm. How many cubic meters and how many liters of water did he use? (1 cubic meter = 1,000 liters.)

1. Change the depth to meters: $10 \text{ cm} = 0.1 \text{ m}$.
2. Volume = length $\times$ width $\times$ depth = $100 \text{ m} \times 50 \text{ m} \times 0.1 \text{ m} = 500 \text{ cubic meters}$.
3. Change to liters: $500 \times 1,000 = 500,000 \text{ liters}$.

Answer: 500 cubic meters, or 500,000 liters, for one watering.

Example 3. Straight across the desert from Ur to Jerusalem is about 1,030 km. Abraham's traditional route went from Ur to Haran (about 930 km in a straight line) and then from Haran to Jerusalem (about 670 km). How much longer is the crescent route, in kilometers and as a percent, and why would a traveler with flocks choose it?

(Use the map or drawing "The long way around was the safe way." shown earlier in this lesson.)

1. Add the two legs: $930 \text{ km} + 670 \text{ km} = 1,600 \text{ km}$.
2. Subtract the direct distance: $1,600 \text{ km} - 1,030 \text{ km} = 570 \text{ km}$ longer (about 350 mi).
3. Percent longer: $570 \div 1,030 \approx 0.55$, so about 55% longer.
4. Reason: the direct line crosses the Syrian Desert, with very few wells. The crescent route follows the Euphrates and the rain-watered hills, where people and animals could find water and grass every day.

Answer: About 1,600 km in all, roughly 570 km (350 mi) or 55% longer, but it had water and pasture the whole way.

PRACTICE

1. **EASY** What does the Greek name Mesopotamia mean, and in which modern country does most of it lie?
2. **EASY** Which river is longer, the Tigris or the Euphrates? Which one runs farther east, closer to the Zagros Mountains?
3. **EASY** What is the river called after the Tigris and Euphrates join, and into what body of water does it flow?
4. **MEDIUM** The Tigris is about 1,850 km long. Convert this to miles ($1 \text{ km} \approx 0.621 \text{ mi}$).
5. **MEDIUM** Use the map. Nineveh lies at about 36.4°N and Babylon at about 32.5°N . How many degrees of latitude apart are they? About how far is that north to south? (1° of latitude $\approx 111 \text{ km}$ or 69 mi .)
(Use the map or drawing "Read the latitude of each city from the grid." shown earlier in this lesson.)
6. **MEDIUM** Wheat can usually be grown on rain alone where at least about 250 mm (10 in) of rain falls a year. Baghdad gets about 150 mm (6 in). How much is Baghdad short, in millimeters and inches, and what must farmers there do?
7. **MEDIUM** Why was the timing of the Tigris and Euphrates floods a problem for farmers?
8. **HARD** Suppose irrigation water carries 0.5 gram of salt in every liter. A farmer pours 500,000 liters on a field, and almost all of it evaporates or is used by plants. About how many kilograms of salt are left in the field after one watering? ($1,000 \text{ g} = 1 \text{ kg}$.)
9. **HARD** Name two things the Mesopotamian plain had plenty of and three things its people had to trade for. Explain how this shaped the way they wrote and built.
10. **CHALLENGE** In a short paragraph, explain how the geography of Mesopotamia both helped and hurt its people. Use at least one physical feature and one historical example.

COMMON MISTAKES

- Thinking the whole Middle East is the Fertile Crescent. The crescent is a fairly narrow curve of good land; the desert in its middle is far larger.
- Mixing up the two rivers. The Tigris is the eastern one, nearer the Zagros Mountains; the Euphrates is the western and longer one.
- Thinking Mesopotamian floods were gentle and well timed like the Nile's. They came in spring, often violently, and had to be controlled with levees and canals.

Make it a game · Tigris or Euphrates?. A parent reads clues one at a time, and the student shouts "Tigris!" or "Euphrates!" and points to it on the map. Clues: "I am the longer river." "I flow past Baghdad." "I am nearer the Zagros." "Babylon stood beside me." "Nineveh stood beside me." "I am called Hiddekel in Genesis." Score one point for each right answer and one bonus point for naming a city on the river. Then switch and let the student write the clues.

Scripture. "And the name of the third river is Hiddekel: that is it which goeth toward the east of Assyria. And the fourth river is Euphrates." (Genesis 2:14, KJV)

The first rivers named in the Bible flow through this very region. From the beginning, God's story is set in real places with real rivers, and the land between these rivers became one of the first homes of farming, cities and writing.

Practice answers

1. "Between the rivers." Most of it lies in Iraq (with parts in Syria and Turkey).
2. The Euphrates is longer (about 2,800 km). The Tigris runs farther east, closer to the Zagros.
3. The Shatt al-Arab, which flows into the Persian Gulf.
4. $1,850 \times 0.621 \approx 1,149$, so about 1,150 miles.
5. $36.4 - 32.5 = 3.9^\circ$. $3.9 \times 111 \approx 433$ km, or $3.9 \times 69 \approx 269$ mi: about 430 km (270 mi).
6. $250 - 150 = 100$ mm, or $10 - 6 = 4$ in, short. Farmers must irrigate from the rivers.
7. The floods came in spring (about April to June), when winter grain was ripening or being harvested, so they could destroy crops. Farmers needed levees to hold the flood back and canals to bring water at the right times.
8. $500,000 \times 0.5 \text{ g} = 250,000 \text{ g} = 250 \text{ kg}$ of salt. Repeated year after year, this is how salinization happens.
9. Plenty: clay, reeds, water, grain, dates (any two). Trade for: timber (cedar), stone, copper, tin, lapis lazuli (any three). They wrote on clay tablets with reed pens and built with mud brick because stone and timber were scarce.
10. Sample answer: The Tigris and Euphrates brought water and silt to a dry plain, so irrigation produced a grain surplus that fed the first cities, such as Ur and Babylon. But the open plain had no mountains or seas to protect it, so armies could march in easily, and kingdom after kingdom (Sumer, Akkad, Babylon, Assyria, Persia) rose and fell. Irrigation also slowly salted the soil in the south.

3.2 DESERTS, OASES AND WATER

OBJECTIVES

- Locate the great deserts of the region (the Sahara, the Arabian Desert and its Empty Quarter, the Syrian Desert and the deserts of Iran) and explain in physical terms why they are dry.
- Explain how wells, oases and the qanat, a gently sloping tunnel fed by groundwater, let people farm and travel in the desert.
- Calculate qanat slopes, shaft counts and evaporation losses, and explain why underground channels save water.

Warm-up. Pour the same amount of water, about a quarter cup, into two saucers. Cover one with an upside-down bowl and leave the other open. Set both in a warm, sunny window or near a heater. Predict which will lose more water by the end of the lesson, and check at the end of the second session. Then ask: if you had to carry water 10 miles (16 km) across a hot desert to your fields, would you send it in an open ditch or a covered pipe?

Watch. *Desert Oasis: The Monastery of Saint Anthony - "Ends of the Earth"* (Drive Thru History with Dave Stotts, 5:55). <https://www.youtube.com/watch?v=q3yo5AQBLc8>
After the story: visit the Monastery of Saint Anthony in Egypt's Eastern Desert and look for the spring that has let people live there in such a dry place for centuries.

Note: Captions were not available to check; preview it first. Drive Thru History is a trusted Christian channel, and this clip comes from a TBN series about early Christianity in North Africa.

KEY TERMS

desert

A region that receives very little rain, usually less than about 250 mm (10 in) a year, so that few plants can grow without extra water.

oasis

A fertile spot in a desert where groundwater comes near or to the surface through springs or wells, so trees and crops can grow.

aquifer

A layer of gravel, sand or porous rock underground that holds water and lets it flow.

water table

The top of the water-soaked zone underground. A well must reach below it to fill with water.

qanat

A gently sloping underground tunnel that carries groundwater from a hillside aquifer to fields and villages by gravity, with vertical shafts along its length.

wadi

A desert valley or streambed that is dry most of the year but can carry sudden floods after a storm.

CORE IDEAS

The story. Around 209 BC the Greek-speaking king Antiochus III led an army east across the dry plains of northern Iran to fight the Parthians. The Greek historian Polybius, writing a few decades later, described what the soldiers found. The land looked waterless, yet it was crossed by underground channels with wells along them that only the local people knew how to find. Polybius explained that when the Persians ruled the region, they had given anyone who brought water to dry land the right to farm it for five generations, so people had dug long tunnels from the mountains at great cost. As the army approached, the Parthians tried to block the wells. Polybius had described the **qanat**.

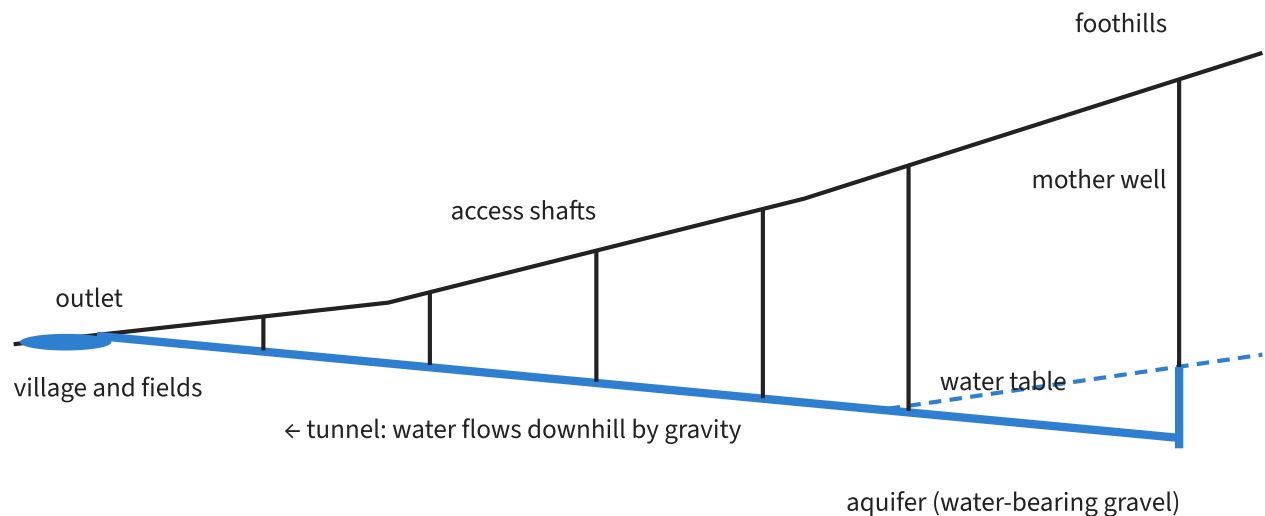
On the map. A belt of deserts stretches from the Atlantic coast of Morocco to Iran. The **Sahara** covers about 9 million km² (3.5 million sq mi), nearly the size of the United States, and much of it is bare rock plateau and gravel plain rather than sand. Across the Red Sea lies the Arabian Desert, whose southern heart, the Rub' al Khali or Empty Quarter, is one of the largest sand seas on earth, about 650,000 km² (250,000 sq mi). North of it the Syrian Desert fills the middle of the Fertile Crescent, and beyond the Zagros lie the salt deserts of Iran. These lands are dry for physical reasons. Between about 20° and 30° north, air that has risen and dropped its rain near the equator sinks back down, warms and dries out, so clouds rarely form. Mountains add rain shadows: the Zagros and the Elburz catch moisture on their outer slopes and leave the plateau of Iran dry.

Water in a dry land. Even a desert has water, but most of it is underground. Where an aquifer reaches the surface, springs make an **oasis**. Siwa in western Egypt and Al-Ahsa in eastern Saudi Arabia, with its millions of date palms, are fed this way. The date palm is the queen of the oasis: it can stand fierce heat if its roots reach water. Elsewhere people dug wells, and the wells became the knots that tied the desert together. Camel caravans moved from well to well and oasis to oasis carrying salt, gold, dates, incense and cloth. Mecca, in a dry valley of western Arabia, was a caravan town, and there Islam began in the early 600s AD. Within about a century Arab armies had carried it across North Africa, where over the following centuries it became the faith of most people. Before that, North Africa had been one of the strongest Christian lands of all. Tertullian and Cyprian taught at Carthage, Augustine (354–430) was bishop of Hippo in what is now Algeria, and Anthony of Egypt went into the desert to pray, helping to start the monastic tradition. The Monastery of Saint Anthony near the Red Sea still stands, and the Coptic Christians of Egypt, numbering in the millions, are today the largest Christian community in the Middle East.

How it worked. A qanat begins with a test well, the **mother well**, dug at the foot of the hills until it strikes the water table. Skilled diggers called *muqannis* then tunneled from the far end, where the water would come out near the village, back uphill toward the mother well. Every 20 to 50 m (65 to 165 ft) they sank a vertical shaft to haul out dirt and let in air and light, so from the air a qanat looks like a line of craters. The tunnel slopes so gently, often

only about 1 m for every 1,000 to 1,500 m, that the water flows without scouring the walls. Gravity does all the work: no pumps, no animals, no fuel. Because the water travels underground, the desert sun cannot evaporate it. The qanat at Gonabad in eastern Iran has a mother well about 300 m (980 ft) deep and runs about 33 km (20 mi), and it has carried water for well over 2,000 years. In 2016 UNESCO listed eleven Persian qanats as a World Heritage site. The idea spread to Oman, where the channels are called *aflaj*, to the Sahara oases of Algeria, where they are called *foggaras*, and with the Arabs to Spain.

Technology overcoming geography. The qanat is a perfect example of people using the land God made instead of fighting it: it follows the slope, takes only what the aquifer gives, and wastes almost nothing. Modern technology has added new tools. Diesel and electric pumps can lift water from deep wells, Libya's Great Man-Made River, begun in 1984, pipes groundwater from beneath the Sahara to the coast, and the countries of the Persian Gulf make much of their drinking water by desalinating seawater. But pumps can draw water faster than rain refills the aquifer. Where wells lower the water table below a qanat's tunnel, the old qanat runs dry. Wise stewardship of desert water is still one of the region's great questions.

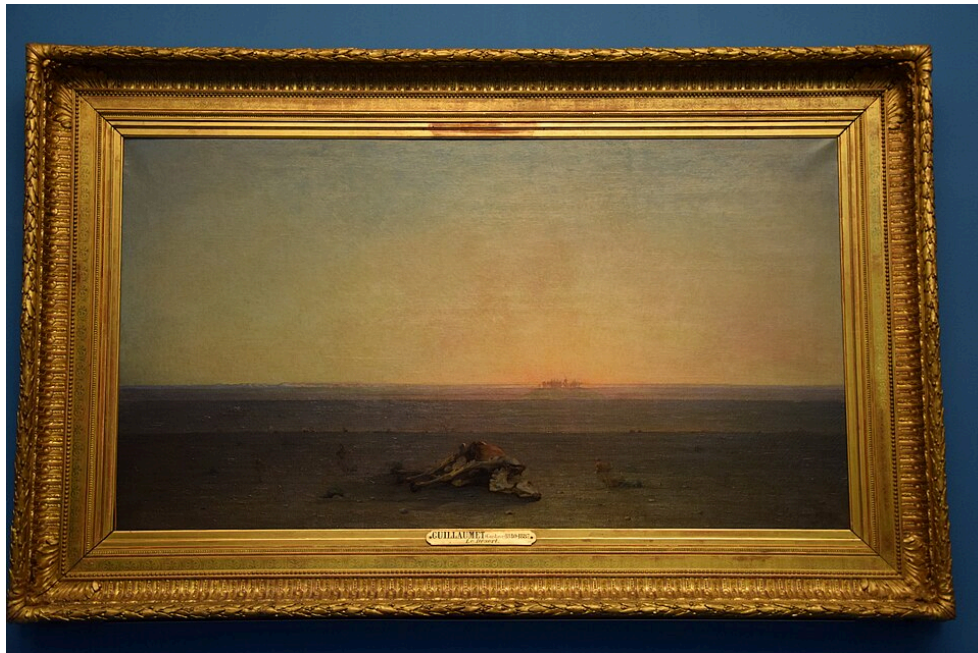


A qanat: the tunnel slopes down more gently than the land, so it comes out at the surface far from the hills.



Deserts, oases and qanat lands from Algeria to Iran.

PICTURE STUDY



The Sahara (also called The Desert), Gustave Guillaumet, 1867 · Oil on canvas · Musée d'Orsay, Paris

Gustave Guillaumet was a French painter who traveled many times to Algeria and lived for months at the edge of the Sahara. Unlike many painters of his time, who filled their desert scenes with colorful costumes and crowds, he wanted to show the desert itself: its size, its silence and its danger.

This painting has almost nothing in it, and that is the point. The flat ground and the low horizon make the viewer feel how far it is to the next well. The only living things are far away, and the nearest thing is a warning.

Look closely

- Find the horizon. How much of the painting is sky, and how much is ground?

- Find the skeleton in the foreground. What do you think happened to this animal?
- Find the caravan far away. How does its small size help you feel the distance?
- Look at the colors. Is this a sandy dune sea or a flat gravel plain? Which is more common in the Sahara?

Talk about it

1. Why would a caravan leader need to know exactly where every well and oasis lay?
2. How might a qanat or an oasis look if it appeared in the middle of this painting?
3. Guillaumet painted the desert as empty and dangerous. How do the stories of Saint Anthony and the desert monasteries show another side of the desert?

PROJECT: A MODEL QANAT WITH STRAWS IN SAND

You will build a working model qanat. Water poured into the “hills” soaks into wet sand, enters a buried straw tunnel and flows out by gravity at the “village,” just as in the real thing. You will also see why the tunnel must slope gently and why it must reach below the water table.

You will need

- A clear plastic storage box or a large foil roasting pan (a clear box lets you see the layers)
- Sand, enough to fill the box about 10 to 15 cm (4 to 6 in) deep at one end
- A handful of aquarium gravel or small pebbles
- Six to eight drinking straws (wide smoothie straws work best) and tape
- A sharp pencil or skewer to poke holes
- A watering can or cup of water, a small dish and a ruler

Steps

1. Pile sand high at one end of the box to make the hills and slope it down to a low end for the village. Measure the height of your hill and the length of the slope.
2. Tape straws end to end to make a tunnel long enough to run from inside the hill to the low end. Poke small holes along the top half of the straws near the hill end only; this is where groundwater will enter.
3. Make an aquifer: spread a layer of gravel at the bottom of the hill end. Lay the straw tunnel on it so that the holed end is buried in the gravel and the other end comes out at the surface at the village end. Check with a ruler that the tunnel slopes down gently toward the village, much more gently than the sand surface.
4. Cover the tunnel with sand. Push a few straws straight down from the surface to the tunnel to make access shafts, and stand one taller straw at the hill end as the mother well.
5. Make it rain: slowly sprinkle water over the hills for several minutes until the sand is soaked and water stands in the mother well. Watch the outlet. Put the dish there to catch your village’s water.

6. Test: change the tunnel to a steep slope and try again, or raise the holed end above the wet gravel. Record what happens in each case.

Tips

- Be patient. Water must soak down to the aquifer before the qanat flows, just as in real hills.
- If sand clogs the straw holes, wrap the holed end in a scrap of old nylon stocking or paper towel as a filter.
- Work outside or on a tray. Wet sand is heavy, so lift the box with a partner.

Check your work

- I can point to the mother well, the access shafts, the tunnel and the outlet on my model.
- I can explain why the tunnel must reach below the water table at the hill end.
- I can explain why a qanat loses less water than an open ditch in the desert.

MAP NOTEBOOK

1. Copy the qanat cross-section into your map notebook and label the mother well, water table, aquifer, access shafts, tunnel, outlet and fields. Add an arrow showing the direction the water flows.
2. On an outline map of North Africa and the Middle East, shade the Sahara, the Arabian Desert, the Empty Quarter, the Syrian Desert and the deserts of Iran. Mark Siwa, Al-Ahsa and Gonabad with a small palm tree or well symbol.
3. Draw a camel caravan route linking three oases and write beside each stop what the caravan might buy or sell there.

From history. Wells were so valuable in the dry south of Canaan that people fought over them. Genesis 26 tells how Isaac reopened the wells his father Abraham had dug near Gerar, which the Philistines had filled in. When the herdsmen quarreled over a new well, Isaac named it Esek, meaning contention; over the next, he named it Sitnah, meaning hatred. Rather than fight, he moved on and dug a third, which no one disputed, and called it Rehoboth, meaning room. He then went up to Beersheba, whose name means well of the oath. At Tel Beersheba in Israel, archaeologists have found a deep ancient well, and the modern city still bears the name.

WORKED EXAMPLES

Example 1. A qanat tunnel drops 1 m for every 1,000 m of length. The tunnel is 5 km long. How much lower is the outlet than the bottom of the mother well, in meters and feet?

(Use the map or drawing “The tunnel slopes far more gently than the ground above it.” shown earlier in this lesson.)

1. Change 5 km to meters: $5 \text{ km} = 5,000 \text{ m}$.
2. Drop = $5,000 \text{ m} \div 1,000 \times 1 \text{ m} = 5 \text{ m}$.
3. Change to feet: $5 \text{ m} \times 3.28 \approx 16 \text{ ft}$.

Answer: The outlet is about 5 m (16 ft) lower. Over 5 km that slope is so gentle that it would look level to your eye.

Example 2. The ground above a qanat slopes down 20 m for every kilometer toward the village, but the tunnel slopes down only 1 m per kilometer. The mother well is 60 m deep. About how far from the mother well will the tunnel reach the surface?

1. Each kilometer, the ground drops 20 m and the tunnel drops 1 m, so the tunnel gets $20 - 1 = 19 \text{ m}$ closer to the surface.
2. At the mother well the tunnel is 60 m below the surface.
3. Distance = $60 \text{ m} \div 19 \text{ m per km} \approx 3.2 \text{ km}$.
4. In miles: $3.2 \times 0.621 \approx 2 \text{ mi}$.

Answer: About 3.2 km (2 mi) from the mother well. This is why qanats come out at the surface far out on the plain, where the farmland is.

Example 3. A village could carry its water 5 km in an open ditch 1 m wide instead of a qanat. In the summer desert sun, about 1 cm of water evaporates from the ditch’s surface each day. How many liters would be lost each day? (1 cubic meter = 1,000 liters.)

1. Surface area of the ditch = $5,000 \text{ m} \times 1 \text{ m} = 5,000 \text{ m}^2$.
2. Depth lost each day = $1 \text{ cm} = 0.01 \text{ m}$.
3. Volume lost = $5,000 \text{ m}^2 \times 0.01 \text{ m} = 50 \text{ m}^3$.
4. In liters: $50 \times 1,000 = 50,000 \text{ liters a day}$.

Answer: About 50,000 liters (about 13,000 US gallons) every summer day, water that a qanat would deliver to the fields instead.

PRACTICE

1. **EASY** About how much rain a year does a place usually receive if geographers call it a desert? Give the answer in millimeters and inches.
2. **EASY** Name four deserts of North Africa and the Middle East.
3. **EASY** Name the four main parts of a qanat in order from the hills to the village.
4. **MEDIUM** The Sahara covers about 9 million km². Convert this to square miles (1 km² ≈ 0.386 sq mi).
5. **MEDIUM** Use the map. Which of these is farthest east: Siwa, Al-Ahsa or Gonabad? Which is farthest west? In which country is each?
(Use the map or drawing "Read the longitudes of the oases." shown earlier in this lesson.)
6. **MEDIUM** A qanat tunnel is 2.4 km long, with an access shaft every 40 m. How many shafts does it have, if the first is 40 m from the outlet and the last is the mother well?
7. **MEDIUM** Give two reasons why the builders put the qanat channel underground instead of digging an open canal.
8. **HARD** A qanat drops 1 m for every 1,500 m. How much does a 12 km tunnel drop, in meters and feet?
9. **HARD** A camel caravan travels about 30 km (19 mi) a day. Two oases are 120 km apart. How many days does the trip take, and how far is it in miles?
10. **CHALLENGE** A farmer near an old qanat drills a deep well with an electric pump. Within a few years the qanat stops flowing. Explain why, using the words water table and aquifer.

COMMON MISTAKES

- Thinking deserts are all sand dunes. Most of the Sahara is rock plateau and gravel plain; sand seas like the Empty Quarter are only part of the picture.
- Thinking a qanat is a pipe that is pumped. It is a dug tunnel, and gravity alone moves the water.
- Thinking the tunnel slopes like the land above it. The tunnel slopes much more gently than the ground, which is why it starts deep at the mother well and comes out at the surface far down the plain.

Make it a game • Oasis Hopping. Lay out paper "oases" across the floor about one big step apart, with a few gaps of two steps. The player starts with three water tokens (coins). Each step from one oasis to the next costs one token, and landing on an oasis refills to three. A parent calls out a destination oasis, and the player must plan a route that never runs out of water. If a gap is too wide, the player must "dig a well" by correctly answering a question about deserts or qanats to place a new oasis. Whoever reaches the far side with the fewest wells dug wins.

Scripture. "The wilderness and the solitary place shall be glad for them; and the desert shall rejoice, and blossom as the rose." (Isaiah 35:1, KJV)

People in desert lands knew the joy of water reaching dry ground. A qanat or an oasis gives a small picture of this promise: where water comes, the desert blooms.

Practice answers

1. Less than about 250 mm (10 in) a year.
2. Any four: the Sahara, the Arabian Desert, the Rub' al Khali (Empty Quarter), the Syrian Desert, the Dasht-e Kavir or Dasht-e Lut of Iran, the Negev, the Sinai.
3. The mother well, the access shafts, the sloping tunnel and the outlet (where the water reaches the surface near the fields).
4. $9,000,000 \times 0.386 \approx 3,474,000$, so about 3.5 million sq mi.
5. Farthest east: Gonabad (about 59°E , Iran). Farthest west: Siwa (about 25.5°E , Egypt). Al-Ahsa (about 49.6°E) is in Saudi Arabia.
6. $2.4 \text{ km} = 2,400 \text{ m}$. $2,400 \div 40 = 60$ shafts (counting the mother well).
7. Underground water is shaded, so little evaporates in the desert heat; the tunnel can reach down to the water table under the hills; blowing sand cannot fill it; the water stays cool and cleaner. (Any two.)
8. $12 \text{ km} = 12,000 \text{ m}$. $12,000 \div 1,500 = 8$, so it drops 8 m. $8 \times 3.28 \approx 26 \text{ ft}$.
9. $120 \div 30 = 4$ days. $120 \times 0.621 \approx 75$ miles.
10. The pump draws water out of the aquifer faster than rain refills it, so the water table drops. A qanat flows only where its tunnel lies below the water table at the hill end. When the water table falls below the tunnel, no water enters and the qanat runs dry, even though water is still deep underground.

3.3 THE LANDS OF THE BIBLE

OBJECTIVES

- Describe the four north-south strips of the land of Israel and its neighbors: the coastal plain, the central hills, the Jordan Rift Valley and the plateau east of the Jordan.
- Trace the Jordan River from Mount Hermon through the Sea of Galilee to the Dead Sea, and explain why the Dead Sea is so low and so salty.
- Explain how this small land bridge between Africa and Asia shaped the history of Jerusalem and the spread of the gospel, and describe the city's present status neutrally and factually.

Warm-up. Fold a sheet of paper into four long strips, like an accordion, and open it partly so it makes hills and valleys. Stand it on the table with the folds running north and south. Pour a spoonful of salt along the lowest fold. Now imagine one side is the Mediterranean Sea and the deepest valley is far below sea level. Which slopes would catch rain from the sea, and which would be dry? Where would you build a city that is hard to attack?

Watch. *Sea of Galilee in Israel* (Drive Thru History with Dave Stotts, 1:27).

<https://www.youtube.com/watch?v=xQ3hBAxWebI>

With On the map: watch this short clip of the Sea of Galilee and look for the Jordan River flowing through it, the steep hills of black basalt rock around the shore, and snowy Mount Hermon far to the north.

Note: Captions were not available to check; preview it first. It comes from Drive Thru History, a trusted Christian channel, and is under two minutes long. The video calls it the Sea of Galilee but also uses its other names (Gennesaret, Tiberias, Kinnereth). It gives the lake's depth as 686 feet below sea level; the exact figure changes as the water level rises and falls.

Backup video. *I Put a Scale Map of Bible Lands Over the Top of the United States.*

Here's What I Noticed (Matt Whitman, 13:00). [https://www.youtube.com/watch?](https://www.youtube.com/watch?v=azmz71bYZCs)

[v=azmz71bYZCs](https://www.youtube.com/watch?v=azmz71bYZCs)

With On the map: watch a scale map of the Bible lands laid over the United States, to see how small and close together those places are. Note: Captions were not available to check; preview it first.

KEY TERMS

land bridge

A narrow strip of land that connects two larger land masses and funnels travel between them. The lands at the eastern end of the Mediterranean link Africa and Asia.

rift valley

A long, deep valley formed where the earth's crust has pulled apart or slid along a great fault. The Jordan Valley and the Dead Sea lie in one.

rain shadow

The dry side of a range of hills or mountains, away from the winds that bring rain.

elevation

Height above or below sea level. Places below sea level have a negative elevation.

inland sea

A lake with no outlet to the ocean. Its water leaves only by evaporation, so salts build up.

pilgrim

A person who travels to a holy place for worship or prayer.

CORE IDEAS

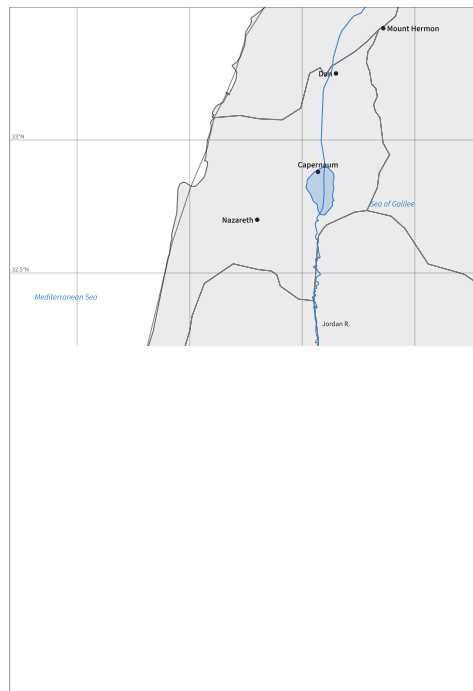
The story. In April 1839 the Scottish painter David Roberts rode up to Jerusalem from the south. He had crossed the Sinai Desert by camel, visited the monastery of Saint Catherine and the rock city of Petra, and now he climbed the Mount of Olives, the ridge just east of the old city. From there, across the deep Kidron Valley, he could see the whole walled city spread on its hills, with the great Dome of the Rock in front of him. He sketched quickly and carefully. Back in London, the artist Louis Haghe turned his drawings into lithographs, published from 1842 in *The Holy Land, Syria, Idumea, Arabia, Egypt and Nubia*. For the first time, many people in Britain and America could see the real shapes of the places they had read about in the Bible.

On the map. The land is small. From Dan in the north to Beersheba in the south is only about 240 km (150 mi). It runs in four strips from west to east. First comes the flat **coastal plain** along the Mediterranean. Then rise the **central hills**, where Jerusalem stands at about 760 m (2,500 ft). East of the hills the land plunges into the **Jordan Rift Valley**, the lowest land on earth. Beyond it rises the **plateau** of modern Jordan. Winter storms blow in from the Mediterranean, so the western slopes are green: Jerusalem gets about 550 mm (22 in) of rain a year. But the eastern slopes lie in a **rain shadow**. Only about 23 km (14 mi) east of Jerusalem, Jericho gets about 150 mm (6 in), and the bare hills between are the Judean wilderness, where David hid from Saul and John the Baptist preached.

The Jordan and its two seas. The Jordan begins with springs at the foot of snowy Mount Hermon, about 2,814 m (9,232 ft) high. It flows south into the **Sea of Galilee**, a harp-shaped freshwater lake about 21 km (13 mi) long and 13 km (8 mi) wide, whose surface lies about 210 m (690 ft) below sea level. Peter, Andrew, James and John fished here, and Capernaum on its northern shore became the home base of Jesus' ministry. From the lake, the Jordan winds south down the rift, about 105 km (65 mi) in a straight line but much farther along its loops, to the **Dead Sea**. Its shore lies about 430 m (1,410 ft) below sea level, the lowest dry land on earth. The Dead Sea has no outlet; water leaves only by evaporating, so salt has built up until the water is nearly ten times saltier than the ocean, and a swimmer floats like a cork. In recent decades so much Jordan water has been used upstream for farms and cities that the Dead Sea has been dropping about 1 m (3 ft) a year.

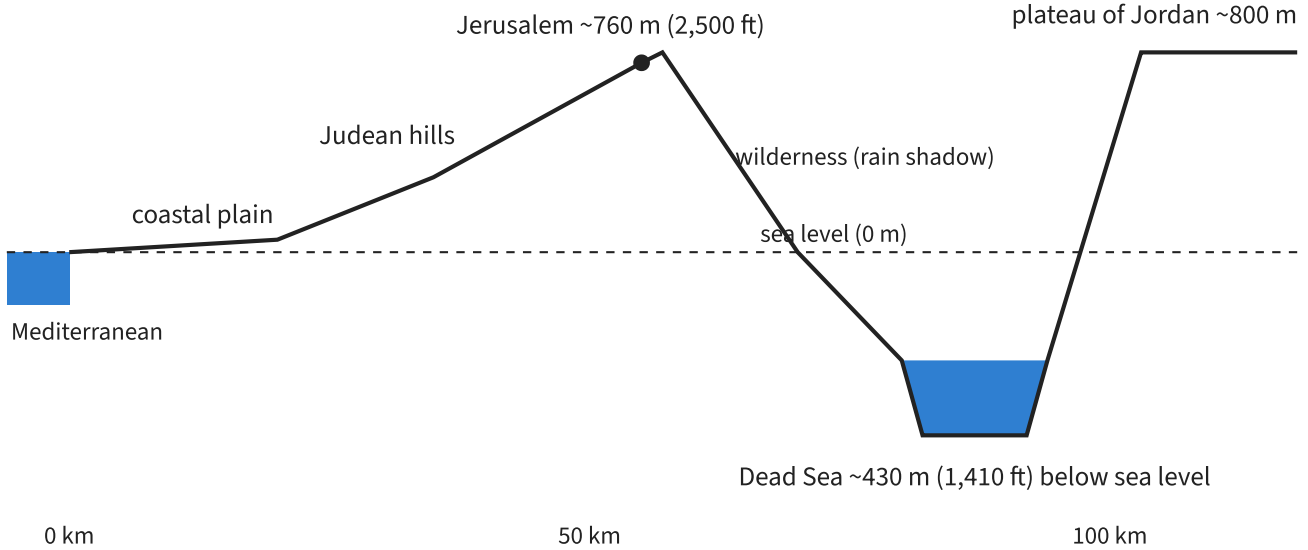
The big idea. This narrow land is a **land bridge**. Desert lies to the east and sea to the west, so the roads between Egypt and Mesopotamia had to pass through it: the coast road and, east of the Jordan, the King's Highway. That made the land valuable, and armies of Egypt, Assyria, Babylon, Persia, Greece and Rome marched through it. Jerusalem itself is a hill fortress. Deep valleys guard it on three sides, and the Gihon Spring gave it water. Around 700 BC King Hezekiah had a tunnel about 533 m (1,750 ft) long cut through the rock to bring that spring inside the walls before an Assyrian siege (2 Kings 20:20).

Faith and history. Here Jesus was born in Bethlehem, grew up in Nazareth, was baptized in the Jordan, taught around the Sea of Galilee, and was crucified and rose again in Jerusalem. At Pentecost the church was born in Jerusalem, and from this small land the gospel went out to the ends of the earth (Acts 1:8). In the 300s the Roman emperor Constantine built the Church of the Holy Sepulchre over the traditional place of the tomb, and churches still stand there and at Bethlehem. Christian communities have lived in the land ever since, though today they are a small minority. Jerusalem is also holy to Jews, for whom the Western Wall is the last remnant of the Temple's enclosure, and to Muslims, for whom the Dome of the Rock (completed in the 690s) and the al-Aqsa Mosque stand on the same hill. The city was ruled by Romans, Byzantines, Arab caliphs, Crusaders (who took it in 1099 with great bloodshed), Saladin (1187), the Ottomans (1517–1917) and Britain, before the State of Israel was founded in 1948. As of 2026, Jerusalem's status is disputed: Israel calls the whole city its capital, Palestinians seek East Jerusalem as the capital of a future state, and most countries keep their embassies in Tel Aviv, though the United States moved its embassy to Jerusalem in 2018.



The lands of the Bible: a narrow land between the sea and the desert.

West → East (vertical scale greatly exaggerated)



*A simplified profile from the Mediterranean through Jerusalem to the Dead Sea and the plateau of Jordan.
The vertical scale is greatly exaggerated.*

PICTURE STUDY



*Jerusalem from the Mount of Olives, David Roberts (drawing); lithograph by Louis Haghe, drawn April 1839; published 1842 · Tinted (and often hand-colored) lithograph · From *The Holy Land, Syria, Idumea, Arabia, Egypt and Nubia* (London, 1842–1849); copies are held by the Library of Congress and many other libraries and museums*

David Roberts (1796–1864) began as a house painter and a painter of theater scenery in Scotland, which taught him to draw big, clear views quickly. In 1838–1839 he made a long journey through Egypt and the Near East, filling notebooks with drawings. His view of Jerusalem from the Mount of Olives is one of the most famous pictures from that journey.

Roberts drew what was really there in his day, including the Ottoman city walls built in the 1500s, the domes and minarets, and the travelers and local people on the hillside. Because he drew carefully, historians still use his pictures to see how the city looked before modern building.

Look closely

- Find the city walls. How does the city's position on its hills make it easier to defend?
- Find the valley between the hillside where Roberts sat and the walls. This is the Kidron Valley.
- Find the large dome standing in an open space inside the walls. This is the Dome of the Rock, on the hill where Solomon's Temple and later Herod's Temple once stood.
- Look at the people in the foreground. What are they doing, and how do they help you judge the size of the view?

Talk about it

1. Roberts's pictures let thousands of people see the Holy Land without traveling there. How did that change the way they read the Bible?
2. Read Psalm 125:2. Which hills around Jerusalem can you see or imagine from this view?
3. Why might an artist choose the Mount of Olives as the best place to draw the whole city?

PROJECT: FROM THE SEA TO THE LOWEST PLACE ON EARTH: A CARDBOARD ELEVATION PROFILE

You will build a cutaway model of the land along a line from the Mediterranean coast through Jerusalem to the Dead Sea and the plateau of Jordan. You will see with your own eyes how far up Jerusalem is and how far down the Dead Sea is.

You will need

- A long piece of cardboard, at least 25 cm by 20 cm (10 in by 8 in)
- Graph paper, ruler and pencil
- Scissors or a craft knife (with a parent's help)
- Blue, green and tan markers or paint
- Glue stick

Steps

1. On graph paper, draw a horizontal line for sea level across the middle of the sheet. Use this scale: across, 1 cm = 5 km; up and down, 1 cm = 100 m.
2. Plot these rounded points (distance east of the coast, elevation): coast (0 km, 0 m); coastal plain (20 km, 50 m); foothills (35 km, 300 m); Jerusalem (55 km, 760 m); Mount of Olives (57 km, 800 m); edge of the wilderness (70 km, 0 m); west shore of the Dead Sea (81 km, -430 m); east shore (93 km, -430 m); plateau of Jordan (103 km, 800 m).

3. Connect the points to make the land surface. Shade below the line tan, color the Dead Sea and the Mediterranean blue, and color the rainy western slopes green.
4. Glue the graph paper to the cardboard and cut along the land surface, leaving a stand at the bottom so it stands upright.
5. Label Jerusalem, the Mount of Olives, the Judean wilderness, the Dead Sea, the plateau and sea level. Add an arrow from the west labeled “winter rain winds” and write “rain shadow” on the dry side.
6. Measure: how many centimeters is Jerusalem above sea level on your model, and how many is the Dead Sea below? Convert back to meters and feet.

Tips

- Your model exaggerates the height 50 times (5 km across but only 100 m up for each centimeter). Real slopes are much gentler than they look on your model, but the drop to the Dead Sea is still the steepest in the land.
- Keep the points rounded; real ground is bumpier than any profile.

Check your work

- I can point to the coastal plain, central hills, rift valley and plateau on my model.
- I can explain why the western slopes are wetter than the eastern slopes.
- I can explain why the Dead Sea is salty and why it is so low.

MAP NOTEBOOK

1. Draw a map of the land from Mount Hermon to the Dead Sea. Label the Jordan River, the Sea of Galilee, the Dead Sea, Jerusalem, Bethlehem, Nazareth, Capernaum, Jericho and the Mediterranean Sea.
2. Draw a small table comparing the Sea of Galilee and the Dead Sea: elevation, size, fresh or salt, outlet or no outlet, and one Bible event at each.
3. Sketch the view of Jerusalem from the Mount of Olives in five simple shapes: the hillside, the valley, the walls, the great dome and the sky. Label each.

From history. In 1880 some boys wading in the old water tunnel under Jerusalem noticed letters carved in the rock wall near the Pool of Siloam. It was an inscription in ancient Hebrew describing the day the two teams of tunnel diggers, cutting from opposite ends, heard each other’s voices through the rock and broke through, pick striking against pick, so that the water flowed from the spring to the pool. It matches the Bible’s note that King Hezekiah “made a pool, and a conduit, and brought water into the city” (2 Kings 20:20). The inscription was cut out of the wall and is now in the Istanbul Archaeology Museums, while visitors can still wade through the tunnel itself.

WORKED EXAMPLES

Example 1. Jerusalem stands at about 760 m above sea level, and Jericho at about 250 m below sea level. What is the difference in elevation in meters and feet? If the two are about 23 km apart in a straight line, what is the average drop per kilometer?

(Use the map or drawing “Jerusalem stands high; the rift valley lies far below sea level.” shown earlier in this lesson.)

1. A height above sea level and a depth below it add together: $760 \text{ m} - (-250 \text{ m}) = 760 + 250 = 1,010 \text{ m}$.
2. Convert to feet: $1,010 \times 3.28 \approx 3,313 \text{ ft}$, about 3,300 ft.
3. Average drop = $1,010 \text{ m} \div 23 \text{ km} \approx 44 \text{ m per km}$ (about 230 ft per mile).

Answer: About 1,010 m (3,300 ft), an average drop of about 44 m per km. That is why the Bible says a traveler “went down from Jerusalem to Jericho” (Luke 10:30).

Example 2. The surface of the Sea of Galilee is about 210 m below sea level, and the Dead Sea about 430 m below. The two lakes are about 105 km apart in a straight line. How much does the Jordan drop between them, and what is its average drop per kilometer? Compare it with the road from Jerusalem to Jericho.

1. Drop = $430 \text{ m} - 210 \text{ m} = 220 \text{ m}$ (about 720 ft).
2. Average drop = $220 \text{ m} \div 105 \text{ km} \approx 2.1 \text{ m per km}$.
3. Compare: $44 \text{ m per km} \div 2.1 \text{ m per km} \approx 21$. The Jerusalem-Jericho road drops about 20 times more steeply.

Answer: About 220 m (720 ft), roughly 2 m per km, about one-twentieth as steep as the Jerusalem-Jericho road (44 m per km). The Jordan is a gentle, winding river, while the hills beside the rift are very steep.

Example 3. Capernaum lies at about 32.9°N and Jerusalem at about 31.8°N, to the south-southwest. How far apart are they north to south? A family walking to Jerusalem for a feast by the Jordan Valley road traveled roughly 150 km. At 25 km (15 mi) a day, how many days did the trip take?

(Use the map or drawing “Use the latitude lines to measure north-south distance.” shown earlier in this lesson.)

1. Difference in latitude: $32.9^\circ - 31.8^\circ = 1.1^\circ$.
2. One degree of latitude is about 111 km (69 mi): $1.1 \times 111 \approx 122$ km, and $1.1 \times 69 \approx 76$ mi.
3. Walking time: $150 \text{ km} \div 25 \text{ km per day} = 6$ days.

Answer: About 122 km (76 mi) apart in a straight line; the walk along the valley road took about 6 days.

PRACTICE

1. **EASY** Name the four north-south strips of the land, from the Mediterranean eastward.
2. **EASY** Which river connects the Sea of Galilee and the Dead Sea, and near which mountain does it begin?
3. **EASY** Why is the Sea of Galilee fresh while the Dead Sea is very salty?
4. **MEDIUM** Mount Hermon is about 2,814 m high. Convert to feet ($1 \text{ m} \approx 3.28 \text{ ft}$).
5. **MEDIUM** Use the map. In which direction would you travel from Jerusalem to reach (a) Bethlehem, (b) Jericho, (c) the Sea of Galilee, (d) Jaffa on the coast?
(Use the map or drawing “Use the compass directions on the map.” shown earlier in this lesson.)
6. **MEDIUM** What is the difference in elevation between the top of Mount Hermon (about 2,814 m) and the shore of the Dead Sea (about -430 m)? Give it in meters and feet.
7. **MEDIUM** If the Dead Sea keeps dropping about 1 m a year, how far will its level fall in 20 years, in meters and feet? Why has it been dropping?
8. **HARD** The Sea of Galilee is about 21 km long and 13 km wide. If it were a rectangle, what would its area be? Its real area is about 166 km². Why is the real area smaller?
9. **HARD** Jerusalem gets about 550 mm (22 in) of rain a year, but Jericho, only about 23 mm away, gets about 150 mm (6 in). Explain why, using the words rain shadow and elevation.
10. **CHALLENGE** In a short paragraph, explain how geography helped make this small land so important in history. Mention the land bridge, Jerusalem’s position and at least one event in the history of Christianity.

COMMON MISTAKES

- Picturing the Jordan as a great river like the Mississippi. It is narrow and shallow in most places, though it winds a long way down the rift valley.

- Mixing up the Sea of Galilee (a freshwater lake full of fish, with an outlet) and the Dead Sea (a salt lake with no outlet).
- Thinking “going up to Jerusalem” means going north. In the Bible it means going uphill: from almost every direction, travelers climbed to reach the city.

Make it a game · Up or Down to Jerusalem? Write place names on cards with their elevations on the back: Mount Hermon (2,814 m), Mount of Olives (about 800 m), Jerusalem (760 m), Bethlehem (about 775 m), Nazareth (about 350 m), the Mediterranean shore (0 m), the Sea of Galilee (−210 m), Jericho (−250 m), the Dead Sea (−430 m). Draw two cards. The player says which is higher and whether a traveler would go “up” or “down” to get from the first to the second, then turns the cards to check. A correct answer scores a point; guessing the difference in meters within 100 m scores a bonus point. Finish by arranging all the cards from highest to lowest.

Scripture. “As the mountains are round about Jerusalem, so the LORD is round about his people from henceforth even for ever.” (Psalm 125:2, KJV)

The psalmist looked at the real hills around Jerusalem, the Mount of Olives to the east and the ridges on every side, and saw a picture of God’s protection. Geography became a way to remember a promise.

Practice answers

1. The coastal plain, the central hills, the Jordan Rift Valley, and the plateau east of the Jordan.
2. The Jordan River, which begins with springs at the foot of Mount Hermon.
3. The Sea of Galilee has an outlet (the Jordan flows out of it), so water keeps moving through. The Dead Sea has no outlet; water leaves only by evaporation and leaves its salt behind.
4. $2,814 \times 3.28 \approx 9,230$ ft (about 9,232 ft).
5. (a) South (slightly southwest). (b) East (slightly northeast). (c) North (slightly northeast). (d) West-northwest.
6. $2,814 + 430 = 3,244$ m. $3,244 \times 3.28 \approx 10,640$ ft.
7. 20×1 m = 20 m, about 66 ft. Much of the Jordan’s water is used upstream for farms and cities, so less reaches the Dead Sea than evaporates from it.
8. $21 \times 13 = 273$ km². The real lake is harp- or pear-shaped, narrow at the ends and curved at the sides, so it fills only part of that rectangle (about $166 \div 273 \approx 61\%$).
9. Winter storms come from the Mediterranean in the west. As the moist air rises over the high central hills (higher elevation), it cools and drops rain on Jerusalem and the western slopes. As the air sinks down the eastern side into the rift valley it warms and dries, so Jericho and the Judean wilderness lie in a rain shadow.
10. Sample answer: With the Mediterranean on the west and desert on the east, the land is a narrow land bridge between Africa and Asia, so the roads between Egypt and Mesopotamia passed through it and great empires fought to control it. Jerusalem stood on high ground guarded by deep valleys, with the Gihon Spring for water, so it made a strong capital. Here Jesus was crucified and rose again, the church began at Pentecost, and from this crossroads of the ancient world the gospel spread out along the roads to every region.

3.4 OIL AND STRAITS

OBJECTIVES

- Explain in physical terms how oil forms and why it collects in traps beneath the lands around the Persian Gulf.
- Locate the region's major oil fields and its three great sea gates: the Strait of Hormuz, the Bab-el-Mandeb and the Suez Canal.
- Calculate oil flows, tanker loads and strait widths in metric and U.S. units, and describe the importance of the Strait of Hormuz factually and neutrally.

Warm-up. Pour about half a cup of water and two tablespoons of cooking oil into a clear plastic bottle, cap it tightly and shake it hard. Then hold the bottle upside down at an angle so its shoulder makes a little dome, and watch. Where does the oil go? Why does it gather there? Underground, oil does the same thing in the tiny spaces of rock: it rises above water until something stops it.

Watch. *3rd March 1938: First major oil discovery in Saudi Arabia at Dammam Well No. 7* (HistoryPod, 2:38). https://www.youtube.com/watch?v=8Y_nDQM5tis

After the story: hear how drillers kept going after six failed wells until Dammam No. 7 struck oil in March 1938, and notice how it changed Saudi Arabia.

Note: Captions were not available to check; preview it first. It is a short history clip, and the description stays on the oil discovery.

Backup video. *The Oil Deal That Tied Britain to the Strait of Hormuz* (The Photographed Past, 3:59). <https://www.youtube.com/watch?v=jGNb90PkCZg>

As review: follow D'Arcy's 1908 strike at Masjid-i-Suleiman to the Abadan refinery, and see why the Strait of Hormuz was the only way for the oil to reach the sea. Note: Captions were not available to check; preview it first. It is from a small archival-photo channel whose narration may be computer-generated, and it includes Winston Churchill and early World War I history. The video spells the oil field Masjid-i-Suleiman; the lesson uses Masjed Soleyman.

KEY TERMS

petroleum

Crude oil, a thick liquid made of hydrocarbons, found in the pores of rock deep underground and refined into gasoline, diesel, jet fuel, plastics and many other products.

reservoir rock

Porous rock, such as sandstone or limestone, whose tiny spaces can hold oil, gas and water like a hard sponge.

trap

An arrangement of rock layers, often a dome or arch called an anticline, where a tight cap rock stops oil from rising any farther.

proven reserves

The amount of oil that geologists are reasonably sure can be produced from known fields with present technology and prices.

strait

A narrow channel of water connecting two larger bodies of water.

choke point

A narrow passage on a major route, such as a strait or canal, through which so much traffic must pass that blocking it would affect trade far away.

CORE IDEAS

The story. In 1901 the Shah of Persia sold a British businessman, William Knox D’Arcy, the right to search for oil across most of his kingdom. For seven years D’Arcy’s drillers, led by the engineer George Reynolds, hauled heavy equipment over the rough foothills of the Zagros Mountains, struggled with heat and sickness, and found nothing worth selling. D’Arcy’s money ran low, and his partners sent orders to wind up the work. But before the order arrived, early on the morning of May 26, 1908, oil burst from a well at Masjed Soleyman in southwestern Persia, now Iran. It was the first great oil discovery in the Middle East. The Anglo-Persian Oil Company, founded in 1909 and later called BP, piped the oil to a refinery at Abadan on the Shatt al-Arab, and in 1914 the British government bought a controlling share so that the Royal Navy, which was changing its ships from coal to oil, would have a steady supply.

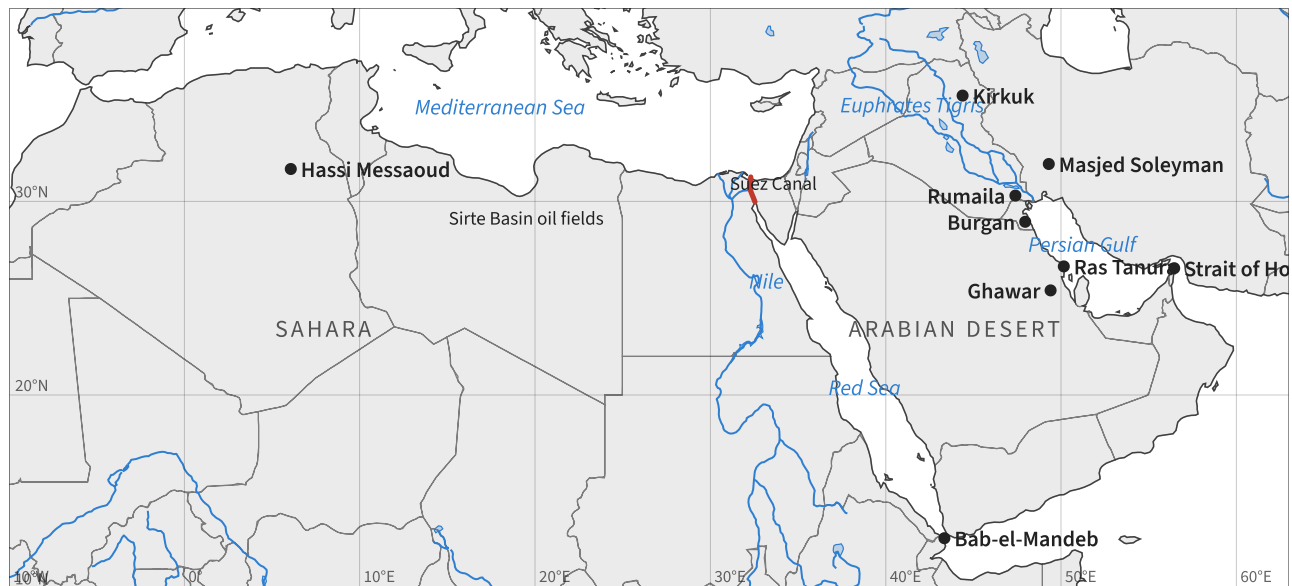
How it formed. Geologists explain that over long ages tiny sea creatures and plants settled in the mud at the bottom of warm, shallow seas. Buried deep under more layers, the heat and pressure of the earth slowly changed them into oil and natural gas. Oil is lighter than water, so it creeps upward through the pores and cracks of the rock until it meets a layer it cannot pass through, a **cap rock** of salt or tight shale. Where the layers are bent up into a dome, the oil gathers at the top like the oil in your upside-down bottle. The lands around the Persian Gulf have almost perfect conditions: thick layers of **reservoir rock**, good cap rocks, and huge gentle domes. In Iran, the Zagros Mountains are made of long folds of rock, each a possible trap. In Saudi Arabia, the Ghawar field, found in 1948, stretches about 280 km (170 mi) and is the largest conventional oil field ever discovered.

On the map. Most of the region’s oil lies in a ring around the Persian Gulf: eastern Saudi Arabia, Kuwait, southern and northern Iraq (at Rumaila near Basra and at Kirkuk, where oil was struck in 1927), southwestern Iran, the United Arab Emirates and Qatar. Under the Gulf between Qatar and Iran lies the world’s largest natural gas field, which the two countries share. In North Africa, Libya and Algeria have large fields beneath the Sahara. Altogether, the Middle East holds nearly half of the world’s proven oil reserves (about 48% in 2020 estimates). Saudi Arabia and Venezuela report the largest totals of any single countries.

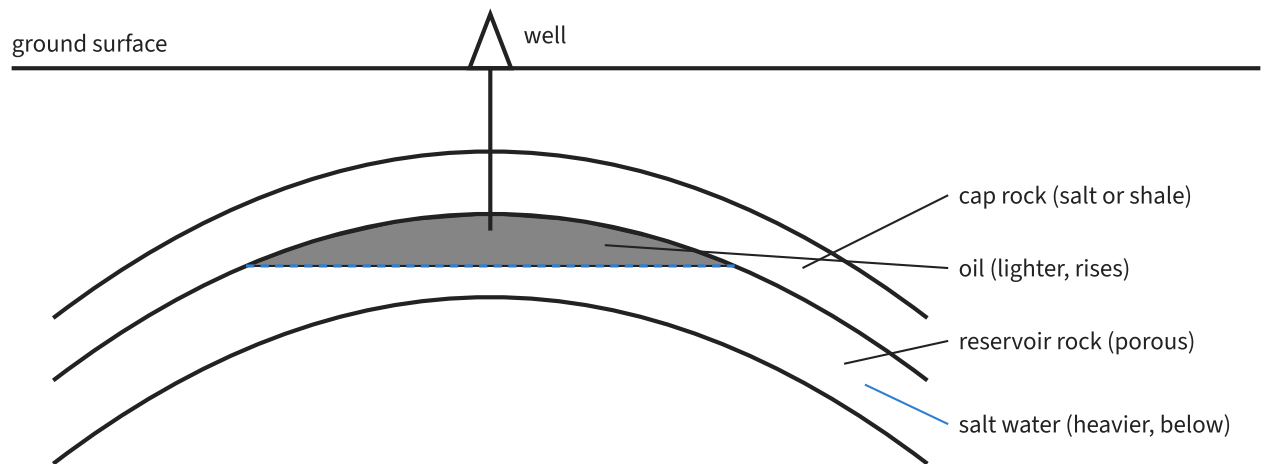
The straits. Oil is only useful if it can reach the people who buy it, and here geography matters again. The Persian Gulf has only one exit, the **Strait of Hormuz**, between Iran to the north and the Musandam Peninsula of Oman to the south. At its narrowest it is about 33 km (21 mi) wide, and the marked shipping lanes are only about 3 km (2 mi) wide in each direction. In 2023 about 20 million barrels of oil a day passed through it, roughly one-fifth of all the oil the world used, along with about a fifth of the world's trade in liquefied natural gas, mostly from Qatar. Most of it goes to Asia: China, India, Japan and South Korea. Saudi Arabia and the United Arab Emirates have built pipelines to the Red Sea and the Gulf of Oman that can bypass the strait, but they can carry only part of the flow. Ships bound for Europe sail south and west to a second **choke point**, the Bab-el-Mandeb, about 32 km (20 mi) wide, between Yemen and Djibouti, then up the Red Sea to the Suez Canal, opened in 1869 and about 193 km (120 mi) long. Since late 2023, attacks on ships near the Bab-el-Mandeb have led many shipping companies to sail all the way around Africa instead. Because conflicts in the region can quickly affect these waterways, the situation as of 2026 is best checked in a current news source with a parent.

The big idea. Oil changed the region in a single lifetime. Kuwait, Doha and Dubai were small towns of pearl divers, fishermen and traders in the early 1900s; today they are modern cities. In 1960 five oil countries met in Baghdad and founded OPEC to coordinate their oil policies, and in 1973 Arab oil producers cut their exports during a war with Israel, and world oil prices roughly quadrupled. A lucky resource and a narrow strait have made this region matter to every nation on earth.

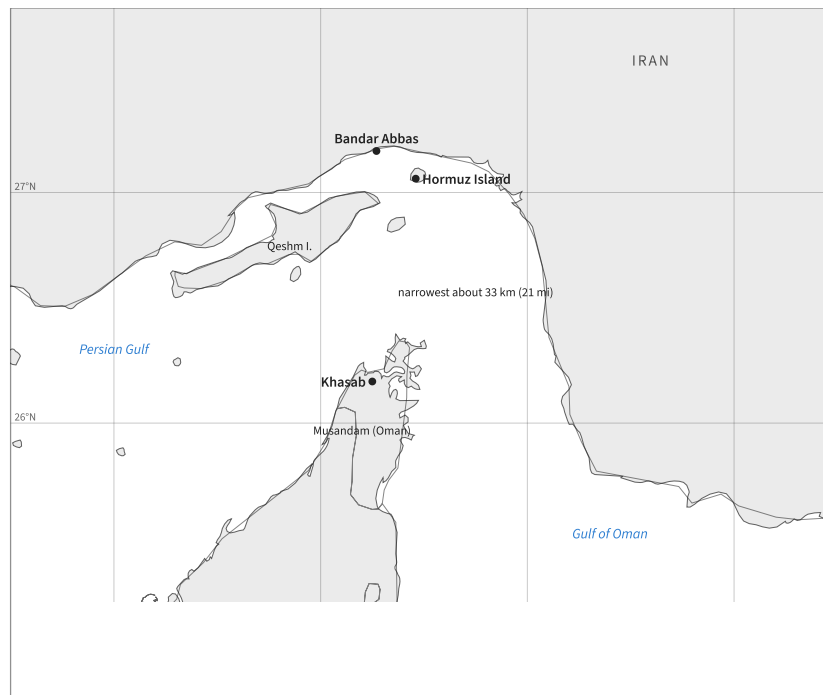
Faith and history. Christianity came to the Gulf long before oil. Archaeologists found the ruins of a Church of the East monastery from about the 600s and 700s AD on Sir Bani Yas Island in the United Arab Emirates in 1992. In 1889 the American missionaries James Cantine and Samuel Zwemer founded the Arabian Mission, and its hospital in Bahrain, opened in 1903, still serves patients today. As of 2026, Islam is the faith of most citizens of the Gulf states: Sunni Islam in most of them, and Shia Islam in Iran and among most citizens of Iraq and Bahrain. Large numbers of Christian workers from India, the Philippines and many other lands worship in churches in the smaller Gulf states.



Rivers, deserts, oil fields and sea gates of the Middle East and North Africa.



An anticline trap. Oil rises through porous rock and collects beneath the cap rock at the top of the dome.



The Strait of Hormuz, the only sea exit from the Persian Gulf.

PICTURE STUDY



*Persici sive Sophorum Regni Typus (Map of the Kingdom of Persia), Abraham Ortelius, 1570 · Copperplate engraving, often hand-colored, from the atlas *Theatrum Orbis Terrarum* (Antwerp) · Copies of the *Theatrum Orbis Terrarum* are held by the Library of Congress and many other libraries*

Abraham Ortelius of Antwerp published the *Theatrum Orbis Terrarum*, the “Theater of the World,” in 1570. It is often called the first modern atlas, because for the first time maps of the whole world were drawn in the same style, bound in one book and sold to the public. This map shows the Persia of the Safavid shahs, whom Europeans called the “Sophi.”

In 1570 no one cared about oil. The prize in the Gulf was the island port of Hormuz at its narrow mouth, which ruled the trade in pearls, horses, silk and spices. The Portuguese captain Afonso de Albuquerque seized it in the early 1500s, and in 1622 a Persian army with English ships drove the Portuguese out. Shah Abbas I then built a new port on the mainland nearby, still called Bandar Abbas. The strait mattered long before the first oil well.

Look closely

- Find the Persian Gulf and follow it to its narrow entrance. Look for the small island of Hormuz, spelled “Ormuz” on many old maps.
- Find the two great rivers flowing into the head of the Gulf. Which rivers are they?
- Find the Caspian Sea. How does its shape compare with a modern map?
- Look at how the mountains are drawn. Which part of Persia looks most mountainous?

Talk about it

1. Why would a strait be valuable to control even in an age of sailing ships, before oil?
2. What parts of this map do you think Ortelius knew well, and what parts may have been guesses? How can you tell?
3. How has the reason the Strait of Hormuz matters changed between 1570 and today, and how has it stayed the same?

PROJECT: CHOKER POINT: A STRAIT OF HORMUZ TRAFFIC MODEL

You will make a scale model of the narrowest part of the Strait of Hormuz with its shipping lanes, then run tankers through it and measure how much oil passes. You will see why such a narrow place matters to the whole world.

You will need

- A large piece of cardboard or poster board
- Ruler, pencil, blue and brown markers
- Twenty bottle caps, coins or small blocks as tankers (mark each “2 million barrels”)
- A timer and a notebook for a tally sheet

Steps

1. Use the scale 1 cm = 2 km. The strait is about 33 km wide at its narrowest, so draw two coastlines about 16.5 cm apart. Label the northern coast Iran and the southern coast Oman (Musandam). Label the west end Persian Gulf and the east end Gulf of Oman.
2. Draw the traffic scheme in the middle of the water: an outbound lane about 3.2 km wide (1.6 cm), a buffer zone about 3.2 km wide (1.6 cm) and an inbound lane about 3.2 km wide (1.6 cm). Color the lanes lightly and the buffer zone with stripes.
3. Play one “day”: in 60 seconds, move as many loaded tankers as you safely can through the outbound lane, one at a time and never touching. Count them and multiply by 2 million barrels.

4. Now close the outbound lane for repairs and send loaded tankers out through the inbound lane, taking turns with empty tankers coming in. Play another 60-second day and compare.
5. Record your results in a table: day, tankers out, barrels out. Write two sentences about what happened when one lane closed.
6. Add a dotted line from the west end of your board labeled “pipeline bypass” and discuss with a parent why pipelines can help but cannot replace the strait.

Tips

- Real tankers are huge and slow. A very large crude carrier is about as long as three football fields and takes kilometers to stop, which is why lanes and buffer zones are needed.
- Keep the model factual. The goal is to understand trade and geography, not to take sides in any dispute.

Check your work

- I can show the Strait of Hormuz, the countries on each side and the bodies of water it connects.
- I can calculate how many barrels pass when I know the number of tankers.
- I can explain what a choke point is and why one narrow place affects countries far away.

MAP NOTEBOOK

1. On your regional map, mark the major oil fields with small black drops: Ghawar, Burgan, Rumaila, Kirkuk, Masjed Soleyman, Hassi Messaoud and the Sirte Basin. Draw the Strait of Hormuz, the Bab-el-Mandeb and the Suez Canal in red.
2. Copy the anticline oil trap diagram and label the cap rock, reservoir rock, oil, salt water and the well.
3. Draw the routes a tanker would take from Ras Tanura in Saudi Arabia (a) to Japan and (b) to Europe through the Suez Canal. Name every strait or canal it passes.

From history. For centuries the most valuable thing in the Gulf was not oil but pearls. Divers from Bahrain, Kuwait, Qatar and the coast of what is now the United Arab Emirates went down holding their breath, again and again, to gather oysters from the shallow sea floor. In the 1920s and 1930s the pearl trade collapsed, as cultured pearls from Japan came on the market and the Great Depression cut demand. Then, in 1932, oil was struck in Bahrain, the first discovery on the Arab side of the Gulf, and in March 1938 the American geologists of the company that became Aramco brought in Dammam No. 7, Saudi Arabia’s first commercial well, after six earlier wells had disappointed. It produced for decades and became known as the Prosperity Well.

WORKED EXAMPLES

Example 1. In 2023 about 20 million barrels of oil a day passed through the Strait of Hormuz. A barrel holds 42 U.S. gallons, or about 159 liters. How many liters and how many gallons is that each day?

1. Liters: $20,000,000 \times 159 = 3,180,000,000$ liters, about 3.2 billion liters.
2. Gallons: $20,000,000 \times 42 = 840,000,000$ gallons, about 840 million U.S. gallons.

Answer: About 3.2 billion liters (840 million U.S. gallons) every day.

Example 2. A very large crude carrier (VLCC) holds about 2 million barrels. How many full VLCC loads would carry 20 million barrels a day? How many loads would that be in a year of 365 days?

1. Loads per day: $20,000,000 \div 2,000,000 = 10$.
2. Loads per year: $10 \times 365 = 3,650$.

Answer: About 10 VLCC loads a day, or about 3,650 a year. (Real traffic includes many smaller tankers too, so the actual number of ships is larger.)

Example 3. The Strait of Hormuz is about 21 mi (33 km) wide at its narrowest. The shipping scheme uses an inbound lane 2 mi wide, an outbound lane 2 mi wide and a 2 mi buffer between them. How wide is the whole scheme in miles and kilometers, and what fraction of the strait's width does it use?

(Use the map or drawing "The strait is narrow, and the shipping lanes are narrower still." shown earlier in this lesson.)

1. Total width: $2 + 2 + 2 = 6$ mi.
2. Convert: $6 \text{ mi} \times 1.61 \approx 9.7 \text{ km}$.
3. Fraction: $6 \div 21 \approx 0.29$, about 29%, a little less than one-third.

Answer: About 6 mi (9.7 km), roughly 29% of the strait's narrowest width. All that oil moves through lanes only about 3 km (2 mi) wide each way.

PRACTICE

1. **EASY** Which two countries lie on either side of the Strait of Hormuz, and which two bodies of water does it connect?
2. **EASY** What is a choke point? Name three in this region.
3. **EASY** Why does oil collect at the top of a dome of rock instead of spreading evenly?

4. **MEDIUM** A barrel holds 42 U.S. gallons. One U.S. gallon is about 3.785 liters. Show that a barrel holds about 159 liters.
5. **MEDIUM** Use the map. Which marked oil field is farthest north? In which countries are Ghawar, Burgan and Hassi Messaoud?
(Use the map or drawing "Find the oil fields and read their latitudes." shown earlier in this lesson.)
6. **MEDIUM** The Ghawar field is about 280 km long. Convert to miles. About how many times longer is it than the Strait of Hormuz is wide (33 km)?
7. **MEDIUM** A tanker sails from Ras Tanura in Saudi Arabia to the Strait of Hormuz, about 600 km, at 26 km/h (about 14 knots). About how many hours does it take? How far is 600 km in miles?
8. **HARD** In 2023 the world used about 100 million barrels of oil a day, and about 20 million barrels a day passed through the Strait of Hormuz. What percent of the world's daily oil use is that?
9. **HARD** Suppose bypass pipelines could carry 6 million barrels a day around the strait, and 20 million barrels a day normally pass through it. If the strait were closed, how many barrels a day could not be moved, and what fraction is that?
10. **CHALLENGE** In a short paragraph, explain why a strait only about 33 km wide matters to families in countries thousands of kilometers away. Keep your answer factual and do not take sides in any conflict.

COMMON MISTAKES

- Picturing oil in underground lakes or caves. Oil fills the tiny pores of rock, like water in a hard sponge, and must flow through the rock to a well.
- Thinking every country in the region is rich in oil. Some, such as Jordan and Lebanon, have little, while a few countries around the Persian Gulf hold most of the reserves.
- Thinking the Strait of Hormuz mainly serves one distant country. Its oil and gas go to many buyers, especially in Asia, and because oil is traded worldwide, its price affects everyone.

Make it a game · Tanker Captain. Lay out a floor map with tape: a Gulf, a narrow strait, the Gulf of Oman, a long path to Asia and another to the Red Sea, the Bab-el-Mandeb and Suez. The player is a tanker captain at Ras Tanura. A parent draws cards: "Fog in the strait: wait one turn," "Lane open: move two spaces," "Name the country to your north to pass," "Convert 2 million barrels to liters to load," "Name the canal ahead to pass." The captain must answer a geography question correctly to move at each choke point. First to deliver a cargo to Yokohama or Rotterdam wins.

Scripture. "And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;" (Acts 17:26, KJV)

Paul told the people of Athens that God made all nations and set their times and places. Where oil lies and where the straits run are not accidents to Him. The nations of the Gulf and

the nations that buy their oil are one human family, made of one blood, and are called to deal with one another in justice and peace.

Practice answers

1. Iran (north) and Oman's Musandam Peninsula (south). It connects the Persian Gulf and the Gulf of Oman (which opens to the Arabian Sea).
2. A narrow passage on a major sea route through which much traffic must pass. Examples: the Strait of Hormuz, the Bab-el-Mandeb and the Suez Canal (also the Bosphorus to the north).
3. Oil is lighter than water, so it rises through the pores of the reservoir rock until a cap rock stops it. Under a dome, the highest point is at the top, so the oil gathers there above the water.
4. $42 \times 3.785 = 158.97$, about 159 liters.
5. Kirkuk (about 35.5°N , in Iraq) is farthest north. Ghawar is in Saudi Arabia, Burgan in Kuwait and Hassi Messaoud in Algeria.
6. $280 \times 0.621 \approx 174$ mi (about 170 mi). $280 \div 33 \approx 8.5$ times.
7. $600 \div 26 \approx 23$ hours, about one day. $600 \times 0.621 \approx 373$ mi.
8. $20 \div 100 = 0.20$, so about 20%, or one-fifth.
9. $20 - 6 = 14$ million barrels a day could not be moved. $14 \div 20 = 0.7$, so 70%, or seven-tenths.
10. Sample answer: The Persian Gulf has only one exit to the ocean, so the oil and gas of Saudi Arabia, Iraq, Kuwait, Iran, the United Arab Emirates and Qatar must pass through the Strait of Hormuz, about one-fifth of the world's oil use in 2023. Most of it goes to Asia, but oil is traded worldwide, so if traffic slowed or stopped, prices for fuel, shipping and many goods could rise for families everywhere. Pipelines can carry only part of the flow, so the strait is a true choke point.

UNIT 3 REVIEW

Answer each question. Show your work for calculations, give both metric and U.S. units where asked, and use complete sentences for explanations. Keep answers about current events factual and neutral. The review is worth 60 points.

1. (6 pts) Name the two rivers of Mesopotamia and tell which is longer and which runs farther east. What does “Mesopotamia” mean, and what is the river called after the two join?
2. (6 pts) On a map with the scale 1 cm = 150 km, the straight line from Nineveh to Babylon measures 2.9 cm. How far apart are they in kilometers and in miles?
3. (6 pts) Explain how a food surplus led to cities in Mesopotamia, and give two things the people had to trade for because the plain lacked them.
4. (6 pts) Name the parts of a qanat from the hills to the village and give two reasons a qanat works well in a desert.
5. (6 pts) A qanat tunnel is 9.6 km long and drops 1 m for every 1,200 m. How much does it drop in meters and feet? If it has an access shaft every 40 m, how many shafts does it have?
6. (6 pts) Give two physical reasons why North Africa, Arabia and the plateau of Iran are so dry. Then explain what an oasis is.
7. (6 pts) Jerusalem stands about 760 m above sea level, and the shore of the Dead Sea about 430 m below sea level. What is the difference in elevation in meters and feet? Why is the Dead Sea so salty?
8. (6 pts) Describe the four north-south strips of the land of Israel from west to east, and explain one way its position as a land bridge shaped its history.
9. (6 pts) Explain how oil is trapped underground in an anticline. Use the words reservoir rock and cap rock.
10. (6 pts) Which two countries border the Strait of Hormuz? If 18 million barrels of oil a day passed through it, how many liters would that be (1 barrel $\approx$ 159 L), and what percent of a world total of 100 million barrels a day?

UNIT PROJECT: ATLAS PAGE: RIVERS, DESERTS AND OIL OF THE MIDDLE EAST AND NORTH AFRICA

Make a two-page spread for your regional atlas. On the first page, draw and color a map of the region from Morocco to Iran showing the Nile, Tigris, Euphrates and Jordan Rivers; the Sahara, Arabian, Syrian and Iranian deserts; at least six major oil fields; and the Strait of Hormuz, the Bab-el-Mandeb and the Suez Canal. Mark Ur, Babylon, Jerusalem, Cairo and one qanat region, and include a key, a compass rose and a scale bar in both kilometers and miles.

On the second page, add a photo or drawing of your model qanat with its parts labeled, your Jerusalem-to-Dead-Sea elevation profile, and a paragraph explaining how water and oil have

each shaped the history, faith and trade of the region. End the unit with a short map quiz on the places you labeled.

- **Accuracy:** Rivers, deserts, oil fields, cities and straits are placed correctly and labeled clearly, with a working key and a scale bar in both units.
- **Model and profile:** The qanat model (or its photo or drawing) shows a mother well, shafts, a gently sloping tunnel and an outlet, and the elevation profile uses correct rounded heights.
- **Explanation:** The paragraph explains clearly how water and oil shaped where people live, farm, worship and trade, and treats current events factually and neutrally.
- **Care:** The atlas pages are neat, colorful, easy to read and finished on time.

Answer key

1. The Euphrates and the Tigris. The Euphrates is longer (about 2,800 km / 1,740 mi); the Tigris runs farther east, nearer the Zagros Mountains. Mesopotamia means “between the rivers.” After they join they form the Shatt al-Arab, which flows to the Persian Gulf.
2. $2.9 \times 150 = 435$ km. $435 \times 0.621 \approx 270$ mi.
3. Irrigated fields on the fertile silt grew more grain than the farmers needed. The surplus could feed craftsmen, priests, soldiers, scribes and traders, so cities like Ur and Babylon grew. The plain lacked stone, timber and metal, so people traded for things such as cedar wood, copper, tin and lapis lazuli (any two).
4. Mother well, access shafts, gently sloping tunnel, outlet near the fields. Reasons: gravity moves the water with no pumps or fuel; the water travels underground, so little evaporates; blowing sand cannot fill it; it taps groundwater that is out of reach at the surface (any two).
5. 9.6 km = $9,600$ m. $9,600 \div 1,200 = 8$ m drop; $8 \times 3.28 \approx 26$ ft. Shafts: $9,600 \div 40 = 240$.
6. (1) Between about 20° and 30° north, dry air sinks and warms, so clouds and rain rarely form. (2) Mountains such as the Zagros and Elburz create rain shadows on their inland sides. An oasis is a fertile place in a desert where groundwater reaches or comes near the surface through springs or wells, so palms and crops can grow.
7. $760 + 430 = 1,190$ m; $1,190 \times 3.28 \approx 3,900$ ft. The Dead Sea has no outlet: water leaves only by evaporation and leaves its salts behind, so the water is nearly ten times saltier than the ocean.
8. Coastal plain, central hills (with Jerusalem), Jordan Rift Valley (Sea of Galilee, Jordan River, Dead Sea), and the plateau east of the Jordan. With the sea on one side and the desert on the other, the roads between Egypt and Mesopotamia had to cross this land, so empires such as Egypt, Assyria, Babylon, Persia and Rome fought to control it, and from this crossroads the gospel spread outward from Jerusalem.
9. Oil and gas form deep in buried layers and, being lighter than water, rise through the pores of the reservoir rock (porous sandstone or limestone). Where the layers bend up into a dome (anticline), a tight cap rock of salt or shale above stops the oil, so it collects at the top of the dome above the water, where a well can reach it.
10. Iran and Oman. $18,000,000 \times 159 = 2,862,000,000$ liters, about 2.9 billion liters a day. $18 \div 100 = 18\%$.

SUB-SAHARAN AFRICA

South of the Sahara lies a land of high plateaus, thundering waterfalls, endless grasslands and the second-largest rain forest on earth. Africa is huge: about 30 million km² (11.7 million square miles), larger than the United States, China and India put together. In this unit you will study it the way we study every region: first the land and its rivers, then the climate, and then how that geography shaped the history, peoples, faith, farming and trade of the lands God set there. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation” (Acts 17:26).

You will paddle with David Livingstone to Victoria Falls and see his steamer stopped by the Kebrabasa rapids, and learn why Africa’s mighty rivers are so hard to sail upstream. You will cross the Sahara with Heinrich Barth into the Sahel, the savanna and the forest, and discover why Africa is striped with bands of climate. You will follow Mansa Musa’s gold to Cairo, sail the monsoon to the Swahili coast, climb to the stone walls of Great Zimbabwe, and meet Africa’s ancient churches in Ethiopia and Nubia. Last, you will see engineers lay the Uganda Railway through lion country to Lake Victoria and build the Kariba Dam across the Zambezi, turning the drop of the same river that once stopped Livingstone’s steamer into power.

Throughout, we will tell the story honestly: the courage of explorers and missionaries, the skill of African builders and traders, and the real wrongs of the slave trades, of colonial rule and of people moved from their land. As of 2026, Sub-Saharan Africa is home to more than a billion people in more than forty countries, and it is one of the places where the Christian church has grown fastest in the last century.

BEFORE YOU BEGIN

- Can find the equator, the tropics and lines of latitude and longitude on a map
- Can use a map scale and convert between kilometers and miles
- Can compute speed, distance and time (distance = speed × time)
- Remembers from Unit 3 how deserts, oases and caravans work

MASTERY CHECKLIST

- I can describe Africa as a high plateau with a narrow coastal plain and explain why its rivers have falls and rapids near the sea.
- I can name and locate Africa’s great rivers, lakes and climate bands, and explain how the moving rain belt creates the bands.
- I can tell the stories of Ghana, Mali, Great Zimbabwe and the Swahili coast and explain how the Sahel and the monsoon made their trade possible.
- I can describe accurately the spread of Islam along the trade routes and the long history of Christianity in Africa, and I can name the slave trades honestly.

- I can explain how the Uganda Railway and the Kariba Dam overcame Africa's geography and weigh their benefits and costs.
- I can solve problems with map scale, gradients, latitude distances, travel times and sun angles using real African places.

OPTIONAL BOOKS AND RESOURCES

- **David Livingstone, *Missionary Travels and Researches in South Africa* (free at Project Gutenberg)** (<https://www.gutenberg.org/ebooks/search/?query=Livingstone+Missionary+Travels>): Free. A parent may choose passages to read aloud, such as Livingstone's description of first seeing Victoria Falls in November 1855 (Lesson 4.1). Some language and attitudes reflect the 1850s; discuss them as you read.
- **J. H. Patterson, *The Man-Eaters of Tsavo* (free at Project Gutenberg)** (<https://www.gutenberg.org/ebooks/search/?query=Man-Eaters+of+Tsavo>): Free. Patterson's own account of building the Uganda Railway bridge at Tsavo in 1898 (Lesson 4.4). Some chapters are frightening; preview before reading aloud.
- **NASA Earth Observatory** (<https://earthobservatory.nasa.gov/>): Free satellite images. Search for Lake Kariba, the Congo River, the Sahel and Victoria Falls to see the climate bands and rivers of this unit from space.

4.1 PLATEAUS AND WATERFALLS ★

OBJECTIVES

- Tell how David Livingstone's hope of sailing up the Zambezi River was stopped by the Kebrabasa rapids in 1858, and why the falls he had seen in 1855 were a sign of the same problem.
- Describe Africa as a high plateau with a narrow coastal plain, and explain why its great rivers fall over rapids and waterfalls near the sea.
- Read a river profile and a map to find where boats must stop on the Congo, and compute the average drop of a stretch of rapids.

Warm-up. Stack three or four books to make a flat-topped “table” and set it near the edge of a baking sheet. Lay a strip of aluminum foil from the top of the books, across the flat top, then sharply down the edge to the baking sheet. Slowly pour a cup of water onto the far end of the top. Where does the water move slowly? Where does it rush? Now float a bottle cap at the bottom and try to push it back up the foil. Where would a real boat have to stop?

Watch. *Earth's Landforms – Plateaus and Canyons* (Next Generation Science, 2:19).

<https://www.youtube.com/watch?v=DHwXKgB3xTY>

With the big idea: watch how a plateau rises sharply above the land around it and how rivers cut deep gorges, then compare it with the gorge at Victoria Falls.

Note: Captions were not available to check; preview it first. The description says canyons usually take millions of years to form and that the Grand Canyon took five to six million years; the lesson describes erosion without giving an age. It uses the Tibetan Plateau, Grand Canyon and Colca Canyon as examples rather than the African plateau or Victoria Falls.

KEY TERMS

plateau

A large area of high, fairly flat land. Much of Africa is a plateau that stands hundreds of meters above the sea.

escarpment

A long, steep slope or cliff at the edge of a plateau. Rivers that cross an escarpment drop in rapids and falls.

cataract

A stretch of rapids or a large waterfall on a river, such as the six cataracts of the Nile.

navigable

Deep and calm enough for boats or ships to travel on.

head of navigation

The farthest point upstream that ships can reach before falls or shallow water stop them.

portage

Carrying boats and cargo over land around rapids or falls.

CORE IDEAS

The story. In November 1855 the Scottish missionary David Livingstone was paddled down the upper Zambezi River in a canoe to see a wonder the local people called *Mosi-oa-Tunya*, “the smoke that thunders.” Columns of spray rose from a crack in the earth, and the whole river, more than 1.6 km (1 mile) wide, plunged into a narrow gorge about 108 m (354 ft) deep. Livingstone named it Victoria Falls after his queen and wrote that scenes so lovely must have been gazed upon by angels in their flight. He hoped the Zambezi would become a highway for the gospel and for honest trade, which would replace the slave trade in the heart of Africa. In 1858 he came back with a British expedition and a small steam launch, the *Ma Robert*, to sail up the river from the Indian Ocean. Far upstream, at a gorge called Kebrabasa, the river squeezed between rocks into foaming rapids. The steamer could not pass. Livingstone’s highway had a wall across it.

How it works. Kebrabasa and Victoria Falls are not accidents. They come from the shape of the continent itself. Geographers often describe Africa as a great **plateau**, a raised table of old, hard rock. The south and east, sometimes called “High Africa,” mostly stand more than 1,000 m (3,300 ft) above the sea. The north and west, “Low Africa,” are lower, but they are still raised above a narrow strip of coastal plain. Around much of the edge, the land drops steeply in an **escarpment**. A river can wander slowly across the high table for hundreds of miles. Then, as it nears the sea, it must fall off the edge, and there it tumbles over **cataracts**, rapids and falls.

The big idea. In much of Europe and North America, ships could sail far inland on deep rivers. In Africa, the falls usually lie close to the coast, so the **head of navigation** is only a short way from the sea. The Congo River is the clearest example. It carries more water than any river in the world except the Amazon, yet ocean ships can go only about 150 km (95 miles) upstream, to the port of Matadi. Above Matadi comes a chain of more than thirty rapids, the Livingstone Falls, where the river drops about 270 m (880 ft) in roughly 350 km (220 miles). Above the falls lies Malebo Pool, where the cities of Kinshasa and Brazzaville face each other. From there, river steamers can travel about 1,700 km (1,050 miles) upstream to Kisangani, where the Boyoma Falls block the way again. The Nile has its six cataracts in Sudan and Egypt, and the Niger has rapids too: the Scottish explorer Mungo Park drowned at the Bussa rapids in 1806. Add a smooth coastline with few deep bays and natural harbors, and you can see why outsiders found Africa’s interior so hard to reach. For nearly four hundred years after the Portuguese first sailed down its coast in the 1400s, most European traders stayed in forts by the sea. Falls and rapids were one reason; deadly diseases like malaria were another.

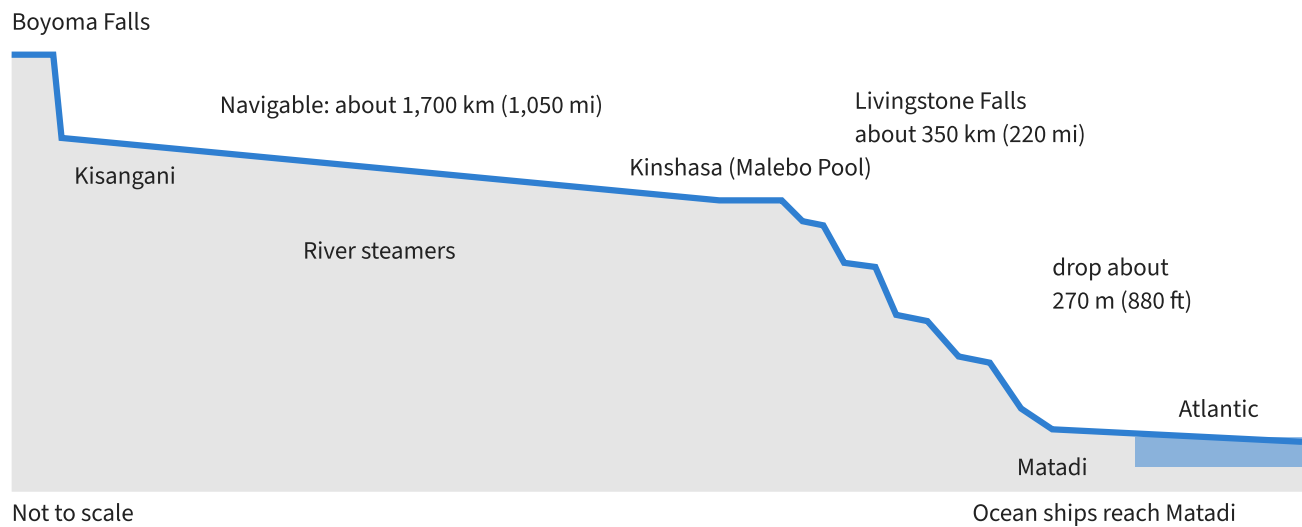
On the map. Look at the eastern side of the continent and you will see long, narrow lakes in a line. They fill the **Great Rift Valley**, where the earth’s crust has cracked and sunk between high walls. Lake Tanganyika is the deepest lake in Africa, about 1,470 m (4,820 ft) deep. Nearby stand volcanoes like Mount Kilimanjaro, Africa’s highest mountain at 5,895 m

(19,341 ft). Lake Victoria, the largest lake in Africa, lies on the plateau at about 1,134 m (3,720 ft) and feeds the White Nile, which flows north for thousands of miles to the Mediterranean. The Congo is the only great river that crosses the equator twice, curving north and then south across its basin before it breaks through the plateau's western edge to the Atlantic.

Technology overcoming geography. If boats cannot climb the falls, carry them around. In the 1880s, the Baptist missionary George Grenfell had a small steamer, the *Peace*, carried around the Livingstone Falls in hundreds of loads and rebuilt at Malebo Pool, then used it to explore the upper Congo and its branches. Between 1890 and 1898, a railway was built from Matadi to Kinshasa to go around the falls for good. It was built in the Congo Free State of King Leopold II of Belgium, whose rule became notorious for forced labor and cruelty, and many workers died in its construction. Today the same drop that stopped the boats is put to work: the Inga dams, opened in 1972 and 1982, turn the falling water of the lower Congo into electricity. The psalmist knew the roar of great waters, and knew Who is greater: "The LORD on high is mightier than the noise of many waters."



Africa's great rivers and some of the falls and rapids that block them.



A profile of the Congo River (not to scale). Ocean ships stop at Matadi; river steamers run between Kinshasa and Kisangani.

PICTURE STUDY



Great Western (or Main) Fall, from Three Rill Cliff to Garden Island, from The Victoria Falls, Zambesi River, Thomas Baines, Sketched in 1862; published by Day & Son, London, October 4, 1865 · Tinted lithographs made from the artist's sketches and oil paintings · Copies in the Royal Geographical Society, London, and other libraries; Baines's oil paintings of the falls are in collections in Britain, Zimbabwe and South Africa

Thomas Baines was an English artist and explorer who spent most of his life in southern Africa. He sailed with Livingstone's Zambezi Expedition in 1858 as its artist and storekeeper, but Livingstone dismissed him in 1859, a decision many historians now think was unfair. In 1862 Baines traveled overland with the trader and hunter James Chapman and reached

Victoria Falls, where he sketched and painted for days, trying to show the falls from every side.

Back in London, his pictures were printed as a set of lithographs so that people who would never see Africa could imagine the falls. Baines was careful about what he saw: the rock walls, the islands on the lip of the falls and the gorge below. His pictures helped people in Europe understand that Africa's rivers do not glide gently to the sea.

Look closely

- Find the lip of the falls, where the river goes over the edge. How wide does the river look compared to the gorge it falls into?
- Find the spray. Why might local people have called this place “the smoke that thunders”?
- Look for people, trees or animals in the picture. How do they help you feel the size of the falls?
- Look at the gorge below the falls. Could any boat go up or down this river here?

Talk about it

1. What does this picture tell you about the land above the falls and the land below them?
2. Baines had no camera. What are the strengths and weaknesses of a painting as a record of a place?
3. Why do you think Livingstone, who wanted a river highway, might have felt both wonder and disappointment at this sight?

PROJECT: RAPIDS-AND-FALLS RIVER MODEL: WHY THE BOATS STOP

You will build a model river that flows across a high, flat plateau and then falls off its edge to the sea, just like the Congo or the Zambezi. Then you will test little boats on it to find the head of navigation, and you will design a way around the falls.

You will need

- A long plastic storage bin, baking pan or a section of rain gutter (outdoors or in a bathtub is best)
- Books, bricks or a box to make the plateau
- Heavy aluminum foil or a plastic sheet
- Pebbles, gravel and a few larger stones for rapids
- A pitcher or watering can, and a bucket to catch the water
- Bottle caps, corks or small foil boats
- A ruler, marker and masking tape; toy blocks or cardboard for a “railway”

Steps

1. Build the land: make a high, flat plateau about 15 to 20 cm (6 to 8 in) tall at one end of your pan, then a steep drop (the escarpment), then a short flat “coastal plain” and the

“sea” at the other end.

2. Cover the whole thing with foil, pressing a river channel into it. Make the channel wander gently across the plateau, then go straight down the escarpment.
3. On the escarpment, glue or press pebbles and stones into the channel to make rapids. Leave one place where the water drops straight down as a waterfall.
4. Pour water slowly onto the high end. Watch where it moves slowly and where it rushes. Mark with tape the places where the water becomes white and fast.
5. Float your boats. Start one at the sea and try to move it upstream with a straw or by blowing. Start another on the plateau and let it float downstream. Mark the head of navigation where boats from the sea must stop.
6. Label your model with Congo names: Atlantic Ocean, Matadi, Livingstone Falls, Malebo Pool (Kinshasa), the long navigable river, and Boyoma Falls (Kisangani).
7. Solve the problem: build a portage path or a little railway of blocks beside the falls, from the head of navigation to the calm water above. Move a boat around the falls by hand on your railway.
8. Write a short report: Where did the boats stop, why, and how did people in history get around the falls?

Tips

- A steeper escarpment makes faster water. Try changing the height of the books and see what happens to the rapids.
- Pour slowly and steadily. A small, steady stream behaves more like a real river than a sudden flood.
- Take a photo of your finished model for your atlas portfolio.

Check your work

- I can point to the plateau, the escarpment and the coastal plain on my model.
- I can show where boats coming from the sea must stop and explain why.
- I can explain how a portage or a railway gets around the falls.

MAP NOTEBOOK

1. Draw a simple outline map of Africa and trace the Nile, Niger, Congo and Zambezi. Mark Victoria Falls, Livingstone Falls and the Nile cataracts with small zigzags.
2. Draw a side view of Africa from the Atlantic to the Indian Ocean: narrow coastal plain, escarpment, high plateau, Rift Valley with lakes, and the drop to the eastern coast. Label each part.
3. Copy the Congo River profile and write the head of navigation and the length of each navigable stretch beside it.

From history. Livingstone’s first great journey (1853–1856) took him from the upper Zambezi west to Luanda on the Atlantic and then east along the Zambezi to Quelimane on the Indian Ocean, making him one of the first Europeans known to cross southern Africa

from coast to coast. His book *Missionary Travels and Researches in South Africa* (1857) sold tens of thousands of copies and stirred many people in Britain to support missions and the fight against the slave trade.

WORKED EXAMPLES

Example 1. The Livingstone Falls drop about 270 m (880 ft) over about 350 km (220 miles) of river. What is the average drop per kilometer, and per mile? How does a single plunge like Victoria Falls (108 m) compare?

(Use the map or drawing “The Livingstone Falls are the steps between Malebo Pool and Matadi.” shown earlier in this lesson.)

1. Average drop = total drop $\div$ distance.
2. In metric: $270 \text{ m} \div 350 \text{ km} \approx 0.77 \text{ m per km}$.
3. In customary units: $880 \text{ ft} \div 220 \text{ miles} = 4 \text{ ft per mile}$.
4. Compare: $108 \text{ m} \div 270 \text{ m} = 0.40$, so Victoria Falls drops in one leap about 40 percent as much as the whole 350 km chain of the Livingstone Falls.

Answer: About 0.77 m per km (4 ft per mile) on average; Victoria Falls drops about 40 percent of that whole amount in a single fall. But an average hides the danger: the real river drops in steps, with calm stretches and violent rapids.

Example 2. On a map with a scale of 1 cm = 50 km, the straight line from Kinshasa to Matadi measures 5.3 cm. How far apart are the two cities in a straight line, in km and miles? The river between them is about 350 km long. How much longer is the river path?

1. Straight-line distance = $5.3 \text{ cm} \times 50 \text{ km per cm} = 265 \text{ km}$.
2. Convert: $265 \text{ km} \times 0.621 \approx 165 \text{ miles}$.
3. River path $\div$ straight line = $350 \div 265 \approx 1.3$.
4. So the river winds about 1.3 times as far as a crow would fly, about 85 km (53 miles) more.

Answer: About 265 km (165 miles) in a straight line; the river is about 1.3 times as long, roughly 85 km (53 miles) longer.

Example 3. Before the railway, cargo going around the Livingstone Falls was carried by porters. Suppose a porter caravan covers 20 km (12 miles) a day on the roughly 370 km (230 mile) route around the falls. A train averaging 25 km/h (15.5 mph) covers the same route. How long does each take?

1. Porters: $370 \text{ km} \div 20 \text{ km per day} = 18.5 \text{ days}$, so about 19 days of walking (and more with rest days).
2. Train: $370 \text{ km} \div 25 \text{ km/h} = 14.8 \text{ hours}$, so about 15 hours.
3. Compare: $18.5 \text{ days} \times 24 \text{ hours} = 444 \text{ hours}$; $444 \div 14.8 = 30$.

Answer: About 19 days on foot versus about 15 hours by train, roughly 30 times faster. That is why the Matadi-Kinshasa railway (1898) made the whole middle Congo reachable from the sea.

PRACTICE

1. **EASY** What is a cataract on a river?
2. **EASY** What did the local people call Victoria Falls, and what does the name mean?
3. **EASY** Victoria Falls is about 108 m high. Convert this to feet ($1 \text{ m} \approx 3.28 \text{ ft}$).
4. **EASY** Name the port that is the head of navigation for ocean ships on the Congo River.
5. **MEDIUM** Use the Congo profile figure. A boat starts at the Atlantic and wants to reach Kisangani. Name the two places where its cargo must leave the water or change boats, and why.
(Use the map or drawing "Use the profile to find where boats must stop." shown earlier in this lesson.)
6. **MEDIUM** Mount Kilimanjaro is 5,895 m high. Convert to feet ($1 \text{ m} \approx 3.281 \text{ ft}$).
7. **MEDIUM** What is the difference between "High Africa" and "Low Africa"?
8. **HARD** A model river drops 600 m on its way to the sea: 100 m over its first 1,500 km across a plateau, and 500 m over the last 200 km. Find the average drop per km in each part. Where would boats be stopped?
9. **HARD** In two or three sentences, explain why Africa's great rivers did not give outsiders an easy road into the interior, as the Mississippi or the Rhine did.
10. **CHALLENGE** Henry Morton Stanley crossed Africa from the east coast (1874–1877) and followed the Congo downstream to the Atlantic rather than trying to sail up it from the mouth. Use the river profile to explain why that route made sense, and what problem he still faced at the end.

COMMON MISTAKES

- Thinking a huge river must be easy to sail. The Congo carries enormous amounts of water, but its falls make it useless for ocean ships beyond Matadi.
- Imagining Africa's interior as low land. Most of it is a raised plateau, which is exactly why rivers drop near the coast.

- Using only the average drop. A river that drops 0.77 m per km on average can still have calm pools and deadly rapids; boats are stopped by the steepest steps, not the average.

Make it a game · Head of Navigation. One player names a river (Congo, Nile, Niger, Zambezi, Mississippi, Rhine, Amazon). The other must say whether ocean ships can travel far up it, and name one place where boats are stopped or one port far inland. A correct answer with a real place name scores 2 points; a correct yes or no without a place scores 1. Switch roles and play to 10 points.

Scripture. “The LORD on high is mightier than the noise of many waters, yea, than the mighty waves of the sea.” (Psalm 93:4, KJV)

Victoria Falls can be heard from far away and its spray seen from many miles off. The God who made the plateau and the falls is greater still, and the explorers who met these barriers had to learn patience and trust.

Practice answers

1. A stretch of rapids or a large waterfall, such as the cataracts of the Nile.
2. Mosi-oa-Tunya, “the smoke that thunders.”
3. $108 \times 3.28 \approx 354$ ft.
4. Matadi, about 150 km (95 miles) from the sea.
5. At Matadi, because the Livingstone Falls block the way to Malebo Pool (cargo goes by railway to Kinshasa); then at Kinshasa it is loaded onto a river steamer that can reach Kisangani, where the Boyoma Falls stop boats again.
6. $5,895 \times 3.281 \approx 19,341$ ft.
7. High Africa, in the south and east, mostly stands more than 1,000 m (3,300 ft) above sea level; Low Africa, in the north and west, is lower, though it is still raised above a narrow coastal plain.
8. Plateau: $100 \div 1,500 \approx 0.07$ m per km. Last part: $500 \div 200 = 2.5$ m per km, about 37 times steeper. Boats from the sea would be stopped near the coast, where the river falls off the plateau; on the plateau they could travel far.
9. Africa is a high plateau with a narrow coastal plain, so its rivers fall over rapids and falls close to the sea, and ships cannot get far upstream. The coast is also smooth, with few natural harbors. Together with diseases like malaria, this kept most outside traders on the coast for centuries.
10. Coming from the mouth, the Livingstone Falls stop boats only about 150 km from the sea, so no one could sail up. Starting inland, Stanley could float down the long navigable middle river (once past Boyoma Falls). But at the end he still had to fight his way down through the Livingstone Falls, which took months and cost lives, before reaching the sea.

4.2 THE SAHEL, THE SAVANNA AND THE RAIN FOREST

OBJECTIVES

- Follow Heinrich Barth's journey (1850–1855) from the Mediterranean across the Sahara into the Sahel and describe the bands of land he passed through.
- Explain how the yearly movement of the overhead sun and its belt of rain creates Africa's bands of climate: rain forest, savanna, Sahel and desert, repeated north and south of the equator.
- Use latitude, rainfall tables and noon sun angles to classify places and explain how climate shaped farming, herding, travel and the spread of faith.

Warm-up. Shine a flashlight straight down onto a sheet of paper and trace the bright spot. Now tilt the flashlight so the light hits the paper at a slant and trace the spot again. Which spot is smaller and brighter? Which is spread out and weaker? The sun does the same thing to the earth. Guess: where in Africa would the sun shine most directly, and what might that do to the air and the rain?

Watch. *The Tropical Monsoon and Tropical Savannah Climates - Secrets of World Climate #2* (Geodiode, 9:05). <https://www.youtube.com/watch?v=tqpA9tswQxM>

With the big idea: watch how the seasonal rains move north and south across the tropics, giving the rain forest rain all year and the savanna a wet season and a dry season, just as Barth saw the land turn green south of the Sahara.

Note: Captions were not available to check; preview it first. This is Geodiode's 'The Tropical Monsoon and Tropical Savannah Climates - Secrets of World Climate #2'. It covers climates around the world, not just Africa, and may use metric units and the British spelling 'savannah'. Spells it 'savannah' where the lesson writes 'savanna'. It covers tropical climates worldwide, not only the Sahel and Congo.

Backup video. *The Savannah Biome - Biomes #2* (Geodiode, 8:45).

<https://www.youtube.com/watch?v=Mle5gmEpYys>

With On the map: watch the African Savannah section (from about 5:23) and the part on fires and the 'transition biome' (3:07) to see how the grassland sits between the desert and the rain forest. Note: Captions were not available to check; preview it first. It is a biome overview that also covers savanna in the Americas, Australia and India, and uses the British spelling 'savannah'. Spells it 'savannah' where the lesson writes 'savanna'. It does not name the Sahel or the seasonal rain belt (ITCZ).

KEY TERMS

Sahel

The belt of dry grassland and thorn scrub along the southern edge of the Sahara, from Senegal to Sudan. Its name comes from an Arabic word for “shore”: the shore of the desert.

savanna

Tropical grassland with scattered trees, with a wet season and a long dry season each year.

tropical rain forest

Thick, tall forest near the equator, where it is hot and rainy in most months of the year.

rain belt

The band of rising air and heavy rain near the equator (geographers call it the Intertropical Convergence Zone, or ITCZ). It follows the overhead sun north and south during the year.

wet and dry seasons

In the tropics, the year is divided by rain rather than by cold: months when the rain belt is overhead, and months when it is not.

tsetse fly

An African fly found in wetter savanna and forest that spreads sleeping sickness in people and a deadly disease in cattle and horses.

CORE IDEAS

The story. In 1850 a young German scholar named Heinrich Barth set out from Tripoli, on the Mediterranean coast of Libya, with a British-sponsored expedition led by James Richardson. They headed south with a camel caravan into the Sahara. For weeks they crossed stony plains and dunes, finding water only at wells and oases. Then, past the mountains of Aïr around the town of Agadez, the land began to change. Grass appeared, then thorn trees, then fields of millet and herds of cattle. Barth reached the great market city of Kano and the shores of Lake Chad. Richardson died in 1851 and their companion Adolf Overweg in 1852, but Barth went on alone. In 1853 he reached Timbuktu, where a respected scholar, Ahmad al-Bakkai, protected him. He returned to London in 1855 with notebooks full of measurements, vocabularies and histories, and published them in five volumes. Without meaning to, Barth had walked across one of the world's clearest patterns: Africa's bands of climate.

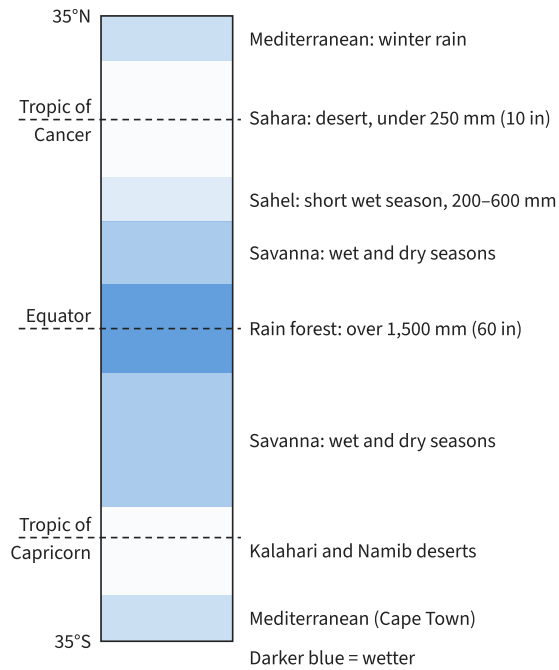
How it works. The sun is overhead at the equator in March and September. In June it is overhead at the Tropic of Cancer (about 23.4°N); in December, at the Tropic of Capricorn (about 23.4°S). Where the sun shines most directly, it heats the ground and the air above it. Warm, moist air rises, cools and drops its water as heavy rain. This **rain belt** follows the sun north and south through the year. Near the equator it passes over twice a year and is never far away, so it rains in most months. Farther north or south, the rain belt arrives for only one season. At the edge of its reach, the rains are short and unreliable. Beyond that, the air that rose at the equator sinks again, warms and dries out, and there you find the great deserts.

The big idea. So Africa is striped like a flag, and the stripes repeat on each side of the equator. In the center lies the **tropical rain forest** of the Congo Basin, the second-largest in the world after the Amazon, with more than 1,500 mm (60 in) of rain a year. Next comes the **savanna**, grassland with scattered trees and a clear wet season and dry season, home of the great herds of the Serengeti. Then the **Sahel**, with perhaps 200 to 600 mm (8 to 24 in) of

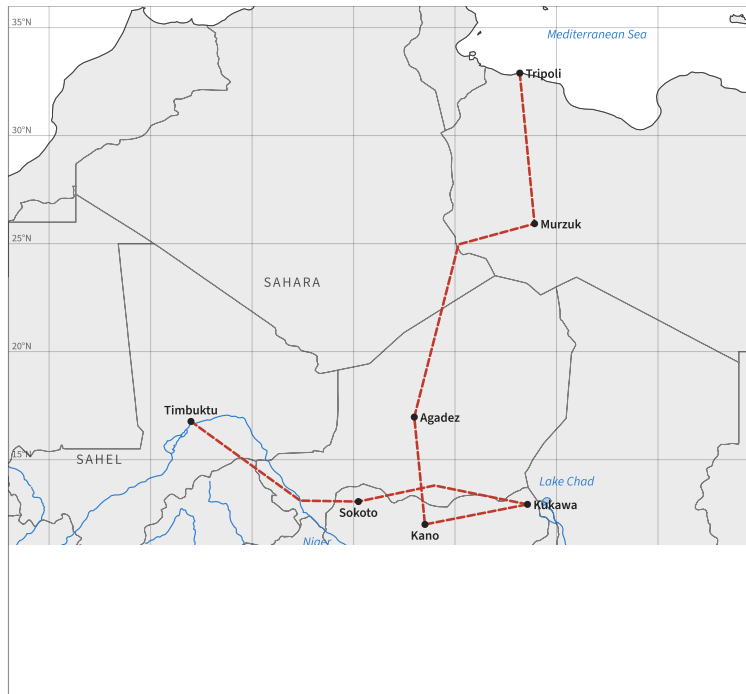
rain in a short summer season, and some years far less. Then the desert: the Sahara in the north, the Kalahari and the Namib in the south, with less than 250 mm (10 in). At the far tips, around the Mediterranean coast and Cape Town, winter rains bring a Mediterranean climate. Geographers using the Köppen system call these Af, Aw, BSh, BWh and Cs. The pattern is broken where land is high: Nairobi, almost on the equator but about 1,700 m (5,600 ft) up, has a pleasant, mild climate, and Kilimanjaro still holds ice near its summit. A cold ocean current, the Benguela, makes the Namib coast one of the driest places on earth.

How geography shaped people. Each band asked something different of the people God placed there. In the Sahel, farmers grow millet and sorghum, which can ripen in a short rainy season, while herders such as the Fulani move their cattle north with the rains and south in the dry months. In the forest belt, farmers grow yams, plantains, oil palms and, since it arrived from the Americas, cassava; later, cocoa became a great crop. The **tsetse fly** of the wetter lands killed horses and cattle, so the horsemen of the Sahel kingdoms could not easily ride into the forest, and the forest peoples built different kinds of states. Faith followed the routes too. Islam came across the Sahara with merchants and scholars, so the Sahel became largely Muslim. Christianity, which had been in Ethiopia since the 300s, came to much of the west and south by sea with missionaries in the 1800s, such as Mary Slessor, who went to Calabar in the rain forest of what is now Nigeria in 1876. That is why several West African countries today have mostly Muslim regions in the north and mostly Christian regions in the south.

On the map. Trace the Sahel from Dakar on the Atlantic eastward through Mali, Niger and Chad to Sudan: more than 5,000 km (3,000 miles) of land that is green for a few months and brown for the rest. South of the equator, find the savannas of Tanzania, Zambia and Angola, then the Kalahari and, along the coast, the Namib. The bands run east and west, but rivers like the Niger and the Nile cut across them, carrying water from rainy highlands into dry lands, as the Nile does for Sudan and Egypt.



Africa's climate bands, simplified. The wettest band is at the equator; the bands repeat to the north and south.



Heinrich Barth's route (simplified), 1850–1853: from the Mediterranean through the Sahara into the Sahel.

PICTURE STUDY



Timbuktu, from the Terrace of the Traveller's House, Johann Martin Bernatz, after sketches by Heinrich Barth, Published 1857–1858 in Barth's *Travels and Discoveries in North and Central Africa* · Tinted lithograph (book illustration) · Copies of Barth's book are in many libraries; digitized copies are on Wikimedia Commons and in library collections

Heinrich Barth was not a trained artist, but he sketched what he saw. Back in Europe, the German painter Johann Martin Bernatz turned his sketches into finished pictures for the book. This view shows Timbuktu as Barth saw it in 1853, centuries after its golden age but still a city of scholars and traders at the meeting place of the Sahara and the Niger.

Look closely and you can read the climate in the picture: the building materials, the trees, the sky and the ground all tell you which band of Africa you are in.

Look closely

- Find the mosque towers. What are they made of? Why would builders use earth instead of wood or stone here?
- Look at the ground and the plants. Is this rain forest, savanna or the edge of the desert?
- Find the people and animals. Which animal would be most useful for travel in this place?
- Look at the roofs. Are they steep or flat? What does that tell you about how much rain falls?

Talk about it

1. How does this picture show that Timbuktu stands at the shore of the desert?

2. Barth's pictures were made from his own sketches on the spot. Why is that important for a historian or a geographer?

PROJECT: SUN, RAIN AND BANDS: A GLOBE-AND-LAMP EXPERIMENT AND A CLIMATE STRIP

First you will show with a lamp and a ball why the overhead sun moves north and south during the year. Then you will make a long climate strip of Africa, from the Mediterranean to the Cape, with a real or drawn sample of what grows in each band.

You will need

- A desk lamp with the shade removed (or a strong flashlight)
- A ball or orange, with a pencil pushed through it for the axis, and a marker
- A strip of paper about 15 cm wide and 1 m long (tape sheets together), or a long piece of cardboard
- Colored pencils or paint
- Small samples or pictures: sand, dry grass, a leaf, millet or birdseed, a picture of a palm tree

Steps

1. Draw the equator and the two tropics on your ball. Tilt the axis about 23° from straight up and keep it pointing the same direction the whole time.
2. Set the lamp in the middle of the table. Carry the ball in a circle around the lamp, keeping the tilt the same. Stop at four places for the four seasons.
3. At each stop, find the spot on the ball where the light hits straight on. Notice that it moves from the Tropic of Cancer, to the equator, to the Tropic of Capricorn and back. That spot is where the rain belt follows.
4. On your paper strip, mark the latitudes 35°N at the top and 35°S at the bottom, with the equator in the middle. Mark the two tropics.
5. Color the bands: Mediterranean, Sahara, Sahel, savanna, rain forest, savanna, Kalahari and Namib, Mediterranean. Use darker blue-green for wetter bands and tan for dry ones.
6. In each band write the rainfall (in mm and inches), one crop or plant, one animal and one city: for example, Sahel: 200–600 mm (8–24 in), millet, camel, Timbuktu.
7. Glue or draw a sample for each band. Hang your strip next to a map of Africa and check that the bands line up with the land.

Tips

- Keep the ball's axis pointing the same direction (toward one corner of the room) all the way around the lamp. That is what makes the seasons.
- The bands are not perfectly straight on a real map; highlands and coasts bend them. Your strip is a simplified model.

Check your work

- I can show with a lamp why the overhead sun moves between the tropics.
- I can name Africa's climate bands in order from north to south.
- I can give one crop, one animal and one city for each band.

MAP NOTEBOOK

1. Draw Barth's route on an outline map of North and West Africa, and color the Sahara, the Sahel and the savanna he crossed.
2. Make a three-column chart: Rain forest, Savanna, Sahel. Under each write rainfall, crops, animals and one problem farmers face.
3. Sketch a simple climate graph for a Sahel town: twelve bars for the months, with rain only in June through September.

From history. Barth was one of the first European travelers to treat African history as a serious subject. He copied and studied Arabic chronicles of the Sahel kingdoms, collected vocabularies of many African languages, and wrote about the scholars and libraries of Timbuktu with respect. His careful records are still used by historians of West Africa today.

WORKED EXAMPLES

Example 1. Timbuktu is at about 16.8°N ; Lagos, on the Gulf of Guinea, is at about 6.5°N . How far apart are they from north to south, in km and miles? (One degree of latitude $\approx 111 \text{ km} \approx 69 \text{ miles}$.)

1. Difference in latitude: $16.8^{\circ} - 6.5^{\circ} = 10.3^{\circ}$.
2. Kilometers: $10.3 \times 111 \approx 1,143 \text{ km}$.
3. Miles: $10.3 \times 69 \approx 711 \text{ miles}$.

Answer: About 1,140 km (710 miles) from north to south. In that distance you pass from the edge of the desert, through the Sahel and savanna, into the forest belt near the coast.

Example 2. Here is the monthly rainfall (mm) for three made-up stations. A: every month 120–250, total 2,000. B: November–April 0–20, May–October 100–250, total 1,000. C: July–September 60–180, other months 0, total 400. Classify each as rain forest, savanna or Sahel.

1. A has heavy rain in every month and a large total: rain forest.
2. B has a clear six-month wet season and a six-month dry season, with a middle total: savanna.
3. C has only three wet months and a small total of 400 mm (about 16 in): Sahel.

Answer: A = rain forest; B = savanna; C = Sahel. The key clues are the number of wet months and the yearly total.

Example 3. Kano is at about 12°N . How far from straight overhead is the noon sun at Kano on June 21, when it is overhead at 23.4°N , and on December 21, when it is overhead at 23.4°S ? What is the sun's height above the horizon at noon on each date?

1. June 21: $23.4^{\circ} - 12^{\circ} = 11.4^{\circ}$ from overhead (toward the north). Height = $90^{\circ} - 11.4^{\circ} = 78.6^{\circ}$.
2. December 21: $12^{\circ} + 23.4^{\circ} = 35.4^{\circ}$ from overhead (toward the south). Height = $90^{\circ} - 35.4^{\circ} = 54.6^{\circ}$.
3. In June the sun is nearly overhead, and the rain belt has moved north over Kano; in December the sun is low in the south, and the rain belt is far away.

Answer: June: 11.4° from overhead, 78.6° high; December: 35.4° from overhead, 54.6° high. Kano's rains fall in the northern summer, roughly June to September.

PRACTICE

1. **EASY** What does the name "Sahel" mean, and why does it fit?
2. **EASY** Name Africa's climate bands in order from the Sahara south to the equator.
3. **EASY** Name the two deserts of southern Africa.
4. **EASY** Convert 600 mm of rain to inches (1 in = 25.4 mm).
5. **MEDIUM** Use the climate band figure. Which band lies right on the equator, and which bands lie on both sides of the Tropic of Cancer and the Tropic of Capricorn?
(Use the map or drawing "Use the strip to answer." shown earlier in this lesson.)
6. **MEDIUM** Why does it rain in most months near the equator but only in one season in the savanna?
7. **MEDIUM** Nairobi is almost on the equator, yet it is mild, not hot. Why?
8. **HARD** Agadez is at about 17.0°N and Kano at about 12.0°N . How far apart are they from north to south in km and miles? Which town would you expect to be drier, and why?
9. **HARD** Explain how the tsetse fly helped shape the history of West Africa.

10. **CHALLENGE** In a short paragraph, explain why many West African countries have mostly Muslim regions in the north and mostly Christian regions in the south. Use geography in your answer.

COMMON MISTAKES

- Thinking all of Africa is jungle or all of it is desert. Africa has bands: rain forest is only the center, and savanna covers more land than forest.
- Forgetting that the bands repeat south of the equator. Southern Africa has its own savanna, deserts and Mediterranean tip.
- Expecting every place near the equator to be hot. Altitude makes the East African highlands mild and even puts ice on Kilimanjaro.

Make it a game • Which Band Am I? One player describes a place in three clues without naming it: rainfall, a plant or crop, and an animal (for example: “Rain every month, very tall trees, gorillas”). The other players name the band: rain forest, savanna, Sahel, desert or Mediterranean. A correct answer on the first clue scores 3 points, on the second 2, on the third 1. Bonus point for naming a real city in that band.

Scripture. “While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease.” (Genesis 8:22, KJV)

In the Sahel, the seasons are marked by rain more than by cold, but the promise holds: the rains come and go in their order year after year, and farmers plant their millet trusting that harvest will follow seedtime.

Practice answers

1. It comes from an Arabic word for “shore.” The Sahel is the shore of the Sahara, the place where travelers crossing the “sea” of sand reach grassland again.
2. Sahara (desert), Sahel, savanna, tropical rain forest.
3. The Kalahari and the Namib.
4. $600 \div 25.4 \approx 23.6$ in, about 24 in.
5. The rain forest lies on the equator. The Sahara lies across the Tropic of Cancer, and the Kalahari and Namib deserts lie across the Tropic of Capricorn.
6. The rain belt follows the overhead sun between the tropics. Near the equator it is never far away and passes overhead twice a year, so it rains in most months; farther away it arrives for only one season, leaving a long dry season.
7. Because of altitude: Nairobi stands about 1,700 m (5,600 ft) above sea level, and air is cooler the higher you go.
8. $5.0^\circ \times 111 \approx 555$ km ($5.0 \times 69 \approx 345$ miles). Agadez is drier, because it is farther from the equator, at the edge of the rain belt’s reach, near the Sahara.
9. The tsetse fly lives in the wetter savanna and forest and spreads a disease that kills horses and cattle. So the cavalry of the Sahel kingdoms could not easily ride into the forest, and herders kept their cattle in drier lands. Forest and Sahel peoples developed different kinds of states and ways of farming.

10. Islam spread south across the Sahara with camel caravans of merchants and scholars, reaching the Sahel cities first, so the northern dry lands became largely Muslim over many centuries. Christianity came mainly by sea, with missionaries landing on the coast in the 1800s and working inland through the forest belt. Because the countries' borders run from the coast inland, they include both zones.

4.3 GREAT TRADING KINGDOMS

OBJECTIVES

- Tell the story of Mansa Musa of Mali's pilgrimage through Cairo in 1324 and explain where Mali's gold came from.
- Explain how the meeting of desert and grassland made the Sahel a place for trading kingdoms (Ghana, Mali, Songhai), and how the monsoon winds built the Swahili coast and linked it to Great Zimbabwe.
- Describe the faith of these peoples accurately, including the spread of Islam along the trade routes and the ancient Christian kingdoms of Ethiopia, Nubia and Kongo, and name the slave trades plainly.

Warm-up. Put a spoonful of salt in one cup and a few “gold” coins (pennies or buttons) in another. Imagine you live where there is gold in the ground but no salt, and your neighbor across the desert has salt but no gold. In the heat, people and animals need salt to live. Which would you value more, and why? Talk about how the two of you could meet to trade, and what you would need for the journey.

Watch. *State-Building in AFRICA [AP World Review—Unit 1 Topic 5]* (Heimler's History, 4:48). <https://www.youtube.com/watch?v=p76pWQi9Hd8>

As review: listen for the Swahili coast city-states and Great Zimbabwe, and notice how trade along the coast and inland made these kingdoms rich.

Note: Captions were not available to check; preview it first. This is a fast AP World History exam review aimed at high schoolers, and it opens with plugs for the presenter's own study guides. This topic (AP Unit 1.5) covers Hausa, the Swahili coast, Great Zimbabwe and Ethiopia. Mali, Mansa Musa and Timbuktu, the center of the lesson's story, are probably not covered.

KEY TERMS

trans-Saharan trade

The camel-caravan trade across the Sahara between North Africa and the Sahel, carrying salt, cloth and books south, and gold, ivory and enslaved people north.

caravan

A large group of traders and animals traveling together for safety, especially across deserts.

haji

The pilgrimage to Mecca that Islam asks every Muslim who is able to make once in a lifetime.

monsoon

A wind that changes direction with the seasons. In the Indian Ocean, it blows from the northeast in winter and from the southwest in summer.

Swahili

The people and the Bantu language of the East African coast; the language has many words borrowed from Arabic. The name comes from an Arabic word for “coasts.”

dry-stone wall

A wall built of carefully fitted stones without mortar, as at Great Zimbabwe.

CORE IDEAS

The story. In 1324 a great caravan arrived at Cairo from the far side of the Sahara. At its head was Mansa Musa, the king of Mali, on his way to Mecca for the **hajj**. Accounts speak of thousands of followers and camels loaded with gold. Musa gave gold so freely as gifts and spent so much in the markets that, according to the Arab writer al-Umari, who gathered reports in Cairo a few years later, the value of gold in Egypt fell and had still not recovered twelve years afterward. The news spread to Europe. In 1375 a mapmaker in Majorca drew Musa on the Catalan Atlas, crowned and holding up a golden nugget, as the richest king in the land. How did a kingdom on the edge of the desert become so rich?

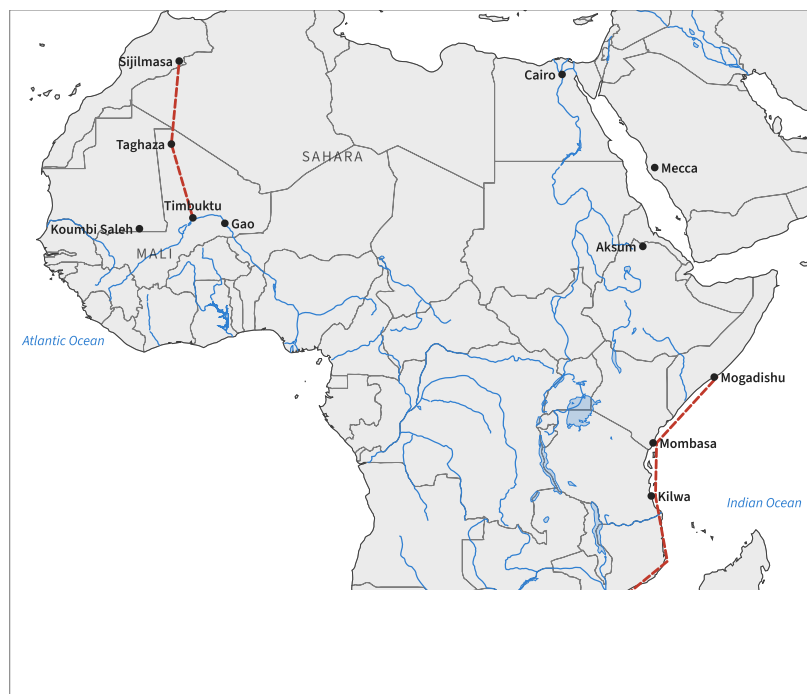
How it worked. The answer lies in geography. Gold was found to the south, in the river valleys of the upper Senegal and Niger near the forest’s edge. Salt was dug from mines in the middle of the Sahara, such as Taghaza, where buildings were even made of salt blocks. People in the hot, humid south needed salt to live, and people in the north wanted gold. The Sahel, the shore of the desert, was the meeting place. There camels from the north met donkeys, porters and river canoes from the south, and whoever controlled the trading towns could tax the trade and grow strong. The first great kingdom was Ghana (not the modern country of that name, but a kingdom in what is now Mauritania and Mali), which grew rich by the 700s. In 1068 the geographer al-Bakri described its capital as two towns: one for Muslim merchants, with mosques, and one for the king. Mali rose in the 1200s under Sundiata Keita and controlled both the gold fields and the Niger River. Its cities, Timbuktu and Djenné, became centers of trade and Islamic learning. Later the Songhai kingdom of Gao ruled the Niger bend, until a Moroccan army crossed the desert and defeated it in 1591.

The other coast. On the east side of Africa, the highway was the sea. Every winter the **monsoon** blows from the northeast, carrying sailing ships called dhows from Arabia and India down to Africa; every summer it blows from the southwest and carries them home. Along this coast grew the Swahili towns: Mogadishu, Mombasa, Zanzibar and Kilwa, with houses and mosques of coral stone. The Swahili people spoke a Bantu language rich in Arabic words, and many became Muslims through trade. In 1331 the traveler Ibn Battuta visited Kilwa and called it one of the most beautiful and well-built towns he had seen. Kilwa’s wealth came from gold carried down from the plateau far inland, through the port of Sofala.

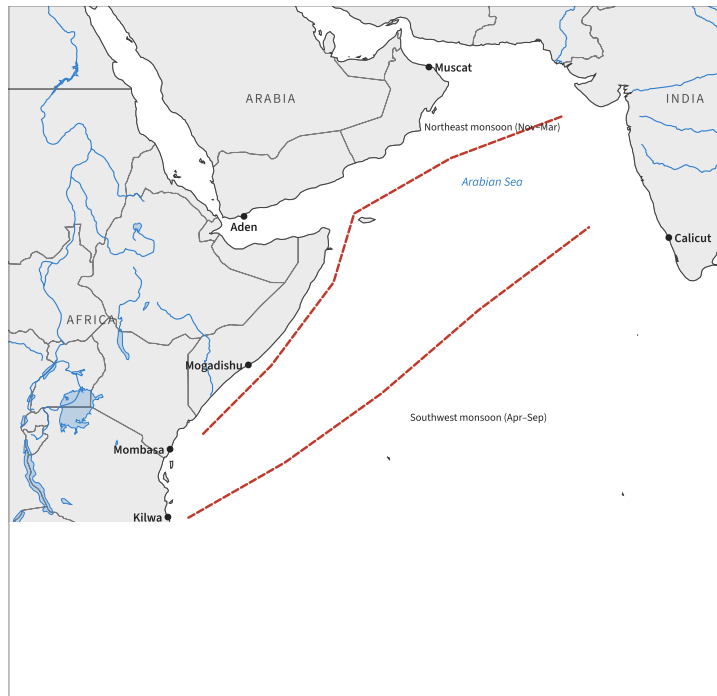
On the plateau. That gold came from the land of **Great Zimbabwe**, a stone city built by the ancestors of the Shona people and at its height from about 1200 to 1450. Its Great Enclosure has granite walls up to about 11 m (36 ft) high, built of fitted blocks with no mortar at all. Archaeologists have found Chinese porcelain, Persian pottery and glass beads there, carried up from the coast in exchange for gold and ivory. In the colonial era some writers claimed Africans could not have built it; archaeologists, beginning with Gertrude Caton-Thompson in

1929, showed clearly that they did. Today the country of Zimbabwe takes its name from the city.

Faith and the hard truth. Islam spread along these trade routes, and the rulers of Mali and the Swahili towns were Muslims. But Christianity in Africa is older still. The Book of Acts tells of an Ethiopian treasurer baptized by Philip. The kingdom of Aksum in Ethiopia became Christian under King Ezana in the 300s, and the Nubian kingdoms along the Nile were Christian for close to a thousand years. Ethiopia's rock-cut churches at Lalibela still stand, and in 1491 the king of Kongo was baptized and his son Afonso I ruled as a Christian king. The trade routes also carried human beings. Enslaved people were sold north across the Sahara and east across the Indian Ocean for centuries, and from the 1500s the Atlantic slave trade carried about 12 million Africans to the Americas. The same geography that carried gold, salt and the gospel also carried great cruelty, and both belong in an honest history.

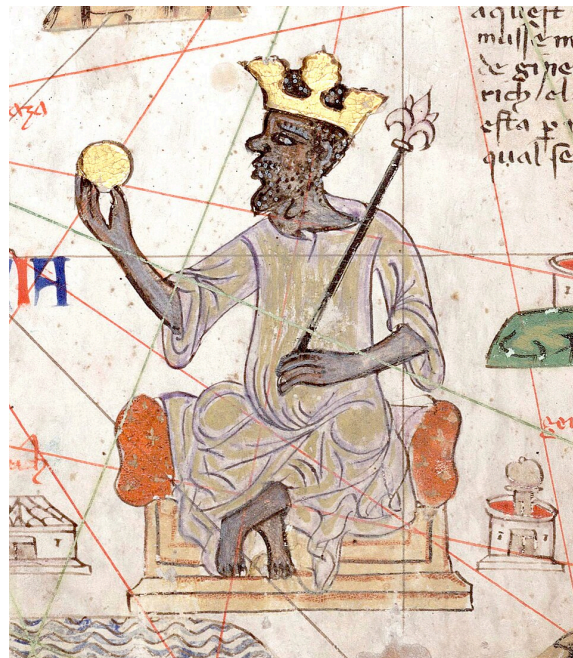


Trading kingdoms of Africa: the gold and salt routes of the west and the monsoon coast of the east.



The monsoon winds: sail to Africa in winter, sail home in summer.

PICTURE STUDY



The Catalan Atlas (detail: Mansa Musa of Mali), Attributed to Abraham Cresques, Majorca, 1375 · Ink, colors and gold on parchment panels · Bibliothèque nationale de France, Paris

The Catalan Atlas was made on the island of Majorca, a busy Mediterranean trading center, and is usually credited to Abraham Cresques, a Jewish mapmaker who drew maps and instruments for the king of Aragon. It was given to the king of France and has been kept in the French royal library and then the national library ever since. It is one of the finest maps of the Middle Ages, painted on parchment panels in bright colors and real gold.

In the part of the map showing West Africa, the mapmaker drew Mansa Musa enthroned, holding out a gold nugget toward a veiled rider on a camel. The Catalan words beside him say, in short, that this lord of the land of Mali is the richest and noblest king of all that region because of the great amount of gold found in his country. Fifty years after Musa passed through Cairo, his fame had become part of Europe's picture of the world.

Look closely

- Find Mansa Musa. What is he holding in each hand, and what is on his head?
- Find the rider on the camel. Who might he be, and why is he riding toward the king?
- Look for the mountains drawn north of Mali. What barrier do they and the desert represent for a trader coming from the Mediterranean?
- Look at the towns drawn as little castles. What do you think a mapmaker in Majorca knew about these places, and how did he learn it?

Talk about it

1. Why would European merchants in 1375 care so much about a king on the other side of the Sahara?
2. What does this map show accurately, and what might the mapmaker have known only from travelers' stories?
3. How does this map show that trade carries news and ideas as well as goods?

PROJECT: GOLD, SALT AND MONSOON: A TRADE-ROUTE BOARD GAME

You will make and play a board game in which players carry salt, gold, cloth and ivory across the Sahara by camel and along the Swahili coast by dhow. The geography of the map decides how far you can travel and when.

You will need

- A large sheet of poster board or cardboard
- Markers, ruler and a printed or traced outline map of Africa
- Small tokens for players (buttons or coins) and for goods (rice for salt, yellow beads or lentils for gold, scraps of cloth, white beans for ivory)
- One die, and index cards for event cards

Steps

1. Trace Africa onto the board. Mark these trading towns with circles: Sijilmasa, Taghaza, Timbuktu, Djenné, Gao, Kilwa, Mombasa, Mogadishu, Sofala and Great Zimbabwe.
2. Draw a path of spaces for the desert route (Sijilmasa to Taghaza to Timbuktu), a river path along the Niger (Djenné to Timbuktu to Gao), an overland path (Great Zimbabwe to Sofala) and a sea path up the coast (Sofala to Kilwa to Mombasa to Mogadishu).
3. Set the rules: desert spaces can only be crossed by camel; you must stop at an oasis or well space every five spaces. Sea spaces can only be sailed northward when a

“southwest monsoon” card is showing and southward when a “northeast monsoon” card is showing.

4. Give each town what it produces: salt at Taghaza, gold at Djenné and Great Zimbabwe, cloth and beads at Mogadishu and Sijilmasa. Goods are worth more far from where they are produced.
5. Write 12 event cards using real geography: a sandstorm (lose a turn), a dry well (go back to the last oasis), a river flood that speeds your canoe, the monsoon changes, a king taxes your caravan at Timbuktu, and so on.
6. Play: each player starts with a few goods and tries to buy where goods are cheap and sell where they are dear. The richest trader after 20 turns wins.
7. After playing, write a paragraph: Which places on the board became rich, and why? How did geography decide the winner?

Tips

- Keep the distances fair: the desert route from Taghaza to Timbuktu should take about as many turns as the sea route from Kilwa to Mogadishu.
- Discuss with a parent how the real trade routes also carried enslaved people, and why that cruelty is a real part of this history even though we do not make it part of a game.

Check your work

- I can explain why salt and gold were traded across the Sahara.
- I can explain how the monsoon decided when ships sailed on the Swahili coast.
- I can name the trading kingdoms and cities of West Africa, the Swahili coast and the Zimbabwe plateau on a map.

MAP NOTEBOOK

1. Draw Mansa Musa as he appears on the Catalan Atlas and write three facts about Mali beside him.
2. Make a map of the trans-Saharan routes with arrows: salt moving south, gold moving north.
3. Draw the Indian Ocean with two monsoon arrows and label the months each wind blows.

From history. Ibn Battuta, the Moroccan traveler, crossed the Sahara to Mali in 1352–1353, about thirty years after Mansa Musa’s pilgrimage. He described the salt town of Taghaza, where houses and the mosque were built of salt blocks roofed with camel skins, and he praised the safety of the roads in Mali, where a traveler need not fear robbers, though he also complained about the stinginess of the king who then ruled. His account is one of the few eyewitness descriptions of medieval Mali.

WORKED EXAMPLES

Example 1. The salt mines of Taghaza lay about 800 km (500 miles) north of Timbuktu. A loaded camel caravan travels about 32 km (20 miles) a day. How many days does the journey take? If the caravan rested one day after every five days of travel, how many days would it really take?

1. Travel days: $800 \text{ km} \div 32 \text{ km per day} = 25 \text{ days}$ (or $500 \text{ miles} \div 20 \text{ miles per day} = 25 \text{ days}$).
2. Rest days: one after each 5 travel days. $25 \div 5 = 5$, but the caravan does not need to rest after arriving, so 4 rest days.
3. Total: $25 + 4 = 29 \text{ days}$.

Answer: 25 days of travel, about 29 days with rests: roughly a month across the desert each way.

Example 2. Kilwa is about 1,400 km (870 miles) down the coast from Mogadishu. A dhow running before the monsoon averages about 8 km/h (5 mph), sailing day and night. How many days does the voyage take? Why couldn't the dhow make the return trip until the following summer?

(Use the map or drawing "Ships sail south on the northeast monsoon and north on the southwest monsoon." shown earlier in this lesson.)

1. Distance per day: $8 \text{ km/h} \times 24 \text{ h} = 192 \text{ km per day}$ ($5 \text{ mph} \times 24 \text{ h} = 120 \text{ miles per day}$).
2. Days: $1,400 \div 192 \approx 7.3 \text{ days}$ ($870 \div 120 \approx 7.3 \text{ days}$).
3. The northeast monsoon blows toward Africa only in the northern winter. To sail back north, the dhow must wait for the southwest monsoon, which begins around April.

Answer: About 7 to 8 days. The return had to wait for the wind to change direction with the season.

Example 3. Timbuktu (about 16.8°N, 3.0°W) and Cairo (about 30.0°N, 31.2°E) are about 3,700 km (2,300 miles) apart in a straight line. If Mansa Musa’s caravan averaged 25 km (15.5 miles) a day, how many days would it need for that distance? Why would the real journey be longer?

1. Days: $3,700 \text{ km} \div 25 \text{ km per day} = 148 \text{ days}$.
2. Check in miles: $2,300 \div 15.5 \approx 148 \text{ days}$.
3. $148 \text{ days} \div 30 \approx 5 \text{ months}$.
4. The real route bent from well to well and oasis to oasis, a great caravan with many people moves slowly, and it stopped to rest and trade.

Answer: About 148 days, or roughly five months, for the straight-line distance alone; the real journey was longer because caravans had to follow the water.

PRACTICE

1. **EASY** Which two goods were traded most famously across the Sahara, and which direction did each travel?
2. **EASY** In what year did Mansa Musa pass through Cairo on his pilgrimage to Mecca?
3. **EASY** Was the medieval kingdom of Ghana in the same place as the modern country of Ghana?
4. **EASY** Name three Swahili coast towns.
5. **MEDIUM** The walls of Great Zimbabwe’s Great Enclosure are up to about 11 m high. Convert to feet. About how many stories of a house is that, if one story is about 3 m?
6. **MEDIUM** Use the trading kingdoms map. Name the port that linked Great Zimbabwe to the coast, and the Swahili city that grew rich from that gold.
(Use the map or drawing “Use the map to answer.” shown earlier in this lesson.)
7. **MEDIUM** Why was the Sahel a good place for trading cities to grow?
8. **HARD** Name one ancient Christian kingdom in Africa and when it became Christian, and explain why Christianity reached it so early.
9. **HARD** A dhow sails about 1,000 km (620 miles) from Mombasa to Mogadishu at an average of 6 km/h (about 3.7 mph), day and night. How many days? Which monsoon does it need?
10. **CHALLENGE** Write a short paragraph explaining how geography made Mali rich and also why a single discovery or invasion could threaten that wealth.

COMMON MISTAKES

- Confusing the medieval kingdom of Ghana with the modern country of Ghana. They are in different places; the modern country took the old name.
- Thinking Christianity came to Africa only with European missionaries in the 1800s. Ethiopia and Nubia were Christian more than a thousand years before that, and Egypt even earlier.

- Leaving out the slave trades, or speaking as if only one existed. Enslaved people were carried across the Sahara, across the Indian Ocean and across the Atlantic, and an honest history names all three.

Make it a game · Caravan or Dhow?. One player names a pair of places (for example, Taghaza to Timbuktu, Sofala to Kilwa, Djenné to Gao, Kilwa to Oman). The other must say how goods traveled between them (camel caravan, river canoe, porters or dhow) and, for sea trips, which monsoon wind was needed. One point for the right way to travel, one point for the right wind. Play to 10.

Scripture. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;” (Acts 17:26, KJV)

Paul spoke these words in Athens. Mali, Great Zimbabwe, Kilwa and Aksum were built by peoples of the same one blood, each placed by God in a particular land with its own gifts of gold, salt, sea and soil, and each with its own season in history.

Practice answers

1. Salt traveled south from the Saharan mines; gold traveled north from the lands near the upper Senegal and Niger.
2. 1324.
3. No. Medieval Ghana lay far to the north and west, in what is now southeastern Mauritania and western Mali.
4. Any three of: Mogadishu, Mombasa, Malindi, Zanzibar, Kilwa, Sofala.
5. $11 \times 3.28 \approx 36$ ft. $11 \div 3 \approx 3.7$, so nearly four stories.
6. Sofala was the port; Kilwa grew rich from the gold trade.
7. It is the meeting place between the desert, where camels carried salt, and the wetter lands to the south, where gold and food were produced. Goods had to change hands there, from camels to donkeys, porters and river canoes, so towns there could control and tax the trade.
8. Aksum in Ethiopia, under King Ezana in the 300s (or the Nubian kingdoms, from the 500s). It lay along the Red Sea and the Nile, trade routes connecting it to Egypt, Palestine and the Roman world, where the church had spread from the first century.
9. $6 \times 24 = 144$ km per day; $1,000 \div 144 \approx 6.9$ days (about 7 days). Sailing north, it needs the southwest monsoon (about April to September).
10. Mali controlled the gold fields near the forest's edge, the Niger River and the Sahel trading towns where salt from the Sahara met gold from the south, so it could tax a trade that both sides needed. But its wealth depended on that position. If traders found another route (as the Portuguese later did by sea along the Atlantic coast) or an army crossed the desert (as Morocco did against Songhai in 1591), the trade and the taxes could be lost.

4.4 RAILWAYS AND DAMS

OBJECTIVES

- Tell the story of the Uganda Railway (1896–1901) from Mombasa to Lake Victoria, including the Tsavo lions, the workers from India and the climb onto the plateau.
- Explain how the Kariba Dam (built 1955–1959) turned the drop of the Zambezi into electricity, and weigh its benefits against its real costs to the people and animals of the valley.
- Compute travel times, average gradients and reservoir filling times, and explain why Africa's plateau, which blocked boats, makes it rich in hydroelectric power.

Warm-up. Lean a book against a stack of other books to make a gentle ramp, and roll a toy car or a marble up and down it. Now make the ramp steeper and try again. How steep can the ramp get before the car will not climb under a gentle push? Then think: a railway must climb from the sea to a plateau more than 1,500 m (5,000 ft) high. How could engineers keep the slope gentle?

Video. Coming soon. The Uganda Railway and the Tsavo man-eaters; how arch dams work and the Kariba Dam on the Zambezi: search Practical Engineering (arch dams, hydropower), The History Guy (Uganda Railway, Tsavo), Smithsonian, NASA Earth Observatory (Lake Kariba from space), and Wendover Productions (candidate, needs vetting).

KEY TERMS

gradient

How steep a railway or river is: the rise divided by the distance, often given as a percent. A 1% grade rises 1 m for every 100 m traveled.

railhead

The farthest point a railway has reached while it is being built, where new track is laid.

hydroelectric power

Electricity made by falling water turning turbines. More water and a greater height make more power.

arch dam

A thin, curved concrete dam that bows upstream and pushes the weight of the water sideways into the rock walls of a narrow gorge.

reservoir

A lake made by a dam that stores water for power, drinking or irrigation.

landlocked

Having no coastline on the sea, like Uganda, Zambia and Zimbabwe.

CORE IDEAS

The story. In March 1898 a British army engineer named John Henry Patterson arrived at Tsavo, in the dry bush country of what is now Kenya, to build a railway bridge over the Tsavo River. Soon workers began to disappear from their tents at night. Two large male lions without manes were hunting men, and for months they terrified the camp, breaking through thorn fences and once halting work altogether. In December 1898, after many failed nights of waiting in trees and traps, Patterson shot both lions. He later told the story in his book *The Man-Eaters of Tsavo* (1907). He claimed 135 victims; scientists who studied the lions' remains in 2009 estimated a much smaller number, about 35. Since 1925 the two lions have stood in the Field Museum in Chicago. The bridge was finished, and the railway pushed on.

Why build it? Remember Lesson 4.1: no river offered a road from the East African coast to the interior. Uganda, around the shores of Lake Victoria, is landlocked, and the lake lies more than 1,100 m (3,700 ft) above the sea. Before the railway, everything traveled on the heads of porters, and a caravan from the coast to the lake needed months. The missionary Alexander Mackay, who reached Uganda in 1878, spent many hard months on the caravan road from the coast, and Bishop James Hannington was killed on his way there in 1885. Britain decided to build a railway from Mombasa to the lake. Its stated aims were to open the interior to trade, to finish off the slave trade that still used the old caravan routes, and to secure British control of the lands around the source of the Nile. Critics in Parliament mocked it as the "Lunatic Line" because of its cost of more than £5 million.

How it worked. Track laying began at Mombasa in 1896, on a narrow gauge of one meter. About 32,000 workers were brought from British India under contract, because Britain ruled India and could recruit experienced railway laborers and craftsmen there. Disease, accidents and lions killed about 2,500 of them, and several thousand stayed in East Africa when their contracts ended, the beginning of the region's Indian community. The line crossed the waterless Taru desert, climbed onto the plateau and, in 1899, reached a swampy stream where a supply depot was set up. That depot became Nairobi, now one of Africa's great cities. Beyond it the railway had to descend the steep wall of the Great Rift Valley, cross the valley floor, and climb to more than 2,500 m (8,000 ft) at Mau Summit before dropping to the lake. In December 1901 the railhead reached Lake Victoria at Kisumu, about 930 km (580 miles) from Mombasa. A journey of months became a trip of a few days. The railway also brought European settlers to the cool highlands, where land was taken from the Kikuyu, the Maasai and other peoples, a wrong that shaped Kenya's later history.

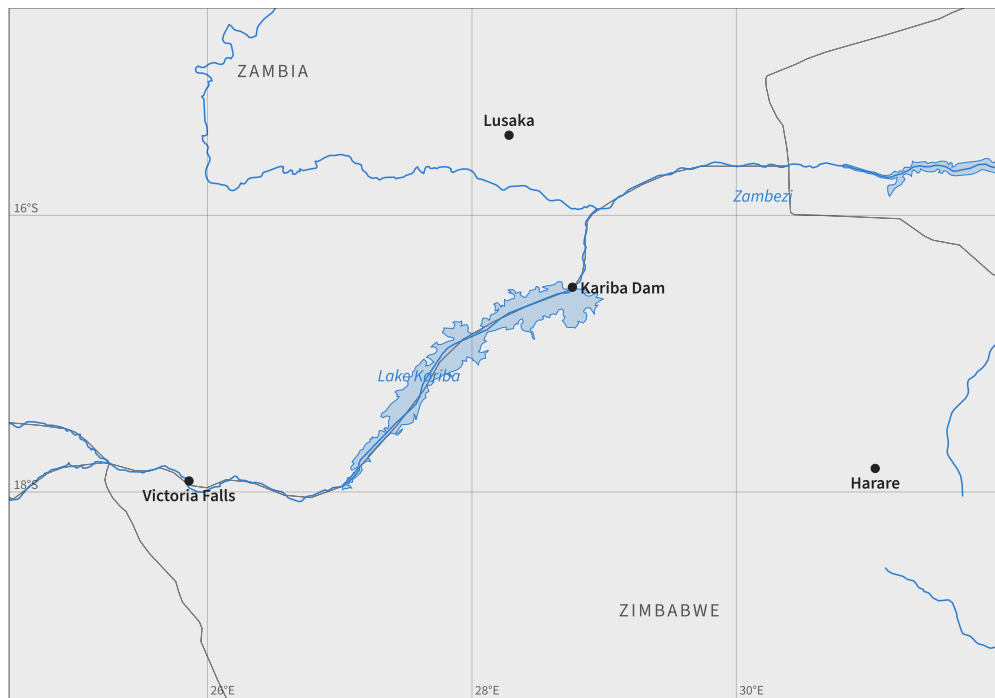
Technology overcoming geography. The falls that stopped Livingstone's steamer hide a gift: wherever a big river drops, its energy can be captured. The Zambezi below Victoria Falls runs through deep gorges, and at Kariba it squeezes through a narrow gap in the rock. Between 1955 and 1959, engineers built the Kariba Dam there, a curved concrete **arch dam** 128 m (420 ft) high and 579 m (1,900 ft) long. The arch bows upstream, so the weight of the water pushes it sideways into the solid rock walls. Behind it rose Lake Kariba, about 280 km (175 miles) long, by volume one of the largest man-made reservoirs in the world. Its power stations sent electricity to the copper mines and cities of what are now Zambia and

Zimbabwe, which share the dam today. Great floods in 1957 and 1958 badly damaged the works before the dam was closed.

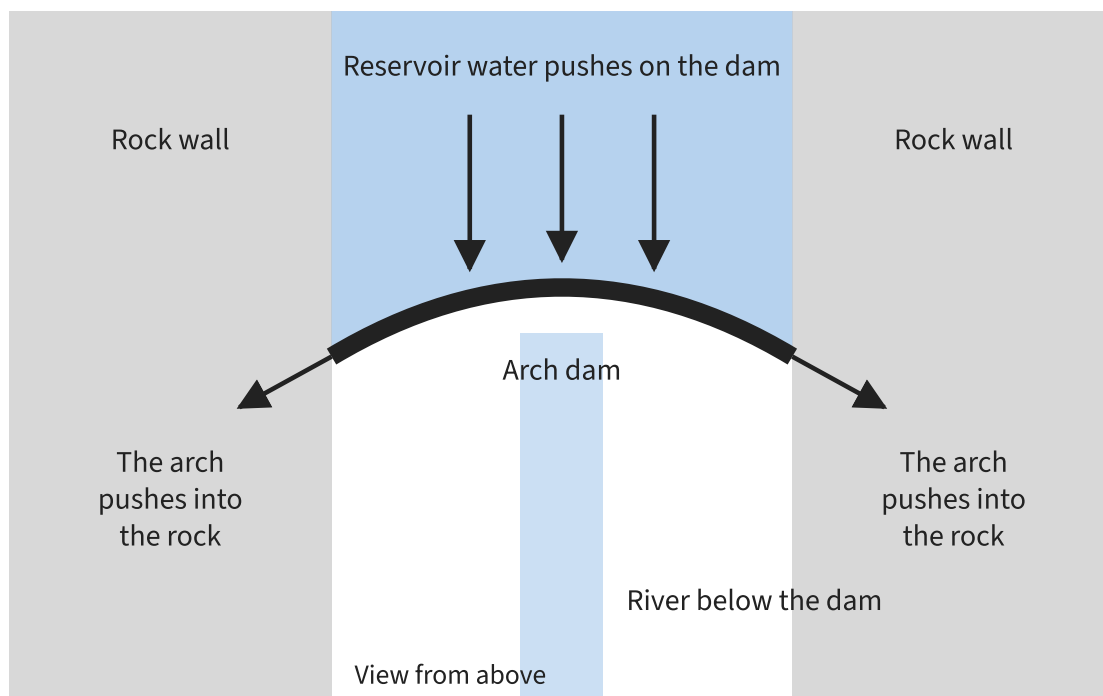
The cost and the lesson. The new lake drowned the homes and fields of about 57,000 Gwembe Tonga people, who were moved, often unwillingly, to poorer land. As the water rose, rangers led by Rupert Fothergill rescued about 6,000 stranded animals in “Operation Noah.” Since then other great dams have used Africa’s rivers in the same way: Akosombo in Ghana (1965), Cahora Bassa in Mozambique (1974), drowning Livingstone’s old Kebrabasa rapids, and the Inga dams on the Congo. The Grand Ethiopian Renaissance Dam on the Blue Nile was inaugurated in 2025; as of 2026, Ethiopia, Sudan and Egypt still disagree about how it should be operated. Railways and dams show both the power God gave people to subdue the earth and the duty to count honestly who pays the price.



The Uganda Railway, 1896–1901: from Mombasa to Lake Victoria.

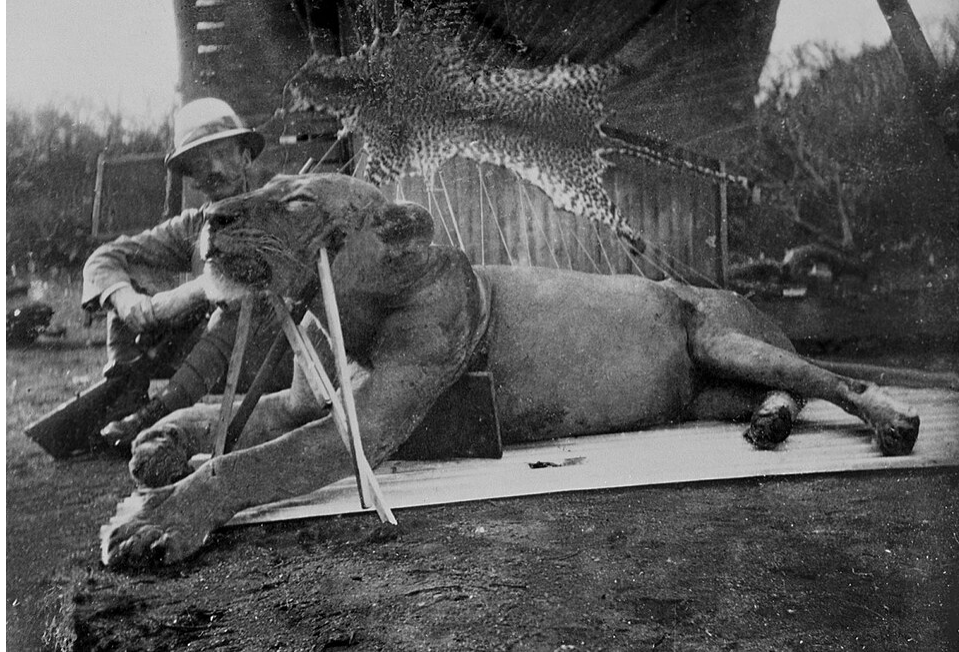


Lake Kariba on the Zambezi, between Zambia (north) and Zimbabwe (south).



How an arch dam works: the curve turns the water's push into a squeeze against the rock walls.

PICTURE STUDY



J. H. Patterson with the First Tsavo Man-Eater, Photograph published by John Henry Patterson, Taken December 1898; published in *The Man-Eaters of Tsavo*, 1907 · Black-and-white photograph · Reproduced in Patterson's book (many library copies); the lions themselves are displayed at the Field Museum, Chicago

Photographs were still fairly new in 1898, and Patterson carried a camera to record the building of the railway. This photograph shows him with the first of the two lions, shot in early December 1898. He published it with others in his book nine years later, and it helped make the Tsavo story famous around the world.

A photograph like this is a primary source, but it does not tell the whole story by itself. It does not show the workers from India and Africa who built the bridge, the heat and disease they endured, or the people whose land the railway crossed. A good geographer asks what a picture shows and also what it leaves out.

Look closely

- Look at the ground and the plants around the lion. What does this tell you about the climate band of Tsavo?
- Look at the lion. Can you see that it has almost no mane? Why might that surprise people who knew lions only from pictures?
- Look at Patterson's clothing and helmet. How are they suited to the sun and heat of the place?

Talk about it

1. Why might Patterson have wanted to photograph the lion rather than only describe it?
2. Whose story is missing from this photograph, and where could a historian look to find it?

3. How does this picture help you imagine what it was like to build a railway through the East African bush?

Safety first. When working with water and clay in the dam project, work outdoors or over a tub and wipe up spills promptly. An adult should handle any cutting of plastic containers.

PROJECT: STRAIGHT WALL OR ARCH? A MODEL DAM TEST

You will build two model dams across a narrow “gorge” in a tray of sand: one straight and one curved like the Kariba arch. Then you will fill the reservoir behind each and see which one holds best and why engineers chose an arch for a narrow, rocky gorge.

You will need

- A long plastic tray or storage bin
- Damp sand, and bricks, blocks or stones for the gorge walls
- Modeling clay (or two strips cut from a plastic bottle, plus clay to seal them)
- A pitcher of water and a ruler
- A marker and masking tape

Steps

1. Fill the tray with damp sand and press a river channel down its middle. Set bricks or stones on each side of the channel at one point to make a narrow, rocky gorge.
2. Build a straight dam of clay about 1 cm thick across the gorge, pressing its ends firmly against the bricks and its bottom into the sand.
3. Slowly pour water upstream of the dam to make a reservoir. Mark the water level on a strip of tape each minute. Watch the dam closely: where does it bend, leak or crack?
4. Empty the water and smooth the sand. Now build an arch dam of the same thickness that bows upstream, toward the reservoir, with its ends pressed into the bricks.
5. Fill the reservoir again in the same way and record how high the water gets before the dam leaks or bends.
6. Compare: which dam held more water? Where did each one fail? Feel the ends of the arch: are they pushed against the bricks?
7. Draw both dams from above and add arrows showing how the water pushes on each. Write two sentences explaining why the arch works best in a narrow gorge with strong rock walls.

Tips

- Keep both dams the same thickness and height so your test is fair.
- An arch dam needs strong sides. Try the arch with sand banks instead of bricks and see what happens.

Check your work

- I can explain how an arch dam pushes the water's weight into the rock walls.
- I can explain why Kariba Gorge was a good place for an arch dam.
- I can describe one benefit and one cost of a large dam.

MAP NOTEBOOK

1. Draw a map of Kenya and Uganda with the Uganda Railway from Mombasa to Kisumu. Mark Tsavo, Nairobi and the Rift Valley, and write the dates 1896 and 1901.
2. Draw a side view (elevation profile) of the railway: sea level at Mombasa, Nairobi at about 1,700 m, the Rift Valley dip, Mau Summit above 2,500 m, and Lake Victoria at about 1,134 m.
3. Make a two-column chart for the Kariba Dam: Benefits and Costs. Write at least three in each column.

From history. When the railway reached the lake in 1901, a British steamer service on Lake Victoria linked Kisumu with Entebbe and the ports of Uganda, finishing the route from the sea to Kampala. Mission schools, hospitals and churches soon spread along the line and the lake. In Uganda the church had already grown despite fierce persecution: in 1885–1887, under King Mwanga, dozens of young Christians, Anglican and Catholic, were put to death for their faith. They are remembered today as the Uganda Martyrs.

WORKED EXAMPLES

Example 1. The Uganda Railway runs about 930 km (580 miles) from Mombasa to Kisumu. A porter caravan averaged about 20 km (12 miles) a day. An early train averaged about 25 km/h (15.5 mph), including stops. How long does each take?

(Use the map or drawing “The route measured in this example.” shown earlier in this lesson.)

1. Caravan: $930 \text{ km} \div 20 \text{ km per day} = 46.5 \text{ days}$, about 47 days of walking, and with rest days and delays usually two months or more.
2. Train: $930 \text{ km} \div 25 \text{ km/h} = 37.2 \text{ hours}$, about a day and a half.
3. Compare: $46.5 \text{ days} \times 24 \text{ hours} = 1,116 \text{ hours}$; $1,116 \div 37.2 = 30$.

Answer: About 47 days of walking versus about 37 hours by train: the railway made the trip roughly 30 times faster.

Example 2. From Mombasa (near sea level) the railway climbs to Nairobi, at about 1,700 m (5,600 ft), over about 530 km (330 miles) of track. What is the average gradient as a percent? Why did engineers still face steep sections?

1. Gradient = rise $\div$ distance. Convert the distance to meters: 530 km = 530,000 m.
2. $1,700 \div 530,000 \approx 0.0032$.
3. As a percent: $0.0032 \times 100 \approx 0.32\%$.
4. The land does not rise evenly. It is flat in some places and steep in others, and beyond Nairobi the line had to go down the wall of the Rift Valley and up to Mau Summit, so some sections were far steeper than the average.

Answer: About 0.32% on average (about 32 cm of climb per 100 m of track); the real line had much steeper stretches where the land rises sharply.

Example 3. Lake Kariba holds about 180 km³ of water. One cubic kilometer is 1,000,000,000 m³. If the Zambezi brought in roughly 1,200 m³ every second and none flowed out, how many years would the lake take to fill?

1. Volume in cubic meters: $180 \times 1,000,000,000 = 180,000,000,000 \text{ m}^3$.
2. Seconds needed: $180,000,000,000 \div 1,200 = 150,000,000$ seconds.
3. Seconds in a year: $60 \times 60 \times 24 \times 365 = 31,536,000$.
4. Years: $150,000,000 \div 31,536,000 \approx 4.8$ years.

Answer: About 5 years. The real lake began filling when the dam was closed in December 1958 and took about four to five years to reach its full level, while water also had to be let through for the power station.

PRACTICE

1. **EASY** Between which two places did the Uganda Railway run, and in which years was it built?
2. **EASY** Which great city began in 1899 as a supply depot on the Uganda Railway?
3. **EASY** On which river is the Kariba Dam, and which two present-day countries share it?
4. **EASY** Convert the Kariba Dam's height of 128 m to feet (1 m $\approx$ 3.28 ft).
5. **MEDIUM** Why is a narrow gorge with strong rock walls a good place for an arch dam?
6. **MEDIUM** A timetable lists Tsavo at 214 km from Mombasa and Nairobi at 526 km. How far is it from Tsavo to Nairobi in km and in miles (1 km $\approx$ 0.621 mi)?
7. **MEDIUM** Use the Uganda Railway map. In which direction does the railway run from Mombasa to Kisumu, and what large valley does it cross between Nairobi and Kisumu? (Use the map or drawing "Use the map to answer." shown earlier in this lesson.)
8. **HARD** Nairobi to Kisumu is about 400 km (250 miles) by rail. How long would a porter caravan at 20 km (12 miles) a day take, and how long a train at 25 km/h (15.5 mph)?

9. **HARD** A simple rule for hydropower: power in kilowatts $\approx 9.8 \times \text{flow (m}^3 \text{ per second)} \times \text{drop (m)}$. Find the power for a flow of 1,000 m³/s falling 100 m. If the machines are 90% efficient, how many megawatts (1 MW = 1,000 kW) are produced?
10. **CHALLENGE** Write a paragraph weighing the Kariba Dam: its benefits, its costs and who bore each.

COMMON MISTAKES

- Thinking the Uganda Railway ran mostly through Uganda. The whole original line lies in what is now Kenya. When it was built, its western part belonged to the Uganda Protectorate, and the line was named for its goal, the lands around Lake Victoria.
- Thinking a thick, straight wall is always the strongest dam. In a narrow, rocky gorge, a thin curved arch can hold more because the rock walls carry the load.
- Telling only the triumph or only the cost. Railways and dams brought real benefits and real harms, and an honest geographer names both.

Make it a game · Railhead Race. Draw a track of 20 squares from Mombasa to Kisumu, with Tsavo at square 5, Nairobi at 11, the Rift Valley at 14 and Mau Summit at 17. Players roll a die to lay track. Landing on Tsavo means lions (go back 2). At the Rift Valley you must roll a 4 or higher to get down the escarpment, and at Mau Summit a 5 or higher to climb over it. Before each roll, answer one question from this unit; a wrong answer means you roll only half (round up). First to reach Lake Victoria wins.

Scripture. “Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain:” (Isaiah 40:4, KJV)

Isaiah’s picture is of a road prepared for the coming of the Lord. Railway builders do something like it on a small scale, filling valleys and cutting through hills to make a level way. The greater road Isaiah describes is the one by which the good news reached every region of the earth, including the highlands of East Africa.

Practice answers

1. From Mombasa on the Indian Ocean to Kisumu on Lake Victoria, 1896 to 1901.
2. Nairobi.
3. The Zambezi; Zambia and Zimbabwe.
4. $128 \times 3.28 \approx 420$ ft.
5. An arch dam pushes the weight of the water sideways into the walls on each side. It needs a short span and hard rock to push against, which a narrow, rocky gorge provides; it also takes less concrete than a wide dam.
6. $526 - 214 = 312$ km; $312 \times 0.621 \approx 194$ miles.
7. Generally northwest (west-northwest). It crosses the Great Rift Valley.
8. Caravan: $400 \div 20 = 20$ days. Train: $400 \div 25 = 16$ hours.
9. $9.8 \times 1,000 \times 100 = 980,000$ kW = 980 MW. At 90%: $980 \times 0.9 \approx 882$ MW.
10. A strong answer names benefits (reliable electricity for the copper mines, cities and homes of Zambia and Zimbabwe; a large lake for fishing and travel; some flood control) and costs

(about 57,000 Gwembe Tonga people moved from their homes and fields, often unwillingly, to poorer land; animals drowned or displaced despite Operation Noah; the river valley changed forever). It notes that the benefits went mostly to mines and cities far away, while the costs fell mostly on the valley's people, and it reaches a reasoned judgment.

UNIT 4 REVIEW

Answer each question. Show your work for calculations, give both kilometers and miles where asked, and use complete sentences for explanations. The review is worth 60 points.

1. (5 pts) Explain why ocean ships can sail only about 150 km (95 miles) up the Congo River, even though it carries more water than any river except the Amazon.
2. (6 pts) The Livingstone Falls drop about 270 m over about 350 km. Find the average drop per km. Then convert 270 m to feet ($1 \text{ m} \approx 3.28 \text{ ft}$).
3. (5 pts) Name Africa's highest mountain and its largest lake, and give one fact about each.
4. (6 pts) List Africa's climate bands in order from the Mediterranean coast of North Africa to Cape Town.
5. (6 pts) Explain why the Sahel gets only a short rainy season while the Congo Basin gets rain in most months.
6. (6 pts) Agadez is at about 17.0°N and Lagos at about 6.5°N . How far apart are they from north to south, in km and miles? ($1^\circ \approx 111 \text{ km} \approx 69 \text{ miles}$.)
7. (6 pts) Explain how the trade in gold and salt made Ghana and Mali rich. Where was each good found?
8. (5 pts) How did the monsoon winds make the Swahili coast trade possible, and where did Kilwa's gold come from?
9. (5 pts) Name two places in Africa where Christianity was established long before European missionaries arrived in the 1800s, with an approximate date for each.
10. (5 pts) The Uganda Railway runs about 930 km (580 miles). How many days would a porter caravan at 20 km a day need, and how many hours would a train at 25 km/h need?
11. (5 pts) Explain how an arch dam like Kariba holds back a lake, and name one benefit and one cost of the Kariba Dam.

UNIT PROJECT: ATLAS PAGE: SUB-SAHARAN AFRICA'S CLIMATE BANDS AND RIVERS

Draw a large map of Africa for your regional atlas. Color the climate bands (Mediterranean, desert, Sahel, savanna and rain forest) with a key, and draw the Nile, Niger, Congo and Zambezi with Lake Victoria and Lake Tanganyika. Mark the falls and rapids that block the rivers (the Nile cataracts, Livingstone Falls, Boyoma Falls, Victoria Falls, Kebrabasa) with small zigzags, and add the trading cities of Lesson 4.3, the Uganda Railway and the Kariba Dam.

Beside the map, include a photo or drawing of your rapids-and-falls river model with a short report explaining where the boats stopped and why, and a paragraph explaining how Africa's plateau both blocked travel and later gave power to its people.

- **Accuracy:** Climate bands, rivers, lakes, falls, cities, the railway and the dam are placed correctly and labeled clearly.

- **River model:** The model shows a plateau, escarpment and coastal plain; the report correctly identifies the head of navigation and a way around the falls.
- **Explanation:** The paragraph explains clearly how the plateau, the falls and the rain belt shaped travel, trade and settlement, and how technology later overcame them, with their costs named honestly.
- **Care:** The map and report are neat, colorful, have a key and scale, and are easy to read.

Answer key

1. Africa is a high plateau with a narrow coastal plain. As the Congo leaves the plateau near the coast, it drops about 270 m (880 ft) through the Livingstone Falls, a chain of rapids above Matadi, so ships must stop at Matadi.
2. $270 \div 350 \approx 0.77$ m per km. $270 \times 3.28 \approx 886$ ft (about 880 ft).
3. Mount Kilimanjaro, 5,895 m (19,341 ft), a volcano in Tanzania near the equator. Lake Victoria, Africa's largest lake, on the plateau at about 1,134 m (3,720 ft); it feeds the White Nile.
4. Mediterranean, Sahara (desert), Sahel, savanna, tropical rain forest, savanna, Kalahari and Namib (desert), Mediterranean.
5. The rain belt of rising, moist air follows the overhead sun between the tropics during the year. The Congo Basin, on the equator, is never far from it, so rain falls in most months. The Sahel is at the northern edge of the rain belt's reach, so it gets rain only for a few summer months, and some years very little.
6. $10.5^\circ \times 111 \approx 1,166$ km; $10.5 \times 69 \approx 725$ miles.
7. Gold was found to the south, near the upper Senegal and Niger Rivers; salt was mined in the Sahara, at places like Taghaza. The Sahel kingdoms controlled the trading towns where the two met, so they could tax the trade. Mali also controlled the gold fields and the Niger River.
8. The monsoon blows from the northeast in winter, carrying ships from Arabia and India to East Africa, and from the southwest in summer, carrying them home. Kilwa's gold came from the Zimbabwe plateau (Great Zimbabwe), brought to the coast through Sofala.
9. Any two: Egypt (Alexandria, first century after Christ); Carthage and North Africa (100s); Aksum in Ethiopia (King Ezana, 300s); the Nubian kingdoms on the Nile (500s); the Kingdom of Kongo (1491, through Portuguese missionaries).
10. $930 \div 20 = 46.5$ days (about 47). $930 \div 25 = 37.2$ hours (about a day and a half).
11. The curved dam bows upstream, so the water's push is turned sideways into the strong rock walls of the narrow gorge. Benefit: electricity for the mines and cities of Zambia and Zimbabwe (also fishing, travel on the lake). Cost: about 57,000 Gwembe Tonga people were moved from their homes; animals drowned or were displaced.

SOUTH ASIA

South Asia is a land set apart. The Himalaya, the highest mountains on earth, wall it off from the rest of Asia, and the Arabian Sea and the Bay of Bengal wash its long coasts. Between them lie the wide river plains of the Indus and the Ganges and the old Deccan Plateau. Over all of it blows the **monsoon**, the great seasonal wind that brings most of a year's rain in four months and sets the rhythm of farming, travel and life for well over a billion people in India, Pakistan, Bangladesh, Nepal, Bhutan and Sri Lanka.

In this unit you will see how mountains make the rains and how river plains have fed hundreds of millions of people since the brick cities of Harappa and Mohenjo-daro. You will ride India's first train out of Bombay in 1853 and climb with the hill railways into the Himalaya and the Nilgiri Hills, where engineers used loops, zigzags and a rack to beat the slopes. Finally you will meet William Carey at Serampore and Amy Carmichael at Dohnavur, and learn how India's many languages and faiths shaped the long story of the church in South Asia.

Through it all, remember the series verse: God "hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation" (Acts 17:26). In South Asia the "times" are the monsoon seasons and the "bounds" are mountains, rivers and seas, and the peoples within them speak many tongues that Christian translators have labored to reach.

BEFORE YOU BEGIN

- Can explain prevailing winds, rain shadows and how altitude affects temperature (Grade 6 physical geography)
- Can use a map scale and read latitude and longitude to about a tenth of a degree
- Can convert between kilometers and miles, meters and feet, and work with percents
- Has built the regional atlas pages from Units 1-4

MASTERY CHECKLIST

- I can describe South Asia's physical setting: the Himalaya, the Indus and Ganges plains, the Deccan, the Ghats and the surrounding seas.
- I can explain how unequal heating of land and sea causes the monsoon, and how mountains create wet windward slopes and dry rain shadows.
- I can trace the Indus and the Ganges from source to sea and explain why their plains can feed so many people.
- I can explain how engineers carried railways over the Western Ghats and into the hills, and calculate speeds and gradients.
- I can describe the faiths and language families of South Asia accurately and tell how Carey, Carmichael and earlier missionaries brought the gospel and the Scriptures there.

- I can draw a map of India's rivers and monsoon winds from memory.

OPTIONAL BOOKS AND RESOURCES

- **NASA Earth Observatory** (<https://earthobservatory.nasa.gov/>): Free. Search "monsoon India," "Himalaya" and "Ganges delta" for satellite images and short articles showing monsoon clouds, snow cover and the Sundarbans from space (Lessons 5.1 and 5.2).
- **UNESCO World Heritage Centre: Mountain Railways of India** (<https://whc.unesco.org/en/list/944>): Free. Official description, maps and photographs of the Darjeeling, Nilgiri and Kalka-Shimla railways (Lesson 5.3).
- **Project Gutenberg: books by and about Amy Carmichael** (<https://www.gutenberg.org/ebooks/search/?query=Amy+Carmichael>): Free. Older public-domain books may be available here; a parent should choose short passages to read aloud (Lesson 5.4).

5.1 THE HIMALAYA AND THE MONSOON ★

OBJECTIVES

- Describe the physical setting of South Asia: the Himalaya wall in the north, the great river plains, the Deccan Plateau, the Western Ghats and the surrounding seas.
- Explain how unequal heating of land and sea makes the seasonal monsoon winds, and how the Himalaya and the Western Ghats shape where the rain falls.
- Read a rainfall map and a cross-section to find a rain shadow, and convert heights and rainfall between metric and U.S. units.

Warm-up. Fill one cup with sand or soil and another with water, and set both in a sunny window (or under a desk lamp) for ten minutes. Touch the top of each. Which warmed faster? Now guess: in May, which is hotter, the land of India or the Indian Ocean beside it? Keep your guess for the end of the lesson.

Watch. *Asian Monsoon 1: Overview* (UTD GEOSCIENCE STUDIO, 5:26).

https://www.youtube.com/watch?v=WEuuRSi_LII

With the big idea: watch how the land heats faster than the ocean in summer and pulls wet sea winds inland, and how the Himalaya and the Tibetan Plateau make the Asian monsoon so strong.

Note: Captions were not available to check; preview it first. The video comes from a university geoscience studio and the series looks at when the monsoon began, so it may give ages in millions of years. The lesson does not give dates like these.

Backup video. *The Asian Monsoon - The World's Largest Weather System* (Geodiode, 16:57). <https://www.youtube.com/watch?v=1nstixjMS7A>

With the big idea: watch how the summer monsoon winds carry rain from the ocean to the Himalaya. Note: Captions were not available to check; preview it first. It is long; the first ten minutes cover the lesson.

KEY TERMS

monsoon

A seasonal reversal of the prevailing winds, from the Arabic *mawsim*, “season.” In South Asia the wet southwest monsoon blows from the sea (about June to September) and the dry northeast monsoon blows from the land (about December to February).

Himalaya

The highest mountain range on earth, an arc about 2,400 km (1,500 mi) long across the north of South Asia; the name means “abode of snow” in Sanskrit.

subcontinent

A large, distinct part of a continent. The Indian subcontinent (India, Pakistan, Bangladesh, Nepal, Bhutan and Sri Lanka) is walled off from the rest of Asia by mountains.

orographic rain

Rain made when moist wind is forced up a mountainside, cools and drops its water.

rain shadow

The dry side of a mountain range, away from the wet wind, where air sinks and warms after losing its moisture.

Western Ghats

A long range of steep hills along India's west coast that catches the monsoon rain before it reaches the Deccan Plateau.

CORE IDEAS

The story. For half a century, British and Indian surveyors of the Great Trigonometrical Survey carried heavy brass theodolites across India, measuring the land in a chain of triangles. Nepal was closed to them, so in 1849 they sighted the far snow peaks from the plains of northern India, more than 160 km (100 mi) away, and simply numbered them. Back in the office, “computers” (people who did the arithmetic by hand), among them the Bengali mathematician Radhanath Sikdar, worked through the angles. In 1856 the Surveyor General, Andrew Waugh, announced that “Peak XV” was the highest mountain yet measured: 29,002 feet. In 1865 it was named for Waugh's predecessor, George Everest, though Everest himself objected. Tibetans call it Chomolungma and Nepalis Sagarmatha. In 2020 China and Nepal announced a new height of 8,848.86 m (about 29,032 ft), only about 30 feet more than the 1856 figure.

The physical setting. South Asia is a great wedge of land pointing south into the Indian Ocean, with the Arabian Sea on the west and the Bay of Bengal on the east. Across the top runs the Himalaya, and behind it rises the Tibetan Plateau, on average about 4,500 m (14,800 ft) high. All fourteen of the world's peaks above 8,000 m stand in the Himalaya and the nearby Karakoram. Geologists explain that the Indian plate pushes northward into the rest of Asia, crumpling and lifting the rocks between them; careful measurements show the mountains are still rising slowly. South of the mountains lie the wide, flat plains of the Indus, Ganges and Brahmaputra. South of those, the old, hard Deccan Plateau tilts gently east, edged by the steep Western Ghats on the west coast and the lower Eastern Ghats on the east.

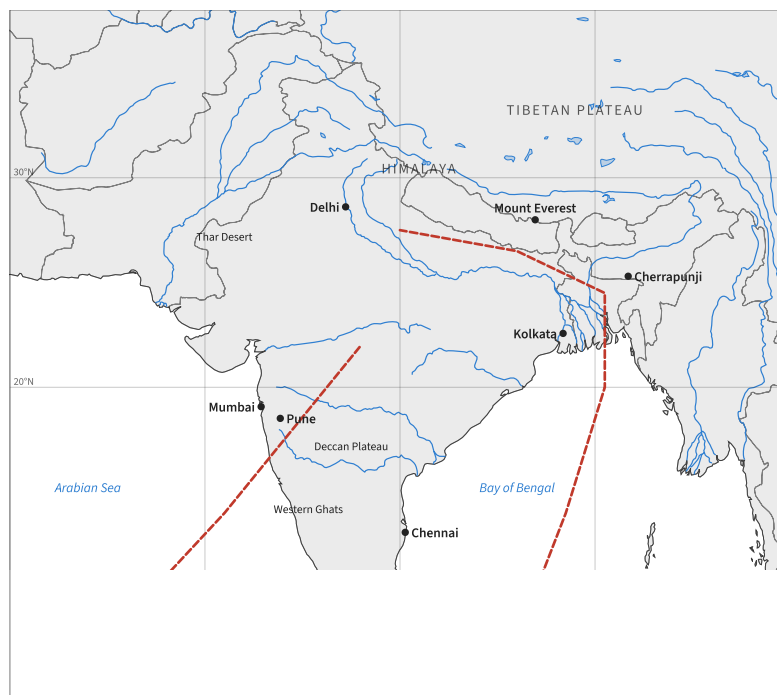
How it works. The monsoon begins with your warm-up: land heats faster than water. By May the plains of northern India are baking, often above 40°C (104°F), the high Tibetan Plateau is heating in the strong sun, and the ocean stays cooler. Hot air over the land rises, leaving low pressure, and cooler air from the sea flows in to take its place. Having crossed thousands of kilometers of warm ocean, that air is loaded with water vapor. The moist wind arrives from the southwest, usually reaching Kerala around June 1 and covering most of India by early July. In winter the pattern reverses: the land cools faster, high pressure builds over Asia, and dry northeast winds blow out from the land. The four monsoon months bring roughly three-quarters of India's yearly rain.

Mountains that make the rains. The Himalaya and the Ghats decide where that water falls. When the Arabian Sea branch of the monsoon hits the Western Ghats, the air is forced

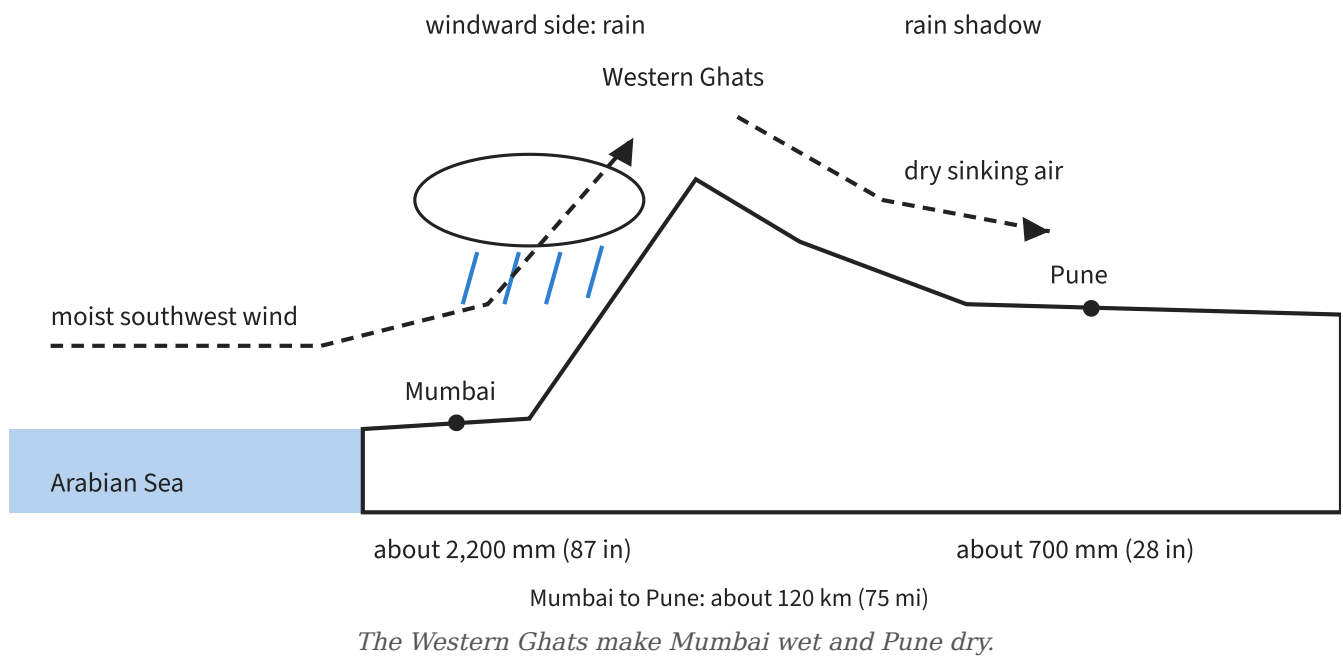
up, cools and pours out its water. Mumbai, at the foot of the Ghats, gets about 2,200 mm (87 in) a year, while Pune, only about 120 km (75 mi) inland on the far side of the hills, gets about 700 mm (28 in), because it sits in the rain shadow. The Bay of Bengal branch drives north into the steep Khasi Hills of Meghalaya. There the town of Cherrapunji recorded 26,461 mm (about 1,042 in) of rain in the twelve months from August 1860 to July 1861, a world record. Turned west by the Himalaya, the same winds water the whole Ganges plain. The mountains also work as a wall in winter, blocking the bitter air of Central Asia, so northern India is far warmer than places at the same latitude in China.

The big idea. In South Asia, the calendar of life follows the wind. Farmers plant rice, cotton and millet when the rains come; a late or weak monsoon has more than once meant hunger, as in the terrible famine of 1876–1878. Long before engines, sailors used the same winds: Arab, Indian and Greek ships sailed east to India with the summer monsoon and home again with the winter one. As Ecclesiastes says, the wind “returneth again according to his circuits.” God ordered the seasons so faithfully that whole nations could plan their year around them. Acts 17:26 tells us He “determined the times before appointed, and the bounds of their habitation,” and few regions show both the times and the bounds as plainly as this one.

On the map. On the monsoon map, trace the Arabian Sea branch striking the west coast and the Bay of Bengal branch sweeping into Bangladesh and turning west along the mountains. Find the Thar Desert, which the rains barely reach, and dry Pune behind the Ghats.



The summer (southwest) monsoon and its two branches.



PICTURE STUDY



Cape Comorin, taken near Calcad, Thomas Daniell and William Daniell, published in *Oriental Scenery* (1795–1808) · Hand-colored aquatint · Copies in the British Library, the Yale Center for British Art and other collections

Thomas Daniell and his young nephew William spent from 1786 to 1793 traveling across India by boat, palanquin and on foot, drawing as they went. Back in London they turned their sketches into 144 aquatints, a kind of etching that can print soft tones like a watercolor, and published them as *Oriental Scenery*. For many people in Britain these prints were their first true look at India's land.

Cape Comorin (today Kanyakumari) is the southern tip of India, where the Arabian Sea, the Indian Ocean and the Bay of Bengal meet. It is also where the Western Ghats come to an end, and it is close to the coast of Kerala, where the summer monsoon first strikes land each year.

Look closely

- Find the highest ground in the picture. These hills are the last of the Western Ghats.
- Find where the hills meet the flatter land. Which side do you think would get the most rain from a southwest wind?
- Look for people, buildings or animals. How big are they compared with the land around them?
- Look at the sky and the light. What season or time of day do you think the artists were showing?

Talk about it

1. Why would artists in the 1790s want to show the people of Britain the shape of India's land?
2. If you stood at this cape on the first of June, what change in the weather might you see coming?
3. An aquatint can be printed many times. How did that help people who would never travel to India?

Safety first. A heat lamp or desk lamp bulb gets very hot. An adult should set it up and move it. Keep the lamp at least 30 cm (12 in) from the trays, never touch the bulb, keep water away from the cord and plug, and switch it off when you finish.

PROJECT: A MONSOON WIND MODEL

You will build a small "subcontinent" of sand beside an "ocean" of water, heat them both with a lamp, and use a thermometer and a wisp of smoke or a thread to see which way the air moves. Then you will cool them and watch the wind reverse, just as the monsoon does.

You will need

- Two identical shallow baking pans or foil trays
- Dry sand or garden soil (enough to fill one pan 3 cm deep)
- Water at room temperature (fill the other pan 3 cm deep)
- A heat lamp or desk lamp with an incandescent or halogen bulb (adult help)
- Two thermometers (kitchen or aquarium), or one used in turns
- A large clear plastic storage box turned on its side, or a cardboard box with the front cut away, to keep drafts out
- An incense stick and matches (adult only), or a 10 cm piece of thin thread taped to a pencil
- A timer, pencil and notebook

Steps

1. Put the sand pan and the water pan side by side, touching, inside the box. Label the sand “India” and the water “Indian Ocean.”
2. Lay a thermometer on the surface of each pan. Record both temperatures at the start.
3. Have an adult aim the lamp so it shines equally on both pans from about 30 cm above. This is the summer sun.
4. Record both temperatures every 2 minutes for 12 minutes. Make a table with columns Time, Sand °C, Water °C.
5. At 12 minutes, an adult lights the incense and holds it low, right where the two pans meet (or hold the thread there). Watch which way the smoke drifts near the surface. Draw an arrow in your notebook.
6. Turn the lamp off and move it away. This is winter. Record temperatures every 2 minutes for another 12 minutes.
7. At the end, test the smoke or thread again at the boundary. Has the direction changed?
8. Make a line graph with two lines, one for sand and one for water, across all 24 minutes.
9. Optional: pile a ridge of damp sand 5 cm high along the edge of the sand pan nearest the water to stand for the Western Ghats, and repeat. Hold a cold metal spoon above the ridge while the lamp heats the water side and look for tiny drops forming on it.

Tips

- Smoke near the surface moves from the cooler pan toward the warmer pan. If it rises straight up, wait a few more minutes for a bigger difference.
- Do the experiment in a still room with fans and air conditioning off.
- Your “winter” wind may be weak. The real winter monsoon is also gentler and drier than the summer one.

Check your work

- I recorded and graphed the temperatures of sand and water.
- I can explain why the sand heated and cooled faster than the water.
- I can explain which way the wind blew in my “summer” and “winter” and how that matches the real monsoon.

MAP NOTEBOOK

1. Draw an outline of South Asia and color the Himalaya brown, the river plains green and the Thar Desert yellow. Add the Western Ghats as a thin brown line on the west coast.
2. Draw the two branches of the summer monsoon as blue arrows, and the winter monsoon as a dashed arrow from the northeast.
3. Draw a side view of the Western Ghats with clouds raining on the Mumbai side and clear sky over Pune. Label “windward” and “rain shadow.”

From history. Sailors learned to ride the monsoon long before anyone could explain it. A Greek merchant's guide written in the first century AD, the *Periplus of the Erythraean Sea*, describes ships sailing straight across the open Arabian Sea to India with the southwest wind instead of creeping along the coast. In 1498 Vasco da Gama, guided by a pilot he had found at Malindi in East Africa, crossed the Arabian Sea with the monsoon behind him and reached Calicut on the Malabar coast in about three and a half weeks.

WORKED EXAMPLES

Example 1. In 1856 Andrew Waugh announced the height of Peak XV as 29,002 feet. In 2020 China and Nepal announced 8,848.86 m. Convert the 2020 figure to feet (1 m = 3.2808 ft) and find how much higher it is than the 1856 figure.

1. Multiply meters by feet per meter: $8,848.86 \times 3.2808 \approx 29,031.5$ ft, about 29,032 ft.
2. Subtract the old figure: $29,032 - 29,002 = 30$ ft.
3. Change 30 ft back to meters: $30 \div 3.2808 \approx 9$ m.

Answer: About 29,032 ft; the 2020 height is about 30 ft (9 m) greater than the 1856 figure, a tiny difference for surveyors working 100 miles away with hand arithmetic.

Example 2. Use the cross-section. Mumbai gets about 2,200 mm of rain a year and Pune, about 120 km (75 mi) inland behind the Western Ghats, gets about 700 mm. (a) How much less rain does Pune get, in mm and inches (25.4 mm = 1 in)? (b) About how many times wetter is Mumbai?

(Use the map or drawing "Windward Mumbai and rain-shadow Pune." shown earlier in this lesson.)

1. (a) $2,200 - 700 = 1,500$ mm less.
2. $1,500 \div 25.4 \approx 59$ in.
3. (b) $2,200 \div 700 \approx 3.1$.

Answer: Pune gets about 1,500 mm (59 in) less rain; Mumbai is about three times wetter, because Pune lies in the rain shadow of the Ghats.

Example 3. A farming town on the Ganges plain gets 1,100 mm of rain a year, and 75% of it falls in the four monsoon months, June through September. How much rain falls in those months, in mm and inches? What is the average per monsoon month, and how much falls in the other eight months together?

1. Monsoon rain: $0.75 \times 1,100 = 825$ mm.
2. In inches: $825 \div 25.4 \approx 32.5$ in.
3. Per monsoon month: $825 \div 4 \approx 206$ mm (about 8 in).
4. Other eight months: $1,100 - 825 = 275$ mm (about 11 in), only about 34 mm a month.

Answer: 825 mm (about 32.5 in) in the monsoon, about 206 mm (8 in) per monsoon month, and only 275 mm (about 11 in) in the other eight months combined. That is why farmers must plant with the rains or irrigate.

PRACTICE

1. **EASY** What language does the word “monsoon” come from, and what does it mean?
2. **EASY** In which months does the wet southwest monsoon usually blow over India, and where does it usually arrive first?
3. **EASY** Name the two seas that the two branches of the summer monsoon cross.
4. **MEDIUM** Mumbai’s yearly rainfall is about 2,200 mm. Convert it to inches ($25.4 \text{ mm} = 1 \text{ in}$).
5. **MEDIUM** Use the monsoon map. Which branch of the monsoon brings rain to Kolkata and Cherrapunji, and which mountains turn that branch toward the west?
(Use the map or drawing “The summer monsoon.” shown earlier in this lesson.)
6. **MEDIUM** Cherrapunji received 26,461 mm of rain from August 1860 to July 1861. Express this in meters and in feet ($1 \text{ m} = 3.281 \text{ ft}$).
7. **MEDIUM** Explain in one or two sentences why Pune is much drier than Mumbai.
8. **HARD** Air cools about 6.5°C for every 1,000 m you climb. If it is 30°C at sea level, about how cold would it be at the height of Mount Everest, 8,849 m? Give $^{\circ}\text{C}$ and $^{\circ}\text{F}$ ($^{\circ}\text{F} = ^{\circ}\text{C} \times 1.8 + 32$).
9. **HARD** The monsoon usually reaches Kerala (about 8.5°N) around June 1 and Delhi (about 28.6°N) around June 28. One degree of latitude is about 111 km. About how fast does the monsoon advance northward, in km and miles per day ($1 \text{ mi} = 1.609 \text{ km}$)?
10. **CHALLENGE** Chennai, on the east coast, gets most of its rain from October to December, not in summer. Using what you know about winds and mountains, explain why.

COMMON MISTAKES

- Thinking “monsoon” means a single storm or just “heavy rain.” A monsoon is a seasonal wind pattern; it brings a wet season and a dry season.

- Thinking water heats as fast as land. Water warms and cools much more slowly, and that difference drives the monsoon.
- Thinking every place in India is wet in summer. Rain shadows, like the Deccan behind the Ghats, and the Thar Desert in the northwest stay much drier.

Make it a game · Which Way Does the Wind Blow?. One player calls out a month and a place, such as “July, Mumbai” or “January, Delhi” or “November, Chennai.” The others hold up a blue card for wet or a tan card for dry and point the way the wind is blowing (southwest wind = point toward the northeast). Score a point for the right weather and a bonus point for naming the reason (sea wind, land wind, mountains or rain shadow). First to ten wins.

Scripture. “The wind goeth toward the south, and turneth about unto the north; it whirleth about continually, and the wind returneth again according to his circuits.” (Ecclesiastes 1:6, KJV)

Solomon noticed that winds follow faithful circuits. The monsoon is one of the clearest examples on earth: year after year it turns with the seasons, and whole nations plant and sail by it.

Practice answers

1. From the Arabic *mawsim*, “season.” A monsoon is a seasonal reversal of the winds.
2. About June through September; it usually reaches the coast of Kerala, in the far southwest, around June 1.
3. The Arabian Sea (west branch) and the Bay of Bengal (east branch).
4. $2,200 \div 25.4 \approx 87$ in.
5. The Bay of Bengal branch; the Himalaya turns it west across the Ganges plain.
6. $26,461 \text{ mm} = 26.461 \text{ m} \approx 26.5 \text{ m}$; $26.461 \times 3.281 \approx 86.8 \text{ ft}$, about 87 feet of water in one year.
7. Moist southwest winds rise over the Western Ghats and drop most of their rain on the Mumbai side; the air that sinks down toward Pune is drier and warmer, so Pune lies in a rain shadow.
8. Drop: $8.849 \times 6.5 \approx 57.5^\circ\text{C}$. Temperature: $30 - 57.5 = -27.5^\circ\text{C}$. In $^\circ\text{F}$: $-27.5 \times 1.8 + 32 = -17.5^\circ\text{F}$.
9. Distance: $(28.6 - 8.5) \times 111 \approx 20.1 \times 111 \approx 2,230 \text{ km}$. Time: 27 days. Speed: $2,230 \div 27 \approx 83 \text{ km a day}$, about 51 mi a day.
10. In summer Chennai lies on the dry, sheltered side of the Western Ghats, so the southwest monsoon gives it little rain. In autumn and early winter the winds turn to the northeast and cross the Bay of Bengal, picking up moisture, and they reach the Tamil Nadu coast from the sea, so Chennai gets its heaviest rain then.

5.2 THE GANGES AND THE INDUS

OBJECTIVES

- Trace the Indus and the Ganges from their mountain sources to the sea and name their main tributaries and cities.
- Explain why the great river plains of South Asia can feed hundreds of millions of people, and how the two farming seasons, kharif and rabi, follow the monsoon.
- Describe how these rivers shaped the history and faiths of the region, from the Indus cities to Hindu, Buddhist, Sikh, Muslim and Christian history, and use map scale and population density.

Warm-up. Pour a cup of water slowly down a tilted cookie sheet sprinkled with a thin layer of sand or flour. Watch where the water runs and where it drops the sand. Where does the most sand pile up: at the top, the middle or the bottom where the water spreads out? That pile is a tiny delta.

Watch. *Indus Valley Civilization - Ancient Civilizations DOCUMENTARY* (Kings and Generals, 19:31). <https://www.youtube.com/watch?v=7GRob-zFs0k>

After the story: watch the sections on the cities of Harappa and Mohenjo-daro and look for the grid streets, covered drains, wells and the Great Bath that Marshall's 1924 report described.

Note: Captions were not available to check; preview it first. It runs nearly 20 minutes and opens with a members and Patreon appeal. It also talks about the Indus people's religion and gives dates in BCE, which may differ from the lesson. It covers the Indus civilization only, not the Ganges. Dates and site spellings (for example 'Mohenjo Daro') may differ from the lesson.

Backup video. *Mohenjo Daro 101 | National Geographic* (National Geographic, 3:15). <https://www.youtube.com/watch?v=QUng-iHhSzU>

After the story: watch this overview of Mohenjo-daro, the planned city on the Indus. Note: Captions were not available to check; preview it first. It may give dates for the city that differ from the book.

KEY TERMS

tributary

A river that flows into a larger river, such as the Yamuna into the Ganges or the Chenab into the Indus.

alluvium

Fine, fertile silt and sand laid down by rivers, especially in floods. The plains of the Indus and Ganges are made of deep alluvium.

delta

Low, flat land built of river sediment where a river splits into branches before reaching the sea.

confluence

The place where two rivers join.

kharif and rabi

South Asia's two main crop seasons: kharif crops (such as rice and cotton) are sown with the summer monsoon and harvested in autumn; rabi crops (such as wheat and mustard) are sown in autumn and harvested in spring.

irrigation

Bringing water to fields by canals, wells or pumps when rain is not enough.

CORE IDEAS

The story. On September 20, 1924, readers of the *Illustrated London News* opened their paper to an astonishing report. Sir John Marshall, head of the Archaeological Survey of India, announced that digs at two sites far apart in the Indus basin, Harappa in the Punjab and Mohenjo-daro in Sindh, had uncovered the same forgotten civilization. Its brick cities had grid streets, covered drains, wells and, at Mohenjo-daro, a great waterproofed bath; bricks and trade weights matched from city to city. Indian archaeologists Daya Ram Sahni (Harappa, 1921) and R. D. Banerji (Mohenjo-daro, 1922) had led the first digs. This Indus civilization flourished from roughly 2600 to 1900 BC, and its writing has never been deciphered.

The physical setting. Both great rivers are born in the Himalaya. The **Indus** rises in Tibet, near Mount Kailash, flows northwest through Ladakh, cuts south through the mountains and runs the length of Pakistan to the Arabian Sea near Karachi, a journey of about 3,000 km (1,860 mi). In the Punjab it gathers five tributaries, the Jhelum, Chenab, Ravi, Beas and Sutlej; *Punjab* means "five waters." The **Ganges** (Ganga) begins at the Gangotri Glacier as the Bhagirathi, joins the Alaknanda at Devprayag, and leaves the mountains at Haridwar. It flows about 2,500 km (1,550 mi) east across northern India, joined by the Yamuna at Prayagraj (Allahabad), past Varanasi and Patna, into Bangladesh. There it meets the Brahmaputra and the Meghna to build the Ganges-Brahmaputra delta, the largest delta on earth, whose southern edge is the mangrove forest of the Sundarbans.

How the plains feed so many. The two rivers are fed twice: by melting Himalayan snow and glaciers in spring and early summer, and by the monsoon rains in summer. For ages their floods spread alluvium over plains hundreds of kilometers wide and almost perfectly flat. Rich soil, steady water and a warm climate let farmers harvest twice a year: *kharif* crops such as rice and cotton are planted when the monsoon arrives, and *rabi* crops such as wheat and mustard in the cool, dry autumn. The wetter east grows rice; the drier Punjab is wheat country. Sindh gets little rain, so, like Egypt on the Nile, it depends on irrigation; Pakistan's Indus canals form one of the largest connected irrigation networks in the world. In the 1960s, high-yielding wheat developed by the American scientist Norman Borlaug, with wells, fertilizer and canals, sharply raised harvests in India and Pakistan, part of the Green Revolution. Today the Ganges basin alone is home to more than 400 million people.

Rivers and the history of peoples and faiths. The river plains were the open road of South Asia, and almost every invader, empire and faith passed along them. The word *India* itself comes from the Sanskrit name of the Indus, *Sindhu*, through Persian and Greek. Hindus revere the Ganga as holy; millions bathe at Varanasi, one of the world's oldest continuously inhabited cities, and at the great Kumbh Mela gatherings at Prayagraj. The Buddha preached his first sermon at Sarnath, just outside Varanasi. Islam arrived in Sindh by the Indus in AD 711, and the Mughal emperors later ruled from Delhi and Agra on the Yamuna. Sikhism began in the Punjab with Guru Nanak (1469-1539), and its holiest shrine, the Golden Temple, stands at Amritsar. Christianity came up the Hooghly, the Ganges distributary on which Kolkata stands, as you will see in Lesson 5.4.

Rivers and borders. When British India was divided in 1947, the new border cut through the Punjab and Bengal, and the Indus system was split between India upstream and Pakistan downstream. After years of talks, the 1960 Indus Waters Treaty, brokered by the World Bank, gave the three eastern rivers (Ravi, Beas, Sutlej) to India and most of the water of the three western rivers (Indus, Jhelum, Chenab) to Pakistan. It lasted through several wars. In April 2025, after a deadly attack on tourists in Kashmir, India announced it was holding the treaty "in abeyance"; Pakistan rejected the move. As of 2026 the dispute over the treaty is unresolved.

On the map. Trace the Indus from Tibet to Karachi and the Ganges from the Himalaya to the Bay of Bengal. Notice that the Ganges plain is a long corridor between the Himalaya and the Deccan.



The Indus and Ganges river plains.

PICTURE STUDY



Hindoo Temples at Bindrabund on the River Jumna, Thomas Daniell and William Daniell, published in *Oriental Scenery* (1795–1808) · Hand-colored aquatint · Copies in the British Library, the Yale Center for British Art and other collections

Bindrabund is the old English spelling of Vrindavan, a town on the River Jumna (the Yamuna), the longest tributary of the Ganges. The Daniells traveled up the Ganges valley in 1788–1789, much of the way by boat, sketching towns, forts and temples along the banks.

Along these rivers, towns face the water. Wide stone steps called *ghats* lead down to the river, where people bathe, wash, draw water and pray. The prints let us see a river town as it looked more than two hundred years ago, before railways and bridges changed the riverbanks.

Look closely

- Find the river. How do the buildings and steps meet the water?
- Look for people. What are they doing, and how does the river fit into their day?
- Look at the buildings. What shapes do the temple towers have?
- Find any boats. Why would a river like this have been a main road for travelers?

Talk about it

1. Why do so many old towns on the Ganges and Yamuna face the river instead of turning their backs to it?
2. What would this riverbank look like in the dry season compared with the height of the monsoon?
3. How do you think the Daniells traveled to reach this place in 1789?

PROJECT: A SAND-TRAY RIVER PLAIN AND DELTA

You will build a river from “mountains” to “sea” in a long tray, watch it carry and drop sediment to build a plain and a delta, and then dig irrigation canals to water fields, as farmers in the Punjab and Sindh have done for centuries.

You will need

- A large shallow plastic storage box or a disposable foil roasting pan (at least 40 cm long)
- Play sand mixed with a few spoonfuls of fine soil or flour
- A few small rocks for the mountains
- A watering can or a plastic cup with small holes punched in the bottom
- A block or book to tilt the tray
- A craft stick or spoon for digging canals
- Small squares of green paper or cress seeds for “fields”
- Toothpick flags labeled Haridwar, Prayagraj, Varanasi, Patna, Kolkata

Steps

1. Pile sand thickly at one end of the tray with rocks on top for the Himalaya. Leave the other end empty for the Bay of Bengal. Prop the mountain end up 3 to 4 cm.
2. Press a gentle, winding channel from the mountains toward the sea with your finger.
3. Sprinkle water slowly on the mountains for two minutes. This is spring snowmelt. Watch where the water runs and where it drops sand.
4. Now pour faster for one minute. This is the monsoon flood. Look for sand spreading out sideways (the flood plain) and fanning out at the sea end (the delta).
5. Sketch what happened. Mark where the river split into branches near the sea.
6. Plant your toothpick city flags along the river in the right order from mountains to sea.
7. Dig a narrow canal from the river to a patch of “fields” away from the river. Pour again gently and see whether the canal carries water to your fields.
8. Measure the length of your river with a string and ruler. If your tray’s river stands for the 2,500 km Ganges, how many kilometers does each centimeter represent?

Tips

- Too much water at once will wash everything into the sea. Gentle and steady works best.
- Real deltas build over centuries; your model shows the same process in minutes.
- Keep a towel under the low end of the tray.

Check your work

- I can point to the source, a tributary, the flood plain and the delta on my model.
- I can explain why floods make river plains fertile.
- I can explain how a canal lets farmers grow crops away from the river.

MAP NOTEBOOK

1. Draw the Indus and its five Punjab tributaries, labeling each river and the cities of Lahore, Harappa, Mohenjo-daro and Karachi.
2. Draw the Ganges from Gangotri to the Bay of Bengal, adding the Yamuna and the Brahmaputra and the cities of Delhi, Prayagraj, Varanasi, Patna, Kolkata and Dhaka.
3. Make a two-row crop calendar for the Ganges plain: one row for kharif (rice) and one for rabi (wheat), with sowing and harvest months marked.

From history. The Greek writer Arrian, drawing on accounts of Alexander the Great's march, described how Alexander's army reached the Hyphasis (the Beas), the easternmost of the Punjab rivers, in 326 BC. His exhausted soldiers, who had marched all the way from Macedonia and faced the monsoon rains in the Punjab, refused to go farther, and Alexander turned back and went down the Indus to the sea. The rivers of the Punjab marked the farthest limit of his empire.

WORKED EXAMPLES

Example 1. On a map with a scale of 1 cm = 100 km, the straight-line distance from Harappa to Mohenjo-daro measures 5.9 cm. How far apart were these two Indus cities, in kilometers and miles (1 mi = 1.609 km)?

(Use the map or drawing "Find Harappa and Mohenjo-daro on the Indus system." shown earlier in this lesson.)

1. Multiply the map distance by the scale: $5.9 \times 100 = 590$ km.
2. Convert: $590 \div 1.609 \approx 367$ mi.
3. Check with latitude: the cities are about 3.3° of latitude apart (about 366 km north-south) and also far apart east-west, so a total near 590 km makes sense.

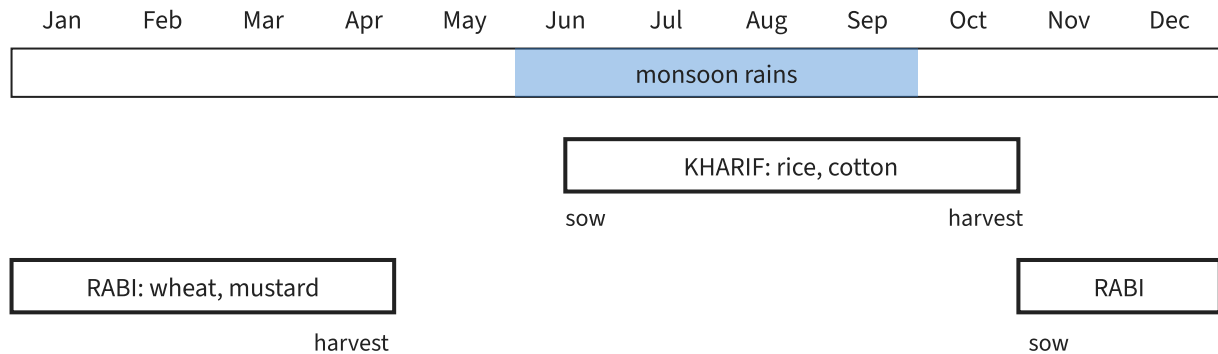
Answer: About 590 km (about 370 mi). That two cities so far apart used the same bricks and weights shows how well the Indus valley was connected by its river.

Example 2. Bangladesh, which lies almost entirely on the Ganges-Brahmaputra delta, counted about 169.8 million people in its 2022 census, on about 147,600 km² (57,000 sq mi) of land. Find its population density per square kilometer and per square mile.

1. Per km²: $169,800,000 \div 147,600 \approx 1,150$ people per km².
2. Per sq mi: $169,800,000 \div 57,000 \approx 2,980$ people per sq mi.
3. Compare: that is many times denser than most countries, possible only because the delta's soil and water allow very intensive rice farming.

Answer: About 1,150 people per km² (about 2,980 per sq mi) in 2022.

Example 3. Use the crop calendar. A Punjab farmer sows rice in late June and harvests it in October, then sows wheat in November and harvests it in April. (a) About how many months is each crop in the field? (b) Which crop depends on the monsoon, and which depends mostly on stored soil water, winter showers and irrigation?



The two crop seasons of the river plains.

1. (a) Rice: late June to October is about 4 months. Wheat: November to April is about 5 months.
2. (b) Rice is a kharif crop, sown when the monsoon rains arrive.
3. Wheat is a rabi crop, grown through the cool, dry winter, so it needs irrigation from canals and wells.

Answer: Rice about 4 months (kharif, monsoon-fed); wheat about 5 months (rabi, irrigated). Two harvests a year from one field is one reason the plains can feed so many.

PRACTICE

1. **EASY** Name the five rivers of the Punjab. What does “Punjab” mean?
2. **EASY** Where does the Ganges begin, and into what body of water does it end?
3. **EASY** At which city does the Yamuna join the Ganges?
4. **MEDIUM** The Indus is about 3,000 km long and the Ganges about 2,500 km. Convert both to miles (1 mi = 1.609 km) and find the difference in miles.
5. **MEDIUM** Use the river map. List these cities in order from upstream to downstream along the Ganges: Patna, Haridwar, Varanasi, Prayagraj.
(Use the map or drawing “The Indus and Ganges river plains.” shown earlier in this lesson.)
6. **MEDIUM** Name two features found in the cities of the Indus civilization that show careful planning.
7. **MEDIUM** Under the 1960 Indus Waters Treaty, which three rivers went mainly to India and which three mainly to Pakistan?
8. **HARD** In the 2011 census, the Indian state of Uttar Pradesh, on the Ganges plain, had about 199.8 million people on about 240,900 km². Find its population density per km² and per sq mi (1 km² = 0.386 sq mi).

9. **HARD** Why does the lower Indus plain in Sindh depend on irrigation more than the Ganges delta in Bangladesh does?
10. **CHALLENGE** In a short paragraph, explain three reasons why the river plains of South Asia have supported so many people for so long.

COMMON MISTAKES

- Placing the Indus in India only. Most of the Indus flows through Pakistan, though its upper course and several tributaries begin in Tibet and India.
- Thinking the Ganges flows south to the sea from its source. It flows mainly east and southeast across northern India before turning south through Bangladesh.
- Thinking a river plain is fertile only because of rain. The soil itself was built by countless floods spreading fresh alluvium.

Make it a game • Source to Sea Relay. Lay ten index cards face down, each naming a place: Gangotri, Devprayag, Haridwar, Prayagraj, Varanasi, Patna, Kolkata, Sundarbans, Bay of Bengal, and one “Yamuna joins here” card. Players race to put them in order from source to sea on the floor, then do the same with an Indus set (Tibet, Ladakh, Punjab’s five rivers, Mohenjo-daro, Karachi, Arabian Sea). Fastest correct line wins; a mistake costs a 10-second penalty.

Scripture. “Thou visitest the earth, and waterest it: thou greatly enrichest it with the river of God, which is full of water: thou preparest them corn, when thou hast so provided for it.” (Psalm 65:9, KJV)

The psalmist sees rain and rivers as God’s care for the land, preparing grain for people to eat. The Indus and the Ganges, filled by snow and monsoon, are a vast example of land enriched by water.

Practice answers

1. Jhelum, Chenab, Ravi, Beas and Sutlej. Punjab means “five waters.”
2. It begins at the Gangotri Glacier in the Himalaya (as the Bhagirathi) and ends in the Bay of Bengal, through the Ganges-Brahmaputra delta.
3. Prayagraj (formerly Allahabad).
4. Indus: $3,000 \div 1.609 \approx 1,860$ mi. Ganges: $2,500 \div 1.609 \approx 1,550$ mi. Difference ≈ 310 mi.
5. Haridwar, Prayagraj, Varanasi, Patna.
6. Any two: streets laid out in a grid, covered drains, standard-sized bricks, standard weights, wells, granaries, the Great Bath at Mohenjo-daro.
7. India: the eastern rivers, Ravi, Beas and Sutlej. Pakistan: the western rivers, Indus, Jhelum and Chenab.
8. $199,800,000 \div 240,900 \approx 829$ people per km^2 . Area in sq mi: $240,900 \times 0.386 \approx 93,000$ sq mi; $199,800,000 \div 93,000 \approx 2,150$ people per sq mi.
9. Sindh lies in the far west, where the monsoon is weak and the land is close to desert, so little rain falls; farmers must take water from the Indus by canals. The delta in Bangladesh receives heavy monsoon rain directly from the Bay of Bengal and is crossed by many river branches.

10. A good answer names reasons such as: deep, fertile alluvium renewed by floods; water from both Himalayan snowmelt and the monsoon, so the rivers keep flowing; flat land that is easy to plow and irrigate with canals; a warm climate that allows two harvests a year (kharif and rabi); and rivers that serve as roads for trade.

5.3 THE RAILWAYS OF INDIA

OBJECTIVES

- Tell the story of India's first passenger train, Bombay to Thane on April 16, 1853, and explain why railways spread so quickly across the plains.
- Explain how engineers carried railways over the Western Ghats and up into the Himalaya and Nilgiri Hills using inclines, reversing stations, loops, zigzags and a rack.
- Calculate average speeds and gradients, and weigh honestly what the railways gave India and whom they first served.

Warm-up. Lean a book against a stack of other books to make a steep ramp and try to push a toy car up it with one finger. Then lay a long ribbon or string in zigzags up the same height on a pillow or a pile of cushions. Which path is longer? Which is easier to climb? Engineers face exactly this choice in the mountains.

Watch. *How India Built the World's Highest Railway Bridge Over a Himalayan Abyss* (Sabin Civil Engineering, 11:49). <https://www.youtube.com/watch?v=5PYjFLMoxOg>
With the big idea: after reading about the mountain railways, watch how engineers carried a railway across a deep Himalayan gorge on the Chenab Bridge, a modern answer to the same problem of getting trains through mountains.

Note: Captions were not available to check; preview it first. It is about a modern bridge, not the 1853 first railway or the Darjeeling and Nilgiri lines, and the channel promotes an engineering company (JAES) and its Patreon. Covers the Chenab Bridge (opened 2025), not the Darjeeling Himalayan Railway, the Nilgiri rack railway or the 1853 Bombay-Thane line.

Backup video. *India's First High Speed Railway: Mumbai-Ahmedabad Bullet Train Project* (Railways Explained, 11:34). <https://www.youtube.com/watch?v=HqeVrXTqLOM>
As review: compare the first train of 1853, which took about an hour to go 34 km (21 mi), with the planned bullet train between Mumbai and Ahmedabad, and notice how India's railways are still growing. Note: Captions were not available to check; preview it first. It is about a high-speed line still being built, so some of its dates and facts may now be out of date, and it opens with Patreon and store plugs. Covers the modern Mumbai-Ahmedabad high-speed project, not the historic railways in the lesson.

KEY TERMS

gradient

The steepness of a track or road, written as a ratio (1 in 40 means a rise of 1 m for every 40 m along) or as a percent (1 in 40 = 2.5%).

ghat

In railway and road building in India, a steep mountain pass, especially across the Western Ghats; the word also means steps leading down to a river.

reversing station (zigzag)

A place where a train runs into a dead-end siding and then backs up a second slope, climbing the hillside in a Z shape without needing to turn around.

loop

A spiral where the track circles around and crosses over itself on a bridge or through a tunnel, gaining height in a small space.

rack railway

A railway with a toothed rail between the running rails; a gear wheel under the locomotive grips it so the train can climb grades too steep for smooth wheels.

gauge

The distance between the two rails. India's main lines use broad gauge, 1,676 mm (5 ft 6 in); some hill lines use narrow gauge, as little as 610 mm (2 ft).

CORE IDEAS

The story. On the afternoon of April 16, 1853, crowds packed the shore at Bori Bunder in Bombay (today Mumbai). A band played and guns fired a salute as a train of fourteen carriages, carrying about 400 guests, pulled out behind three steam locomotives named *Sultan*, *Sindh* and *Sahib*. It ran north about 34 km (21 mi), off Bombay Island and across Salsette Island, to Thane in a little over an hour. It was the first passenger train in South Asia, built by the Great Indian Peninsula Railway. That same year the governor-general, Lord Dalhousie, wrote a famous minute (report) urging a network of trunk lines to tie the ports of Bombay, Calcutta and Madras to the interior.

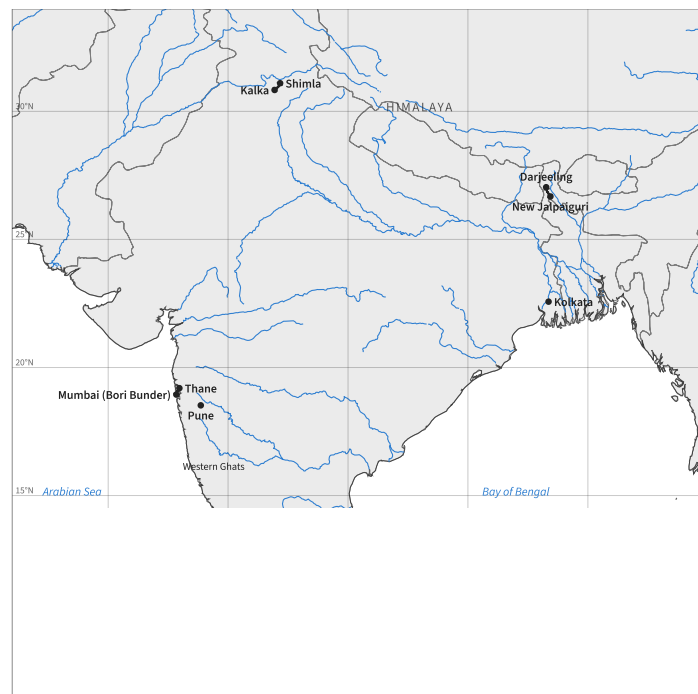
Why the plains were easy. As you saw in Lesson 5.2, the Ganges plain is enormous and almost perfectly flat, and engineers could lay track across it for hundreds of kilometers with few grades. The hard parts were the great rivers, which needed long bridges able to survive monsoon floods, and the mountains. By 1900 India had about 40,000 km (25,000 mi) of railway. Lines carried cotton from the Deccan and wheat from the Punjab to the ports, and grain could now move quickly to districts struck by drought.

How they climbed. Bombay's trains had to cross the Western Ghats, a wall rising about 600 m (2,000 ft) out of the coastal plain. The Bhor Ghat incline toward Pune (1863) and the Thal Ghat incline toward Nashik (1865) wind up the cliffs through tunnels and over viaducts. On the Bhor Ghat, engineers used a **reversing station**: the train ran into a dead-end ledge and then backed up the next slope. Thousands of laborers cut the rock by hand, and many died of accidents and disease. Later came the hill railways. The **Darjeeling Himalayan Railway** (1881) climbs from the plains to Darjeeling, about 2,100 m (6,800 ft) high, on track only 610 mm (2 ft) wide, using tight **loops** and **zigzag reverses**. The **Nilgiri Mountain Railway** (completed to Ooty in 1908) is as steep as 1 in 12.28 in places, too steep for plain wheels, so it uses a **rack** and Swiss-built locomotives with gear wheels. The **Kalka-Shimla Railway** (1903) reached the summer capital of British India through more than 100 tunnels. UNESCO lists all three as the Mountain Railways of India.

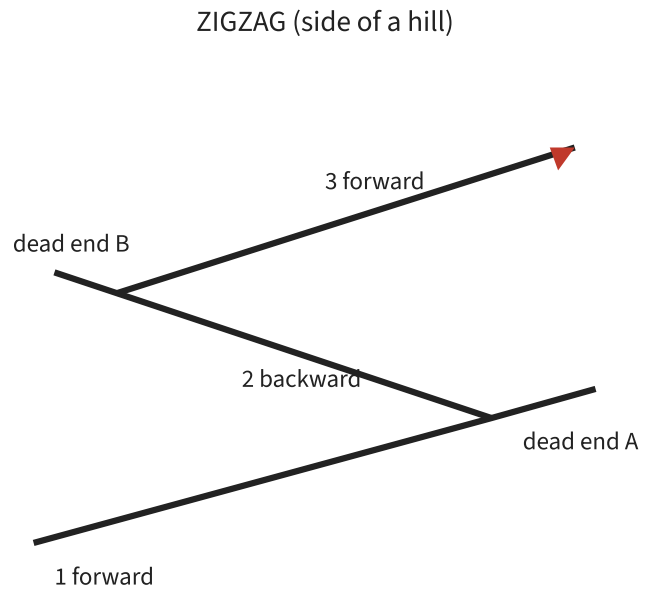
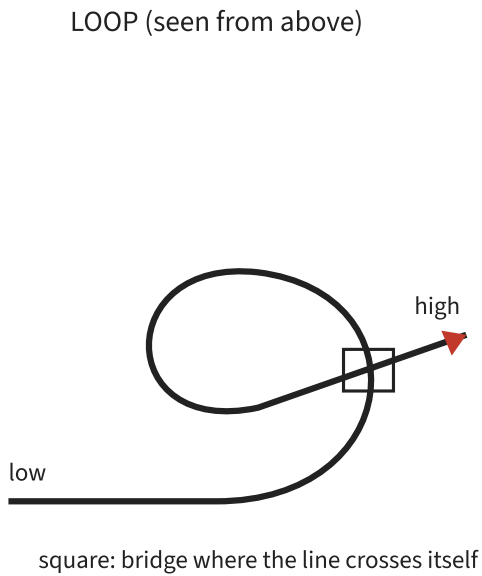
Technology overcoming geography, weighed honestly. The railways were built mainly to serve British trade and the British army, and private companies were guaranteed a profit paid out of Indian taxes even when lines lost money. In the famine of 1876–1878 grain still moved by rail to markets and ports while people starved in some districts, though in later famines the railways became a main tool of relief. Yet the railways also bound the subcontinent together. Pilgrims, students and traders could cross India in days instead of months; Mohandas Gandhi traveled the country third class to meet ordinary people. After independence in 1947, Indian Railways became one of the largest railway systems and largest employers in the world.

The big idea. Mountains do not move, but people can find ways over them: by lengthening the route to lessen the grade, by turning back on themselves, by gripping the rail with gears. Each method trades distance or speed for height. Today Mumbai's suburban trains carry millions of riders every day along the same corridor as the 1853 line, and new engineering keeps pushing into hard country: the Chenab Bridge in Jammu and Kashmir, opened in 2025, carries trains about 359 m (1,180 ft) above the river, the highest railway arch bridge in the world.

On the map. Find Mumbai, Thane and the Western Ghats just inland, then the three hill railways: Darjeeling in the eastern Himalaya, Shimla in the western foothills, and Ooty in the Nilgiri Hills, where the Western and Eastern Ghats meet.



India's first railway and the three mountain railways.



Two ways to climb a mountain by rail.

PICTURE STUDY



Victoria Terminus, Bombay, Photographer unknown, about 1890–1910 · Albumen print mounted in a travel album · Rijksmuseum, Amsterdam (RP-F-F01104-AG)

Within sight of Bori Bunder, where the first train left in 1853, the Great Indian Peninsula Railway built a grand new headquarters and terminus. Designed by the architect Frederick William Stevens and finished in 1888, it was named Victoria Terminus. It mixes the pointed arches of European Gothic churches with domes, carvings and craftsmanship from Indian traditions, much of it carved by students of Bombay's art school. On top of the central dome stands a statue of a woman holding a torch, called *Progress*.

Today the station is called Chhatrapati Shivaji Maharaj Terminus, after the seventeenth-century Maratha king, and it is a UNESCO World Heritage Site. It is still one of the busiest stations in India.

Look closely

- Find the central dome and the statue on top. Why do you think the builders chose “Progress” for a railway station?
- Look at the arches, towers and windows. Do they remind you more of a church, a palace or a factory?
- Look for people, carriages or carts in front. How did travelers reach the station before motor cars?
- Compare the size of the building with the people. What message does its size send?

Talk about it

1. Why would a railway company spend so much money on a beautiful station instead of a plain shed?
2. The station has been renamed twice. What does a new name tell us about how a country remembers its history?
3. What would the land have looked like here in 1853, when the first train left from Bori Bunder?

PROJECT: CLIMB THE GHATS: A MODEL MOUNTAIN RAILWAY

You will build a cardboard “mountain” and lay three different routes up it: straight, looping and zigzag. Then you will measure each route’s length and gradient and test which one a toy car or marble can climb or descend safely.

You will need

- A sturdy cardboard box about 20 to 30 cm tall, or a stack of books, for the mountain
- Thin cardboard strips (cereal-box card) about 4 cm wide, or flexible plastic marble-run track
- Masking tape and scissors
- A ruler or tape measure and a string
- A small toy car or marble
- Pencil, notebook and calculator

Steps

1. Measure the height of your mountain in centimeters. Write it down; this is the rise for every route.
2. Route 1, the straight climb: tape one strip from the floor straight to the top. Measure its length along the strip.
3. Route 2, the zigzag: make a path of three or four sloping legs that switch back across the face of the box. At each turn, add a short flat “dead end” where a train would stop

and reverse. Measure the total length.

4. Route 3, the loop: curl a strip in a spiral around the box, crossing over itself once, from the floor to the top. Measure its total length with string.
5. For each route, find the gradient: divide the length by the height to get "1 in __," and divide the height by the length and multiply by 100 to get a percent.
6. Test each route by letting the car or marble roll down from the top. Which route lets it arrive slowest and most safely? Which would be easiest for a heavy train to climb?
7. Make a table: Route, Length, Rise, Gradient (1 in __), Gradient (%), Notes.
8. Write two sentences: Which route would you build for a real railway, and what would it cost in extra track, time or tunnels?

Tips

- Real main-line railways try to keep gradients gentler than about 1 in 40 (2.5%); your model will be much steeper, but the comparison still works.
- Tape the strips firmly at every turn so they do not sag.
- A zigzag needs space for the train to fit fully on each flat dead end.

Check your work

- I built and measured three routes to the same height.
- I can calculate a gradient as a ratio and as a percent.
- I can explain why longer routes make gentler grades, and what they cost.

MAP NOTEBOOK

1. Draw a map of India and mark Mumbai, Thane, Pune, Darjeeling, Shimla and Ooty. Draw the first 1853 line in red.
2. Draw a side view of a reversing station: the train runs forward into a dead end, then backs up the next slope.
3. Sketch a rack rail from above and from the side, showing the toothed rail and the locomotive's gear wheel.

From history. The famous little blue engines of the Darjeeling Himalayan Railway, the B class, were built mostly in Glasgow between 1889 and 1925, and several are still at work more than a century later. Near Darjeeling the line passes the Batasia Loop, where the track spirals around a garden; on a clear morning passengers there can see Kangchenjunga, at 8,586 m (28,169 ft) the third-highest mountain in the world.

WORKED EXAMPLES

Example 1. The first train ran about 34 km (21 mi) from Bori Bunder to Thane. Accounts of the run give times of a little over an hour. Using 75 minutes, find the average speed in km/h and mph.

1. Change the time to hours: $75 \div 60 = 1.25$ h.
2. Speed = distance $\div$ time = $34 \div 1.25 = 27.2$ km/h.
3. In miles: $21 \div 1.25 = 16.8$ mph.

Answer: About 27 km/h (about 17 mph), slow by today's standards but faster and smoother than any bullock cart or palanquin.

Example 2. The steepest part of the Nilgiri Mountain Railway has a gradient of 1 in 12.28. (a) How many meters does the track rise in 1 km of track? (b) Express the gradient as a percent. (c) Compare with a typical main-line limit of about 1 in 40.

1. (a) Rise = $1,000 \text{ m} \div 12.28 \approx 81$ m per km of track (about 430 ft per mile).
2. (b) Percent = $1 \div 12.28 \times 100 \approx 8.1\%$.
3. (c) $1 \text{ in } 40 = 2.5\%$. The Nilgiri grade is about $8.1 \div 2.5 \approx 3.3$ times steeper.

Answer: About 81 m of rise per km, a grade of about 8.1%, more than three times the usual main-line limit. That is why the line needs a rack.

Example 3. Use the map. The Darjeeling Himalayan Railway runs about 88 km (55 mi) from New Jalpaiguri, about 114 m above sea level, to Darjeeling, about 2,076 m. Find the total rise and the average gradient as a percent and as "1 in ____."

(Use the map or drawing "Find New Jalpaiguri and Darjeeling." shown earlier in this lesson.)

1. Rise: $2,076 - 114 = 1,962$ m (about 6,440 ft).
2. Change the track length to meters: $88 \text{ km} = 88,000$ m.
3. Percent: $1,962 \div 88,000 \times 100 \approx 2.2\%$.
4. Ratio: $88,000 \div 1,962 \approx 45$, so about 1 in 45.

Answer: A rise of about 1,960 m (6,440 ft) at an average gradient of about 2.2%, or 1 in 45. Some stretches are much steeper, which is why the line needs loops and zigzags.

PRACTICE

1. **EASY** On what date did India's first passenger train run, and between which two places?
2. **EASY** What is a rack railway, and which of India's mountain railways uses one?
3. **EASY** Name the three lines listed by UNESCO as the Mountain Railways of India.

4. **MEDIUM** Use the loop and zigzag diagram. Explain in your own words how a zigzag lets a train climb without turning around.
(Use the map or drawing “A loop and a zigzag.” shown earlier in this lesson.)
5. **MEDIUM** The Nilgiri line climbs from Mettupalayam, about 326 m above sea level, to Ooty (Udhagamandalam), about 2,203 m. Find the rise in meters and feet (1 m = 3.281 ft).
6. **MEDIUM** The uphill Nilgiri trip of about 46 km takes about 5 hours. What is the average speed in km/h and mph?
7. **MEDIUM** Convert a gradient of 1 in 40 to a percent, and say how many feet a train climbs in one mile (5,280 ft) of such track.
8. **HARD** India’s broad gauge is 1,676 mm and the Darjeeling line’s gauge is 610 mm. How many times wider is broad gauge? Give both gauges in feet and inches. Why might a narrow gauge suit a mountain line?
9. **HARD** Use the map. Which of the three hill railways lies farthest south, and which lies farthest east? Name the mountains each climbs.
(Use the map or drawing “India’s mountain railways.” shown earlier in this lesson.)
10. **CHALLENGE** Write a short paragraph weighing the railways of British India: name two ways they served British interests first and two ways they helped the people of India.

COMMON MISTAKES

- Thinking a steeper, shorter route is always better. Locomotives lose grip on steep grades, so engineers often build a longer, gentler line.
- Confusing a loop with a zigzag. A loop spirals and crosses over itself; a zigzag reverses direction at dead ends.
- Writing a gradient of 1 in 40 as 40%. It is $1 \div 40$, which is 2.5%.

Make it a game • Grade Detective. Set up a ramp with a board and books. One player sets a height and a length; the others race to call out the gradient as “1 in ___” and as a percent. Then roll a toy car down. If it rolls off the end before the 3-second count, the grade is “too steep for a train” and the setter must make it gentler. A correct gradient scores a point; a correct “rack, loop or zigzag?” call for a very steep setting scores a bonus.

Scripture. “Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain:” (Isaiah 40:4, KJV)

Isaiah’s words are about preparing the way for the Lord, as John the Baptist did. Engineers who cut ledges into the Ghats and build bridges over rivers are doing on a small scale what the prophet pictured: making a level road where none could go.

Practice answers

1. April 16, 1853, from Bori Bunder in Bombay (Mumbai) to Thane.
2. A railway with a toothed rail between the running rails that a gear wheel on the locomotive grips, so the train can climb very steep grades. The Nilgiri Mountain Railway uses one.

3. The Darjeeling Himalayan Railway, the Nilgiri Mountain Railway and the Kalka-Shimla Railway.
4. The train climbs one slope forward into a dead-end siding, then the points are changed and it runs backward up the next slope to another siding, then forward again, climbing the hillside in a Z shape.
5. $2,203 - 326 = 1,877$ m; $1,877 \times 3.281 \approx 6,158$ ft, about 6,160 ft.
6. $46 \div 5 = 9.2$ km/h; $9.2 \div 1.609 \approx 5.7$ mph, about the speed of a brisk jog.
7. $1 \div 40 \times 100 = 2.5\%$. $5,280 \div 40 = 132$ ft per mile.
8. $1,676 \div 610 \approx 2.75$ times. Broad gauge is 5 ft 6 in; the Darjeeling gauge is 2 ft. Narrow-gauge trains are lighter and can take much tighter curves, so the track can wind around steep slopes and cost less to build.
9. Farthest south: the Nilgiri Mountain Railway (to Ooty), in the Nilgiri Hills. Farthest east: the Darjeeling Himalayan Railway, in the eastern Himalaya. (The Kalka-Shimla line climbs the western Himalayan foothills.)
10. A good answer notes, for example, that the lines were planned to carry raw cotton and grain to the ports and to move troops, and that private companies were guaranteed profits paid from Indian taxes; and on the other side that railways later carried famine relief, let pilgrims, traders and families travel cheaply, connected distant regions and helped build a sense of one country. The answer should judge both sides fairly.

5.4 CAREY, CARMICHAEL AND THE CHURCH IN INDIA

OBJECTIVES

- Describe the main faiths of South Asia accurately and the long history of Christianity there, from the ancient churches of Kerala to the missionaries of the 1700s and 1800s.
- Tell the stories of William Carey at Serampore and Amy Carmichael at Dohnavur, and explain how geography (rivers, ports, colonies and languages) shaped their work.
- Explain how India's major language families are spread across the map, and calculate distances, travel times and census shares.

Warm-up. Write the word “water” in English. Now try to say it in any other language you know (Spanish *agua*, French *eau*, German *Wasser*). If you had to translate a whole book into a language you had never heard before, with no dictionary, how would you start? List three steps.

Watch. *The Continuing Growth of Christianity in India - "Ends of the Earth"* (Drive Thru History with Dave Stotts, 4:01). https://www.youtube.com/watch?v=7V_58L6PSkE
As review: after reading about Carey and Carmichael, watch Dave Stotts show how the church in India has kept growing since their time.

Note: Captions were not available to check; preview it first. It is about the church in India today and may not name Carey or Carmichael. The video description mentions the 2020 health crisis in a broadcast notice, not in the video itself. It may not mention William Carey, Serampore, Amy Carmichael or Dohnavur.

Backup video. *Missionaries in India, 1950s Film 44252* (HuntleyFilmArchives, 26:54). <https://www.youtube.com/watch?v=Nk1qsIhod50>

As review: watch this 1950s archive film of missionary work in India, and look for the villages, rivers and crops from the lesson. Note: Captions were not available to check; preview it first. Old archive film.

KEY TERMS

missionary

A person sent to make the gospel known to people in another place or culture, often also teaching, healing or translating.

translation

Carrying the meaning of words from one language into another. Bible translation was the heart of Carey's work.

language family

A group of languages that grew from a common ancestor. North India speaks mostly Indo-Aryan languages (such as Hindi and Bengali); the south speaks mostly Dravidian languages (such as Tamil and Telugu).

Thomas Christians

The ancient churches of Kerala, which trace their founding by tradition to the apostle Thomas in the first century; Christians are recorded there by the sixth century.

Serampore

A Danish trading town on the Hooghly River, about 20 km (12 mi) north of Calcutta, where Carey and his colleagues built their mission, press and college.

script

A system of written letters. Hindi is written in Devanagari, Bengali in the Bengali script and Tamil in the Tamil script.

CORE IDEAS

The story. On November 11, 1793, after about five months at sea on a Danish ship, a thirty-two-year-old English shoemaker and Baptist pastor named William Carey landed at Calcutta with his wife Dorothy, their children and a fellow missionary, John Thomas. A year earlier, in a sermon at Nottingham, Carey had urged his fellow ministers to expect great things from God and to attempt great things for God, and the Baptist Missionary Society had been formed to send him. He had taught himself several languages while mending shoes, with a map of the world on his wall. The first years were hard. The East India Company did not want missionaries in its territory, money ran out, and Carey managed an indigo factory near Malda to feed his family. His son Peter died, and Dorothy fell into a lasting mental illness. Yet he spent those years learning Bengali and translating the New Testament.

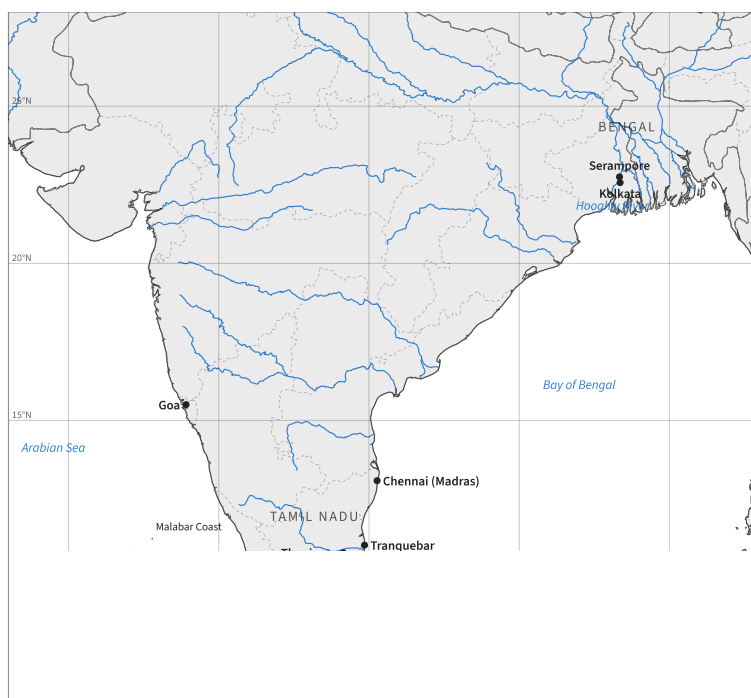
How geography shaped the work. In 1800 Carey moved to Serampore, a small Danish colony up the Hooghly River from Calcutta, where the Danish governor gave the missionaries protection the British would not. There, with the printer William Ward and the teacher Joshua Marshman, the “Serampore Trio,” he built a mission, a school and a printing press. In December 1800 Krishna Pal, a carpenter, became the first Bengali believer the mission baptized, and the Bengali New Testament came off the press in 1801. Carey also taught Bengali and Sanskrit at Fort William College in Calcutta. In 1812 a fire destroyed the press’s type and many manuscripts; the team cast new type and began again. By Carey’s death in 1834, Serampore had printed the Bible, in whole or in part, in about forty languages and dialects. Carey also founded Serampore College (1818) and pressed for an end to *sati*, the burning of widows on their husbands’ funeral pyres, which the British banned in Bengal in 1829.

The church before and after Carey. Carey was not the first Christian in India. The Thomas Christians of Kerala on the Malabar coast trace their church to the apostle Thomas, and a traveler named Cosmas recorded Christians there in the sixth century. Francis Xavier arrived at the Portuguese port of Goa in 1542 and preached along the southern coasts. In 1706 two German Lutherans, Bartholomäus Ziegenbalg and Heinrich Plütschau, landed at the Danish port of Tranquebar in Tamil country, the first Protestant missionaries in India; Ziegenbalg printed a Tamil New Testament in 1714. Ports and small European colonies were the doors through which most missionaries entered.

Amy Carmichael. Born in what is now Northern Ireland in 1867, Amy Carmichael arrived in South India in 1895 and never went home again. She wore a sari, learned Tamil, and traveled the villages of the Tirunelveli district near India's southern tip. In 1901 a seven-year-old girl named Preena, who had been given to a temple and had run away, came to her for help. Learning that many children were given to temples, where they faced abuse, Carmichael gave the rest of her life to rescuing and raising them. At Dohnavur she built a home, a school and later a hospital: the Dohnavur Fellowship. After a fall in 1931 she was mostly confined to her room for twenty years, yet she kept writing books still read today. She died at Dohnavur in 1951.

The big idea. South Asia is one of the most religiously and linguistically varied regions on earth. In India's 2011 census, about 80% of people were Hindu, 14% Muslim, 2.3% Christian, 1.7% Sikh and smaller numbers Buddhist and Jain. Pakistan and Bangladesh are mostly Muslim, Nepal mostly Hindu, and Sri Lanka and Bhutan mostly Buddhist. Christians are a large share in Kerala and a majority in the northeastern states of Nagaland, Mizoram and Meghalaya. India's constitution recognizes 22 scheduled languages, with Hindi and English used by the central government. The missionaries' insistence on learning people's own languages fits Acts 17:26: God made all nations "of one blood" and set the bounds of their habitation, and the gospel was meant to reach each of them in its own tongue. As of 2026, several Indian states have laws regulating religious conversion; supporters say they prevent forced or paid conversions, and critics say they limit religious freedom.

On the map. Find the Malabar coast, Goa, Tranquebar, Serampore and Dohnavur. Notice that most lie on coasts or rivers, where ships could come and go.



Places in the history of Christianity in India.

PICTURE STUDY



The Great Bull, an Hindoo Idol, at Tanjore, Thomas Daniell and William Daniell, July 1798, published in *Oriental Scenery* (1795–1808) · Hand-colored aquatint · Copies in the British Library, the Yale Center for British Art and other collections

Tanjore (today Thanjavur) in Tamil Nadu is the home of the great Brihadeeswarar Temple, built by the Chola king Rajaraja I and finished about AD 1010. In its courtyard lies an enormous statue of Nandi, the bull that Hindus associate with the god Shiva, carved from a single block of stone. The Daniells drew it on their tour of South India in the early 1790s.

Tanjore matters to the story of Christianity in India, too. The Danish port of Tranquebar, where the first Protestant missionaries landed in 1706, lies close by, and the German missionary Christian Friedrich Schwartz spent his last twenty years at Tanjore, respected by the Hindu raja, who asked him to help guide his young heir. A missionary who wanted to be understood here had to understand this world of temples, festivals and the Tamil language.

Look closely

- Find the bull. How large is it compared with the people near it?
- Look at the shelter built over the statue. What shapes do the pillars and roof have?
- Look behind the shelter. What can you see of the rest of the temple?
- What are the people in the picture doing?

Talk about it

1. Why would the Daniells choose to draw this place for readers in Britain?
2. How does a picture like this help us describe another people's faith accurately and respectfully, even when we do not share it?
3. What would a missionary arriving at Tanjore in the 1790s need to learn first?

PROJECT: A LANGUAGE MAP OF INDIA

You will make a map of India's major language regions, with each language's name written in its own script, and add the places where Carey, Carmichael and earlier missionaries worked. You will see how a language map helps explain why translators were needed and where.

You will need

- A large outline map of India with state borders (printed or traced from an atlas)
- Colored pencils in at least six colors
- A printed or library chart of Indian scripts (Devanagari, Bengali, Gurmukhi, Gujarati, Tamil, Telugu, Kannada, Malayalam)
- Fine black pen, glue stick and small paper labels
- An atlas or a reliable language map of India for reference

Steps

1. Lightly shade the Indo-Aryan language regions of the north and west in warm colors (red, orange, yellow): Hindi across the Ganges plain, Punjabi in the Punjab, Gujarati, Marathi, Bengali and Odia.
2. Shade the Dravidian language regions of the south in cool colors (blue, green, purple): Tamil, Telugu, Kannada and Malayalam.
3. Shade the northeast hill states in a separate color and label it "many Tibeto-Burman languages."
4. In each region, write the language's name in English and copy the word for the language in its own script from your chart, carefully.
5. Mark with a small cross and label: Kottayam (Thomas Christians), Goa (Xavier, 1542), Tranquebar (Ziegenbalg, 1706), Serampore (Carey, 1800) and Dohnavur (Carmichael, from 1901).
6. Draw a thin line from Serampore to every language region where the Serampore press printed Scripture, as far as your source shows. Choose at least Bengali, Hindi, Marathi, Odia, Punjabi and Sanskrit.
7. Add a title, a key for your colors and a compass rose.
8. On the back, write three sentences explaining why a missionary in Bengal and a missionary in Tamil Nadu needed to learn completely different languages.

Tips

- Language borders are not sharp lines; many people speak two or three languages. Let your colors blend at the edges.
- Copy scripts slowly and check each letter against the chart. Ask a speaker of the language to check if you can.
- Use a pencil first and ink only when you are sure.

Check your work

- My map shows the Indo-Aryan north and the Dravidian south in different colors.
- I labeled at least eight languages, some in their own scripts.
- I marked five places from the history of Christianity in India and can tell what happened at each.

MAP NOTEBOOK

1. Draw the Hooghly River from the Ganges to the Bay of Bengal and mark Serampore and Calcutta (Kolkata). Add a sailing ship arriving from the sea.
2. Make a timeline from 1542 to 1951 with Xavier, Ziegenbalg, Carey's arrival, the Bengali New Testament, the 1812 fire, Carmichael's arrival, Preena and Carmichael's death.
3. Copy the word for "God" or the opening words of John 3:16 in one Indian script from a printed Bible or chart, and label the language.

From history. When the order banning sati arrived at Serampore in December 1829 for translation into Bengali, the story is told that Carey received it on a Sunday morning, gave his preaching to a colleague, and set to work at once so that the law could be published without a day's delay, because every day lost might cost a widow her life. Carey had collected figures on the practice for years and had pressed officials to act.

WORKED EXAMPLES

Example 1. Carey's ship left England on June 13, 1793 and he landed at Calcutta on November 11, 1793. The voyage around Africa was about 22,000 km (13,700 mi). How many days did it take, and what was the average distance per day in km and miles?

1. Count the days: June 13 to June 30 = 17; July 31; August 31; September 30; October 31; November 1 to 11 = 11.
2. Total: $17 + 31 + 31 + 30 + 31 + 11 = 151$ days.
3. Per day: $22,000 \div 151 \approx 146$ km ($13,700 \div 151 \approx 91$ mi).
4. Per hour: $146 \div 24 \approx 6$ km/h, about walking speed.

Answer: 151 days, about 146 km (91 mi) a day. A modern flight from London to Kolkata takes about 10 hours.

Example 2. Use the map. Serampore lies at about 22.75°N and Kolkata at about 22.57°N , almost due north and south of each other on the Hooghly. One degree of latitude is about 111 km. About how far apart are they?

(Use the map or drawing “Find Serampore and Kolkata on the Hooghly.” shown earlier in this lesson.)

1. Difference in latitude: $22.75 - 22.57 = 0.18^{\circ}$.
2. Distance: $0.18 \times 111 \approx 20$ km.
3. In miles: $20 \div 1.609 \approx 12$ mi.

Answer: About 20 km (12 mi), close enough to reach Calcutta by boat in a few hours, yet under a different flag.

Example 3. India’s 2011 census counted about 1,211 million people. About 43.6% reported Hindi as their mother tongue and about 8.0% Bengali. How many people is that for each language?

1. Hindi: $0.436 \times 1,211$ million ≈ 528 million.
2. Bengali: $0.080 \times 1,211$ million ≈ 97 million.
3. So more than half of Indians in 2011 had a mother tongue other than Hindi.

Answer: About 528 million Hindi speakers and about 97 million Bengali speakers in 2011. Carey’s first translation, Bengali, served a language with tens of millions of speakers even in his day.

PRACTICE

1. **EASY** Name the three missionaries known as the “Serampore Trio.”
2. **EASY** Why did Carey’s mission settle at Serampore rather than in British Calcutta?
3. **EASY** Who were the first Protestant missionaries in India, where did they land, and in what year?
4. **EASY** Which language family is spoken mostly in North India, and which mostly in South India? Give two languages of each.
5. **MEDIUM** Use the map. In which present-day Indian state is Dohnavur, and roughly how far is it from the southern tip of India at Kanyakumari: about 5 km, 50 km or 500 km? (Hint: the two places are about 0.4° of latitude apart, and $1^{\circ} \approx 111$ km.)
(Use the map or drawing “Places in the history of Christianity in India.” shown earlier in this lesson.)
6. **MEDIUM** Carey lived in India from 1793 to his death in 1834 and never returned to England. Carmichael lived in India from 1895 to 1951. How many years did each spend in India?
7. **MEDIUM** In India’s 2011 census, about 2.3% of 1,211 million people were Christian. About how many Christians is that?

8. **MEDIUM** On which coast of India do the ancient Thomas Christians live, and how does that coast's geography help explain an early church there?
9. **HARD** The first Bengali New Testament was printed in 1801, eight years after Carey arrived. Give two likely reasons why it took so long.
10. **CHALLENGE** In a short paragraph, explain how geography (rivers, ports, colonies and languages) shaped where and how missionaries worked in India.

COMMON MISTAKES

- Thinking Christianity first reached India with the British. The churches of Kerala are far older, and Catholic and Lutheran missionaries came long before Carey.
- Thinking all Indians speak one language called "Indian." India has many major languages in different families and scripts.
- Describing other faiths carelessly. Hinduism, Islam, Sikhism, Buddhism and Jainism should be described accurately, using the words their own followers use.

Make it a game · Script Detective. Print or copy the same short word or name, such as "India," in six Indian scripts on cards (Devanagari, Bengali, Gurmukhi, Tamil, Telugu, Malayalam), with the script names on separate cards. Players race to match each script to its name and then place it on the region of the map where it is used. Score a point for each correct match and a bonus for naming a missionary who worked in that language region.

Scripture. "After this I beheld, and, lo, a great multitude, which no man could number, of all nations, and kindreds, and people, and tongues, stood before the throne, and before the Lamb, clothed with white robes, and palms in their hands;" (Revelation 7:9, KJV)

John saw people of every tongue before God's throne. Carey and the translators who followed him gave their lives to making that vision real in Bengali, Tamil, Hindi and dozens of other languages of South Asia.

Practice answers

1. William Carey, Joshua Marshman and William Ward.
2. Serampore was a Danish colony, and the Danish governor protected the missionaries, while the British East India Company at that time opposed missionaries in its territory.
3. Bartholomäus Ziegenbalg and Heinrich Plütschau, at the Danish port of Tranquebar in Tamil country, in 1706.
4. North: Indo-Aryan, such as Hindi, Bengali, Punjabi, Marathi or Gujarati. South: Dravidian, such as Tamil, Telugu, Kannada or Malayalam.
5. Tamil Nadu; about 50 km (30 mi): $0.4 \times 111 \approx 44$ km, nearly due north of Kanyakumari.
6. Carey: $1834 - 1793 = 41$ years. Carmichael: $1951 - 1895 = 56$ years.
7. $0.023 \times 1,211$ million ≈ 27.9 million, about 28 million.
8. The Malabar coast of Kerala, in the southwest. It was a busy port coast on the monsoon sea routes, visited by traders from the Red Sea and Persian Gulf for centuries, so travelers and ideas from the Middle East arrived early.

9. Any two: Carey had to learn Bengali from scratch, with few books or teachers; he had to earn a living managing an indigo factory; the mission had little money and faced Company opposition; the mission had to obtain a printing press, and type for the Bengali script had to be made; his family suffered illness and loss.
10. A good answer notes that missionaries arrived by sea and settled in ports and small European colonies such as Goa, Tranquebar and Serampore, where they could land and be protected; that rivers like the Hooghly linked these bases to great cities and the interior; and that India's many language regions, Indo-Aryan in the north and Dravidian in the south, meant each region needed its own translators, scripts and printed books, so missionaries like Carey and Carmichael had to learn local languages and live among the people.

UNIT 5 REVIEW

Answer each question. Show your work for calculations, give both metric and U.S. units where asked, and use complete sentences for explanations. The review is worth 60 points.

1. (6 pts) Explain how the summer monsoon forms. Use the words land, sea, heat, pressure and moisture.
2. (6 pts) Mumbai gets about 2,200 mm of rain a year and Pune, behind the Western Ghats, about 700 mm. Find the difference in mm and inches ($25.4 \text{ mm} = 1 \text{ in}$) and name the effect that explains it.
3. (6 pts) Give two ways the Himalaya affects the climate of northern India.
4. (6 pts) Trace the Ganges from its source to the sea, naming the glacier where it begins, the tributary that joins at Prayagraj, two cities on its banks, the river it meets in Bangladesh, and the sea it enters.
5. (6 pts) What are kharif and rabi crops? Give one example of each and say when each is sown.
6. (6 pts) On a map with a scale of $1 \text{ cm} = 50 \text{ km}$, the distance from Varanasi to Patna along a straight line measures 4.3 cm. How far apart are they in km and miles ($1 \text{ mi} = 1.609 \text{ km}$)?
7. (6 pts) Give the date of India's first passenger train, the two places it linked and the approximate distance in km and miles.
8. (6 pts) A hill railway climbs 1,200 m over 30 km of track. Find its average gradient as a percent and as "1 in __," and give the rise in feet ($1 \text{ m} = 3.281 \text{ ft}$).
9. (6 pts) Describe two methods engineers used to carry railways up steep mountains in India, and name a railway that uses each.
10. (6 pts) Tell what William Carey and Amy Carmichael each did in India, naming the place where each worked and one way geography or language shaped their work.

UNIT PROJECT: ATLAS PAGE: INDIA'S RIVERS AND MONSOON WINDS

Make a large, carefully drawn atlas page of South Asia for your regional atlas. Show the Himalaya, the Western and Eastern Ghats, the Deccan Plateau and the Thar Desert; the Indus with its five Punjab tributaries, and the Ganges, Yamuna and Brahmaputra to the Ganges-Brahmaputra delta; and the two branches of the summer monsoon as blue arrows with the winter monsoon as dashed arrows. Mark at least ten cities, India's first railway and the three mountain railways, and the mission sites of Lesson 5.4.

Beside the map, attach the temperature graph from your monsoon wind model and write a paragraph explaining how the land, the sea and the mountains together decide where South Asia's rain falls and where its people live.

- **Accuracy:** Mountains, rivers, seas, cities, railways and wind arrows are placed correctly and labeled clearly.

- **Monsoon model:** The model's temperature table and graph are complete and correctly labeled, and the observed wind directions are recorded.
- **Explanation:** The paragraph correctly explains land and sea heating, the two monsoon branches, orographic rain and rain shadow, and links rainfall to farming and population.
- **Care:** The page has a title, key, scale bar and compass rose, and it is neat, colorful and easy to read.

Answer key

1. In late spring the land heats up much faster than the sea. Hot air rises over the land, leaving low pressure, and cooler air from the sea, where pressure is higher, flows in to replace it. Because this sea air has crossed warm ocean, it carries a great deal of moisture, which falls as rain when it rises over the land and mountains.
2. $2,200 - 700 = 1,500$ mm; $1,500 \div 25.4 \approx 59$ in. Pune lies in the rain shadow of the Western Ghats.
3. Any two: it forces the moist monsoon winds to rise and drop rain on the plains and foothills; it turns the Bay of Bengal branch westward along the Ganges plain; it blocks cold, dry winter air from Central Asia, keeping northern India warmer; the heating of the high Tibetan Plateau behind it helps strengthen the summer low pressure that draws in the monsoon.
4. It begins at the Gangotri Glacier (as the Bhagirathi), is joined by the Yamuna at Prayagraj, flows past cities such as Haridwar, Varanasi and Patna, meets the Brahmaputra in Bangladesh, and enters the Bay of Bengal through the Ganges-Brahmaputra delta.
5. Kharif crops are sown with the summer monsoon (June-July) and harvested in autumn, for example rice or cotton. Rabi crops are sown in the cool, dry autumn (October-December) and harvested in spring, for example wheat or mustard.
6. $4.3 \times 50 = 215$ km; $215 \div 1.609 \approx 134$ mi.
7. April 16, 1853; Bori Bunder in Bombay (Mumbai) to Thane; about 34 km (21 mi).
8. $1,200 \div 30,000 \times 100 = 4\%$; $30,000 \div 1,200 = 25$, so 1 in 25. Rise: $1,200 \times 3.281 \approx 3,937$ ft, about 3,940 ft.
9. Any two: a zigzag or reversing station, where the train runs into a dead end and backs up the next slope (Darjeeling Himalayan Railway; the old Bhor Ghat incline); a loop, where the line spirals over itself (Darjeeling Himalayan Railway, Batasia Loop); a rack rail with a gear wheel on the locomotive (Nilgiri Mountain Railway); long winding routes with many tunnels (Kalka-Shimla Railway).
10. Carey (arrived 1793) worked at Serampore, a Danish colony on the Hooghly near Calcutta, where the Danes protected the mission; he learned Bengali and Sanskrit, translated and printed the Bible in many Indian languages, founded Serampore College and opposed sati. Carmichael (arrived 1895) worked in the Tirunelveli district of Tamil Nadu, learned Tamil and wore Indian dress, and founded the Dohnavur Fellowship to rescue and raise children who had been given to temples. Both had to learn local languages to work among the people.

EAST ASIA

East Asia is a land of great rivers, high mountains and island chains. In China, the Yellow River and the Yangtze flow east from the roof of the world, the Tibetan Plateau, across some of the most crowded farmland on earth. Across the sea, Korea reaches south as a mountainous peninsula, and Japan's islands curve along the Ring of Fire. In this unit you will see how these rivers, mountains, seas and ocean currents shaped the way the peoples of East Asia farm, fish, trade and worship, and how their history has been bound up with water, both as a gift and as a danger.

You will watch the Yellow River break its dikes in 1855 and find a new road to the sea, follow grain barges up the Grand Canal through the world's first pound lock, sail with the shipwrecked Dutch sailor Hendrick Hamel across the Korea Strait, and travel with the missionaries Matteo Ricci and Hudson Taylor, who learned the land and the language of China so they could make the gospel known. Through it all, remember Paul's words in Athens: God "hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation" (Acts 17:26).

The technology story of this unit is the Grand Canal, a man-made river nearly 1,800 km (1,100 miles) long that tied China's rice-growing south to its capitals in the north. You will build a working model of a pound lock and finish the unit with an atlas page of China's rivers and the Grand Canal.

BEFORE YOU BEGIN

- Can find places on a map by latitude and longitude
- Can convert kilometers to miles and meters to feet
- Knows what a river source, mouth, tributary and delta are
- Can use the Pythagorean theorem (or a simple right-triangle rule) to combine north-south and east-west distances

MASTERY CHECKLIST

- I can trace the Yellow River and the Yangtze from the Tibetan Plateau to the sea and explain why the Yellow River floods and changes course.
- I can explain how the Qinling-Huai line divides China into a wheat-growing north and a rice-growing south.
- I can explain how a pound lock works and why the Grand Canal mattered to China for more than a thousand years.
- I can describe how mountains, seas and ocean currents shape farming, fishing and trade in Japan and Korea.
- I can tell the stories of Matteo Ricci and Hudson Taylor and describe the history of Christianity in China, Korea and Japan.

- I can calculate distances, lock volumes, travel times and sun times using real places in East Asia.

OPTIONAL BOOKS AND RESOURCES

- **UNESCO World Heritage Centre: The Grand Canal**
(<https://whc.unesco.org/en/list/1443>): Free. The official World Heritage page for the Grand Canal (listed in 2014), with a description, maps and photographs of its locks, bridges and canal towns (Lesson 6.2).
- **NASA Earth Observatory** (<https://earthobservatory.nasa.gov/>): Free. Search for “Yellow River delta,” “Yangtze” and “Three Gorges” to see satellite images of the rivers in Lesson 6.1, including the muddy plume where the Yellow River meets the Bohai Sea.
- **Writings by and about Hudson Taylor (free at Project Gutenberg)**
(<https://www.gutenberg.org/ebooks/search/?query=Hudson+Taylor>): Free. Older public-domain books about Hudson Taylor and the China Inland Mission. A parent may choose short passages to read aloud with Lesson 6.4.

6.1 CHINA'S TWO GREAT RIVERS ★

OBJECTIVES

- Trace the Yellow River and the Yangtze from the Tibetan Plateau to the sea and name the main landforms and cities along each.
- Explain why the silt-laden Yellow River rises above its plain and changes course, using the great shift of 1855, and why the Yangtze is China's main river highway.
- Describe how the two rivers divide China into a wheat-and-millet north and a rice-growing south, and how that shaped China's history, peoples and faith.

Warm-up. Fill two clear glasses with water. Stir a heaping spoonful of fine garden soil or flour into one and nothing into the other. Watch for five minutes. What settles to the bottom of the muddy glass? Now imagine the muddy glass is a river 5,000 km (3,000 miles) long that drops its mud on its own bed every year. What would happen to the bottom of that river over a hundred years? Over a thousand?

Watch. *Deliberate Disaster: The 1938 Yellow River Flood* (The History Guy: History Deserves to Be Remembered, 14:01). <https://www.youtube.com/watch?v=W49nX3RhNPw>
After the story: watch how the Yellow River's dikes held the river in its bed, and what happened when they were broken on purpose in 1938 and the river changed its course again.

Note: Captions were not available to check; preview it first. This is a wartime disaster: Chinese forces broke the dikes to slow the Japanese army, and the video describes very large numbers of deaths and refugees. The lesson's story is the 1855 dike break and course change at Tongwaxiang. The video covers a different event, the 1938 flood near Huayuankou, which the lesson does not mention.

Backup video. *Why Engineers Can't Control Rivers* (Practical Engineering, 15:52). <https://www.youtube.com/watch?v=vLZELIYHmAI>

With the big idea: watch the stream-table demonstrations of how a river carrying silt builds up its bed, breaks out and finds a new path, then think about why the Yellow River's dikes kept failing. Note: Captions were not available to check; preview it first. Practical Engineering videos usually include a sponsor message; skip it. The examples are probably American rivers, not Chinese ones. The video probably does not discuss the Yellow River or the Yangtze. It teaches the general idea of sediment, levees and rivers changing course.

KEY TERMS

loess

Fine, yellowish, wind-blown dust that has built up into deep, soft soil. The Loess Plateau of north-central China is the largest loess region on earth.

silt

Fine bits of soil and rock carried by moving water and dropped where the water slows down.

dike (levee)

A long bank of earth or stone built along a river to keep its water in its channel during floods.

suspended river

A river whose bed has been raised by silt until it flows above the level of the land around it, held in only by its dikes. Parts of the lower Yellow River are suspended rivers.

avulsion

A sudden change of a river's course, when it breaks out of its channel and cuts a new path to the sea.

Qinling-Huai line

The line of the Qinling Mountains and the Huai River, which roughly divides China's colder, drier, wheat-growing north from its warmer, wetter, rice-growing south.

CORE IDEAS

The story. In the summer of 1855 the Yellow River was running high across the North China Plain. At Tongwaxiang, near the town of Lankao in Henan province, its earthen dikes gave way. The river poured north and east over farms and villages, and when the water settled it had found a new road to the sea. Since the 1100s it had flowed southeast and emptied into the Yellow Sea south of the Shandong peninsula. Now it ran northeast and reached the Bohai Sea north of Shandong, with a mouth roughly 400 km (250 miles) from the old one. With China torn by the Taiping Rebellion, the river wandered for years before new dikes held it. This was not the first time. Chinese records describe more than a thousand dike breaks and about two dozen major changes of course over three thousand years.

On the map. China's land falls from west to east in great steps: the high Tibetan Plateau, then middle uplands and basins, then the low eastern plains. Both great rivers begin on the plateau in Qinghai province, more than 4,000 m (13,000 feet) above the sea, and both flow east. The **Yellow River** (Huang He) runs about 5,460 km (3,395 miles). It swings far north around the Ordos Desert, then turns south through the **Loess Plateau**, where it scours away soft yellow **loess** and becomes one of the muddiest rivers in the world. The **Yangtze** (Chang Jiang, "Long River") runs about 6,300 km (3,900 miles), the longest river in Asia and third in the world after the Nile and the Amazon. It crosses the Sichuan Basin past Chongqing, cuts through the steep Three Gorges, and then flows across a wide plain of lakes past Wuhan and Nanjing to Shanghai on the East China Sea.

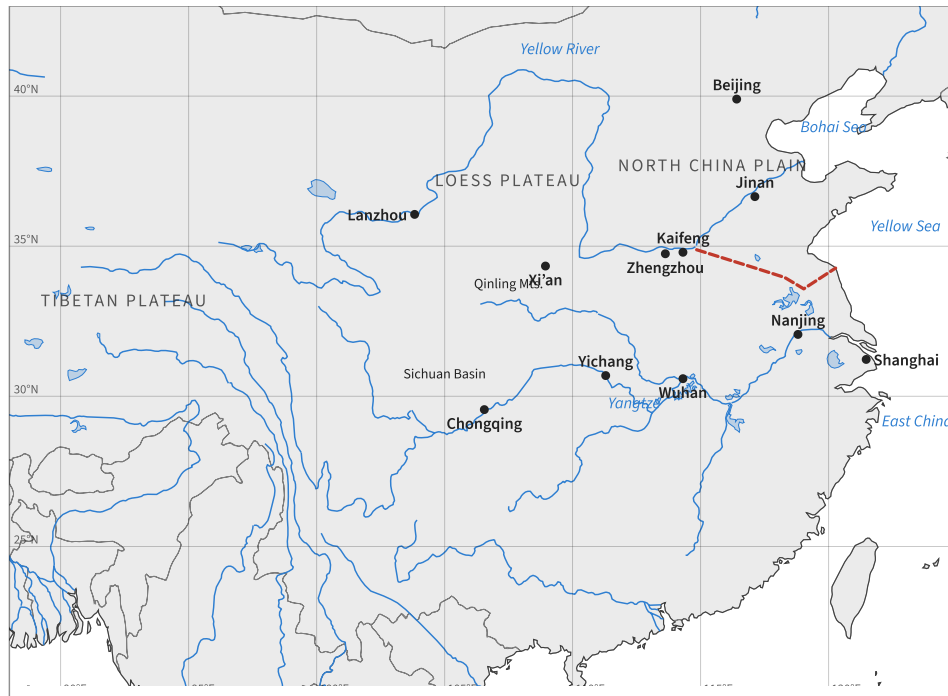
The big idea. The two rivers behave very differently. When the muddy Yellow River slows on the flat plain, it drops its **silt** on its own bed. Farmers raised the **dikes**, the silt raised the bed again, and over centuries parts of the lower river came to flow above the fields around it, a **suspended river**. When such a dike breaks, the water runs downhill away from the river and may never come back, which is why the Yellow River has been called "China's Sorrow." The Yangtze carries even more water, but it is deeper and steadier, and its silt goes

mostly to its delta. Ocean-going ships sail up it to Nanjing, and river ships go far inland to Chongqing, so the Yangtze is China's great water highway.

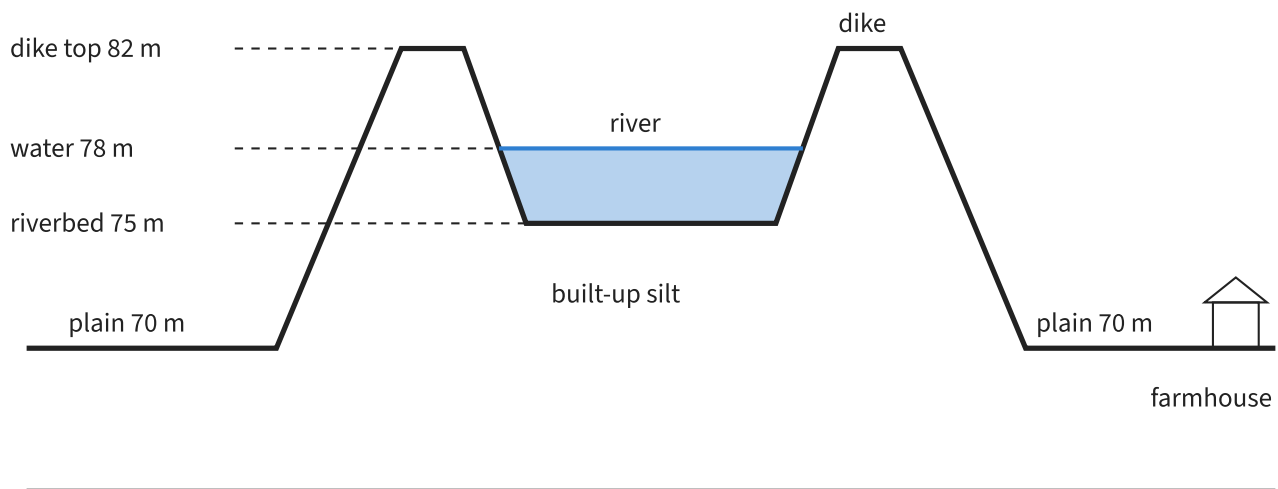
North and south. The rivers also mark two Chinas. North of the **Qinling-Huai line**, winters are cold and dry, summer rains are lighter (under about 800 mm or 31 inches a year), and farmers grow wheat and millet. South of it, the summer monsoon brings heavy rain, and rice grows in flooded paddies, often two crops a year, with tea on the hills. Chinese civilization first grew strong in the north, on the soft, easily dug loess of the Yellow River and its tributary the Wei, where Chang'an (today's Xi'an) was the capital of many dynasties. Over the centuries people and wealth moved south, and by the Song dynasty (960-1279) the lower Yangtze was China's richest farmland. Rulers in the north needed rice from the south, but both rivers run east. Lesson 6.2 shows how China solved that problem.

Technology overcoming geography. Ancient Chinese tradition honors Yu the Great, who is said to have tamed a great flood by digging channels to lead the water away rather than only building walls against it. Whatever the history behind the story, dike-building and river control became a chief duty of every Chinese government. In modern times the Three Gorges Dam on the Yangtze, built from 1994 to 2006, became the largest hydroelectric power station in the world. It holds back floods and lifts ships through a staircase of locks, but it also flooded old towns and required more than a million people to move, so its costs and benefits are still debated.

Peoples and faith. Most people in China are Han Chinese, and the government also recognizes 55 minority peoples. Confucius (about 551-479 BC) taught near the lower Yellow River in the state of Lu, and his teaching on family, duty and honoring ancestors shaped Chinese life for two thousand years, alongside Daoism and Buddhism, which came from India along the Silk Road. Christianity came that way too. A stone tablet carved in 781 and found near Xi'an records that a monk named Alopen of the Church of the East reached Chang'an in 635 and that Emperor Taizong allowed him to teach. God, who "hath made of one blood all nations of men" (Acts 17:26), had brought the gospel down the Wei valley to China's capital almost fourteen hundred years ago.

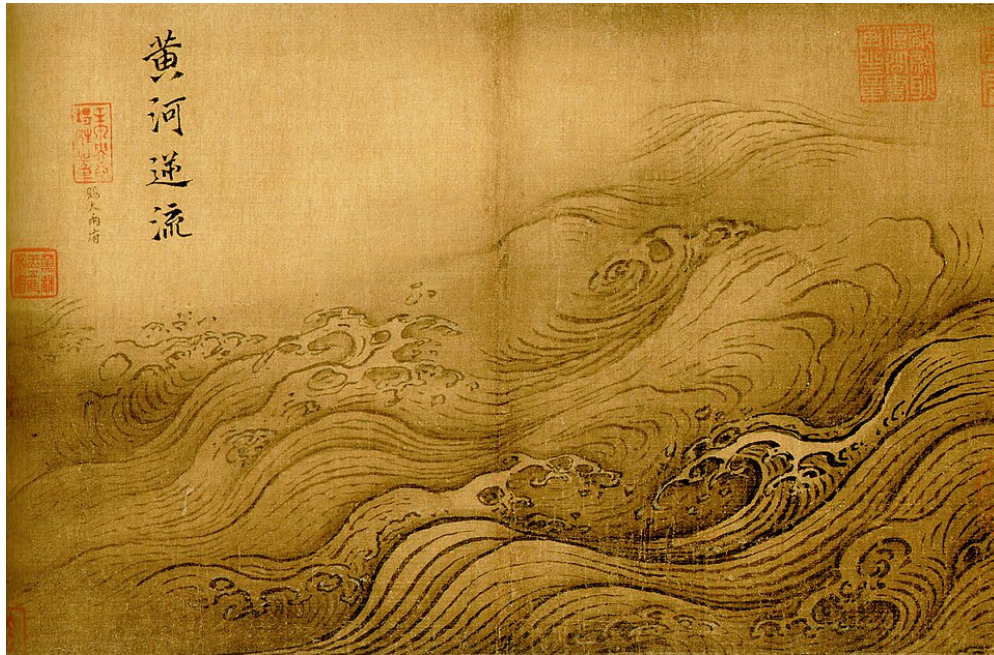


China's two great rivers flow east from the Tibetan Plateau. The red line shows the Yellow River's old course south of Shandong, used until the dikes broke in 1855.



A suspended river: silt has raised the riverbed above the surrounding plain. Elevations are round teaching numbers.

PICTURE STUDY



Water album: “The Yellow River Breaching Its Course” and “The Vast Expanse of the Yangtze”, Ma Yuan, about 1222 (Southern Song dynasty) · Twelve album leaves (now mounted as a handscroll), ink and light color on silk · Palace Museum, Beijing

Ma Yuan was a court painter of the Southern Song dynasty, when the capital was at Hangzhou in the rich Yangtze delta. In one of the most unusual works in Chinese art, he painted an album of twelve leaves showing nothing but water: water in wind, water at dawn, water in a quiet pond. He drew every wave with lines of ink, using almost no color.

Two of the leaves are named for China’s great rivers. One is called “The Yellow River Breaching Its Course,” a title sometimes translated “The Yellow River Flows Backward.” Another is “The Vast Expanse of the Yangtze.” Ma Yuan had probably never stood on the banks of the Yellow River, which was then held by the Jurchen Jin state to the north, yet he and his viewers knew its fame for wild, destructive water.

Look closely

- Compare the two river leaves. Which has tall, twisting, crowded waves? Which has long, calm ripples?
- Look at the ink lines. How does Ma Yuan show that water is moving fast in one leaf and slowly in the other?
- Find the empty space in each leaf. Where does the water seem to go on forever?
- Notice that there are no people, boats or banks. What does that make you feel about the rivers?

Talk about it

1. How does Ma Yuan's Yellow River leaf match what you learned about the river's floods and changes of course?
2. Why might a painter living on the Yangtze delta show the Yangtze as broad and steady?
3. If you painted one river you know using only lines, how would you show its character?

Safety first. Do this project outdoors or over a floor covered with towels, and wash hands after handling soil.

PROJECT: A SAND-TRAY RIVER THAT CLIMBS OUT OF ITS BED

You will build a model river on a sloped tray, feed it muddy water, and watch the silt build up its bed until the river breaks through its dike and finds a new path, just as the Yellow River did in 1855. Then you will try a clear-water river for comparison.

You will need

- A large shallow plastic tray, baking sheet with sides, or plastic storage-box lid
- Damp sand to fill the tray about 3 cm (1 inch) deep
- A cup of very fine soil, flour or clay dust (your "loess")
- Two pitchers or large cups of water and a spoon
- A book or block to raise one end of the tray about 3 cm
- A ruler, a pencil, toothpicks and small paper flags
- Old towels and a bucket to catch the outflow

Steps

1. Spread the damp sand evenly and raise one end of the tray. The high end is the Loess Plateau; the low end is the sea.
2. Press a winding channel about 2 cm wide from the high end to the low end. Build low sand dikes about 1 cm high along both banks on the lower half of the tray (your North China Plain).
3. Plant flags beside the river for three "villages" on the plain.
4. Stir two big spoonfuls of fine soil into a pitcher of water. Pour it slowly and steadily into the top of the channel.
5. Watch where the silt settles. Stand a toothpick in the channel bed on the plain and mark the bed level on it before and after each pour.
6. When the bed rises, raise the dikes a little higher, as Chinese farmers did. Pour another pitcher of muddy water.
7. Keep going until the river breaks a dike. Record where it broke out, which villages it reached, and where its new mouth is.
8. Smooth the tray, make a fresh channel and repeat with clear water. Compare how much the bed rose.

Tips

- Pour slowly. A gentle, steady flow drops more silt on the plain, just like a real river that slows down.
- Take a photo or sketch the tray after each pour so you can compare the old and new courses.

Check your work

- I measured how much the riverbed rose with muddy water and with clear water.
- My model river broke out of its dikes and found a new course, and I can explain why.
- I can explain why raising the dikes higher did not solve the problem for good.

MAP NOTEBOOK

1. On a blank map of China, draw the Yellow River in yellow and the Yangtze in blue from source to sea. Label the Tibetan Plateau, Loess Plateau, North China Plain, Sichuan Basin, Three Gorges, Bohai Sea, Yellow Sea and East China Sea.
2. Draw a dashed line for the Yellow River's course before 1855 and a solid line for its course after. Write the year beside the break near Lankao.
3. Make a two-column chart titled "North and South": list the climate, crops, river and one great city for each side of the Qinling-Huai line.

From history. In June 1938, during the war with Japan, China's Nationalist army deliberately broke the Yellow River dikes at Huayuankou, near Zhengzhou, to slow the Japanese advance. The flood spread across parts of Henan, Anhui and Jiangsu and joined the Huai River system. It did slow the invasion, but hundreds of thousands of Chinese civilians died and millions lost their homes. The river flowed south for nine years until engineers closed the gap in 1947 and sent it back to its northern course to the Bohai Sea, where it still flows today.

WORKED EXAMPLES

Example 1. Before 1855 the Yellow River reached the sea at about 34.3°N , 120.3°E . Today its mouth is at about 37.8°N , 119.2°E . About how far did the mouth move? Use 111 km for one degree of latitude and about 90 km for one degree of longitude at 36°N .

(Use the map or drawing “Compare the old mouth south of Shandong with today’s mouth on the Bohai Sea.” shown earlier in this lesson.)

1. North-south difference: $37.8^{\circ} - 34.3^{\circ} = 3.5^{\circ}$. $3.5 \times 111 \text{ km} \approx 389 \text{ km}$.
2. East-west difference: $120.3^{\circ} - 119.2^{\circ} = 1.1^{\circ}$. $1.1 \times 90 \text{ km} \approx 99 \text{ km}$.
3. These two distances form the legs of a right triangle. Distance = $\sqrt{(389^2 + 99^2)} = \sqrt{(151,321 + 9,801)} = \sqrt{161,122} \approx 401 \text{ km}$.
4. Convert: $401 \times 0.621 \approx 249 \text{ miles}$.

Answer: About 400 km (about 250 miles), from south of the Shandong peninsula to north of it.

Example 2. Wuhan stands on the Yangtze at about 30.6°N , 114.3°E , and Shanghai near its mouth at about 31.2°N , 121.5°E . At about 31°N , one degree of longitude is about 95 km. How far apart are they in a straight line, in km and miles? Why is the trip by river longer?

1. East-west difference: $121.5^{\circ} - 114.3^{\circ} = 7.2^{\circ}$. $7.2 \times 95 \text{ km} = 684 \text{ km}$.
2. North-south difference: $31.2^{\circ} - 30.6^{\circ} = 0.6^{\circ}$. $0.6 \times 111 \text{ km} \approx 67 \text{ km}$.
3. Distance = $\sqrt{(684^2 + 67^2)} = \sqrt{(467,856 + 4,489)} = \sqrt{472,345} \approx 687 \text{ km}$.
4. Convert: $687 \times 0.621 \approx 427 \text{ miles}$.
5. The river bends back and forth across its plain, so the boat route is much longer than the straight line.

Answer: About 690 km (about 430 miles) in a straight line; the winding river route is longer.

Example 3. The cross-section shows a suspended river with round teaching numbers: the plain is at 70 m above sea level, the riverbed at 75 m, the normal water surface at 78 m, and the tops of the dikes at 82 m. (a) How far above the plain is the riverbed, in meters and feet? (b) In a flood the water rises to 81 m. How far above the farmhouses on the plain is the water surface? (c) Why is a break in the dike so dangerous?

(Use the map or drawing “A river above its plain. Read the elevations from the labels.” shown earlier in this lesson.)

1. (a) $75\text{ m} - 70\text{ m} = 5\text{ m}$. $5 \times 3.28 \approx 16$ feet.
2. (b) $81\text{ m} - 70\text{ m} = 11\text{ m}$. $11 \times 3.28 \approx 36$ feet, about the height of a three-story house.
3. (c) The plain is lower than the river, so if the dike breaks, all the water runs downhill out of the river onto the fields, and the river may never return to its old bed.

Answer: (a) 5 m (about 16 feet). (b) 11 m (about 36 feet). (c) Because the river sits above the land, a break sends the whole river downhill across the plain.

PRACTICE

1. **EASY** Which is longer, the Yellow River or the Yangtze? Give both lengths in km and miles.
2. **EASY** Why is the Yellow River yellow?
3. **EASY** List these Yangtze cities in order from upstream to downstream: Nanjing, Chongqing, Shanghai, Wuhan.
(Use the map or drawing “Follow the Yangtze from west to east.” shown earlier in this lesson.)
4. **EASY** What crops are typical north of the Qinling-Huai line, and what crop is typical south of it? Give one reason for the difference.
5. **MEDIUM** The Qinling-Huai line roughly follows the 800 mm rainfall line. How many inches is 800 mm? (1 inch = 25.4 mm)
6. **MEDIUM** Lanzhou (about 36.1°N , 103.8°E) and Jinan (about 36.7°N , 117.0°E) are both on the Yellow River. At 36°N one degree of longitude is about 90 km. About how far apart are they in a straight line? Why is the river distance between them much longer?
7. **MEDIUM** The Three Gorges Dam is about 2,300 m long. How long is that in feet and in miles? (1 m $\approx$ 3.28 ft; 1 mile = 5,280 ft)
8. **MEDIUM** All of China keeps one clock time, based on 120°E . The sun moves 1° of longitude every 4 minutes. Kashgar, in the far west, is at about 76°E . When it is 12:00 noon by the clock in Kashgar, has the sun reached its highest point yet? About what clock time will the sun be highest there?
9. **HARD** The Yangtze carries much more water than the Yellow River, yet the Yellow River has caused more terrible floods. Explain why.
10. **CHALLENGE** For much of China’s history the capital stood in the north, while by the Song dynasty the richest rice lands were in the lower Yangtze valley. Write a short paragraph

explaining the geographic problem this created and suggest how a government might solve it.

COMMON MISTAKES

- Thinking the Yellow River is the longest river in China. The Yangtze is longer and carries much more water.
- Thinking higher dikes solve the flood problem for good. Higher dikes let the silt pile even higher, so the river ends up farther above the plain.
- Thinking both rivers start in eastern China. Both begin high on the Tibetan Plateau in Qinghai and flow east to the sea.

Make it a game · Upstream, Downstream. Write these place names on cards: Tibetan Plateau, Lanzhou, Loess Plateau, Zhengzhou, Kaifeng, Jinan, Bohai Sea (Yellow River) and Tibetan Plateau, Chongqing, Three Gorges, Wuhan, Nanjing, Shanghai, East China Sea (Yangtze). Shuffle them. Race a partner to lay out both rivers in order from source to sea. Then flip one card face down; your partner must name the missing place and one fact about it. Best of five rounds.

Scripture. “The floods have lifted up, O LORD, the floods have lifted up their voice; the floods lift up their waves. The LORD on high is mightier than the noise of many waters, yea, than the mighty waves of the sea.” (Psalm 93:3–4, KJV)

The Yellow River has broken the strongest dikes people could build. The psalmist knew floods too, and he reminds us that the God who made the rivers is mightier than any of them.

Practice answers

1. The Yangtze, about 6,300 km (3,900 miles). The Yellow River is about 5,460 km (3,395 miles).
2. It carries huge amounts of fine yellow silt that it picks up as it cuts through the soft loess of the Loess Plateau.
3. Chongqing, Wuhan, Nanjing, Shanghai.
4. North: wheat and millet. South: rice (and tea). The south is warmer and gets much more summer rain, which rice paddies need; the north is colder and drier.
5. $800 \div 25.4 \approx 31.5$ inches, about 31 inches a year.
6. $117.0^\circ - 103.8^\circ = 13.2^\circ$; $13.2 \times 90 \approx 1,190$ km (about 740 miles). The river is much longer because it makes its great loop north around the Ordos Desert and then turns south through the Loess Plateau before heading east.
7. $2,300 \times 3.28 \approx 7,540$ feet. $7,540 \div 5,280 \approx 1.4$ miles.
8. No. Kashgar is $120^\circ - 76^\circ = 44^\circ$ west of 120°E . $44 \times 4 = 176$ minutes, about 2 hours 56 minutes, so the sun is highest at about 2:56 p.m. by Beijing time.
9. The Yellow River carries far more silt. On the flat North China Plain it drops that silt on its bed, raising it until the river flows above the plain between dikes. When a dike breaks, the water rushes downhill over a huge, crowded plain and the river may change course entirely. The Yangtze is deeper, carries less silt for its size, and has lakes and a wide valley that hold extra water.

10. The capital and the armies of the north needed large amounts of food, but the surplus rice grew far to the south. Both great rivers flow east to the sea, not north and south, so there was no natural waterway to carry grain from the Yangtze to the north, and moving it overland by cart was slow and costly. A good answer suggests a man-made waterway (a canal) linking the rivers from south to north, or shipping grain along the coast, and notes the cost and labor involved. This is the story of the Grand Canal in Lesson 6.2.

6.2 THE GRAND CANAL ★ ⚙️

OBJECTIVES

- Trace the Grand Canal from Hangzhou to Beijing and name the five river systems it links.
- Explain how a pound lock works and why Qiao Weiye's lock of 984 was a great step beyond hauling boats over slipways.
- Tell how the canal carried the rice of the south to the capitals of the north, from the Sui to the Qing, and calculate lock volumes, lifts and journey times.

Warm-up. Set two bowls side by side, one on a stack of books and one on the table, and fill both with water. Float a bottle cap in the low bowl. Your job is to move the cap into the high bowl without lifting it out of the water with your fingers. You may use a cup, a third container and anything else in the kitchen. Sketch your best idea. Engineers in China solved this exact problem for heavy grain barges more than a thousand years ago.

Watch. *The Grand Canal - UNESCO World Heritage Site* (World Heritage Journey, 3:26). <https://www.youtube.com/watch?v=-O19SeNgauA>

After the story: take this short tour of the Grand Canal from Beijing to Hangzhou and look for where it links the Yellow River and the Yangtze.

Note: Captions were not available to check; preview it first.

Backup video. *The Engineering Marvel called Panama Canal* (Sabin Civil Engineering, 14:39). <https://www.youtube.com/watch?v=jh79YSCC8mM>

With the big idea: watch how lock chambers fill and empty to raise and lower ships, the same idea as Qiao Weiye's pound lock. Note: Captions were not available to check; preview it first. The channel may promote its sponsor company (JAES) in the video. The video is about the Panama Canal, not China's Grand Canal; use it only to show how locks work.

KEY TERMS

canal

A waterway dug by people to carry boats (or water) where no natural river goes.

pound lock

A chamber with a gate at each end that is filled or emptied to raise or lower boats from one water level to another.

lift

The difference in height between the water above a lock and the water below it.

sluice

An opening or valve that lets water flow into or out of a lock chamber.

summit level

The highest stretch of a canal. It must be fed with fresh water, because every boat that passes through takes water down the locks on either side.

grain tribute

Tax grain, mostly rice, that the provinces of the south shipped north to feed the capital and the army.

CORE IDEAS

The story. In 984, during the Song dynasty, an official named Qiao Weiyue was in charge of transport in the Huainan region, between the Huai River and the Yangtze. On the canal there, wherever the water changed level, boats were hauled over *double slipways*: sloping stone ramps up which oxen and winches dragged each boat out of one level of water and slid it down into the next. Heavy grain barges sometimes broke apart on the ramps, and cargo was lost or stolen. Qiao replaced a slipway with two gates set about fifty paces apart, with a chamber of water between them. A boat floated in, the gate closed behind it, and the water in the chamber was raised or lowered until it matched the level ahead. It is the earliest **pound lock** known anywhere in the world. Europe's first pound locks appeared about four hundred years later.

How it worked. Look at the lock diagram. To raise a boat, (1) the lock keeper empties the chamber to the lower level and opens the lower gate; (2) the boat floats in and the lower gate closes; (3) the **sluice** in the upper gate opens and water from the upper pool pours into the chamber, lifting the boat; (4) when the levels match, the upper gate opens and the boat floats on. To go down, the steps are reversed. No one lifts the boat. Gravity and the water do the work, and the boat never leaves the water. The height difference is the **lift**. Each time the lock is used, one chamberful of water flows downhill from the upper pool to the lower one.

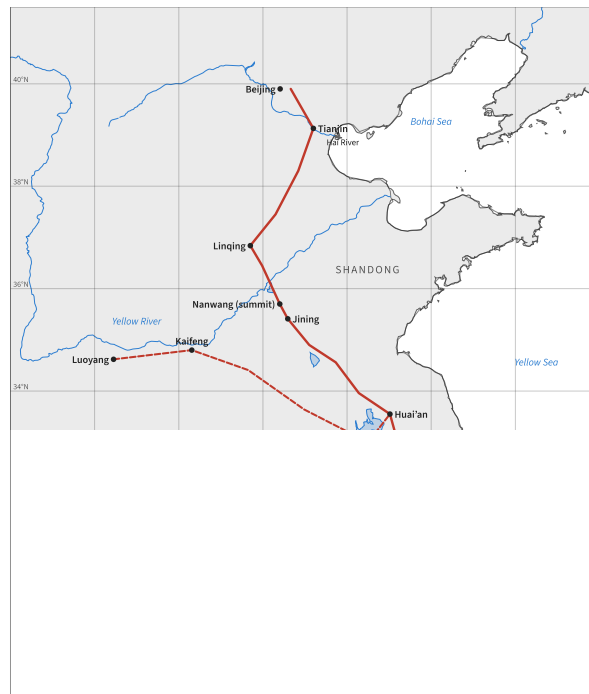
On the map. The Grand Canal runs about 1,794 km (1,115 miles) from Hangzhou in the south to Beijing in the north, making it the longest canal in the world. It crosses the grain of China's land, linking five river systems that all flow east: the Qiantang at Hangzhou, the Yangtze, the Huai, the Yellow River and the Hai near Tianjin. From the Yangtze north the land rises toward the hills of Shandong, where the canal reaches its **summit level**. In 1411 the Ming minister Song Li rebuilt this stretch; following the advice of a local man, Bai Ying, he dammed the Wen River at Daicun and led its water to the summit at Nanwang, so that water could flow both north and south from there. Locks then stepped the canal down in both directions.

The big idea. In Lesson 6.1 you saw the problem: the rice grew in the south, the capitals stood in the north, and the great rivers run east. A canal is a man-made river laid across the natural ones. The oldest piece, the Han Gou, was dug in 486 BC to link the Yangtze and the Huai. Emperor Yang of the Sui joined many canals into one network between 605 and 610, centered on Luoyang, with branches to Hangzhou and toward the Beijing region. He drove the work with forced labor on a huge scale; the records speak of more than a million workers, and many died. The Sui dynasty fell in 618, partly under the weight of such burdens, but the Tang and Song who followed lived on the canal. The Song capital, Kaifeng,

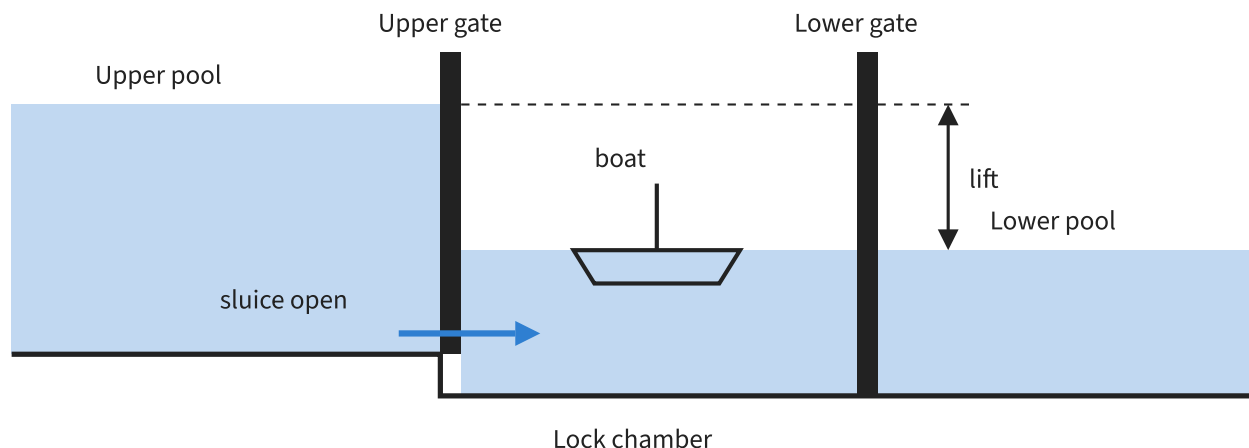
stood on its Bian River section. When Kublai Khan made Beijing his capital, his engineers cut a shorter route straight north through Shandong (finished in 1293), the line the canal still follows.

Technology overcoming geography. For more than a thousand years, fleets of barges carried the **grain tribute** north, feeding the capital and the army and tying north and south into one country. Canal towns such as Yangzhou, Suzhou and Hangzhou grew rich on the traffic. Then geography struck back. In 1855 the Yellow River broke out and swung north (Lesson 6.1), cutting across the canal in Shandong and silting it up. Steamships along the coast and, in 1912, the Tianjin-Pukou railway took over the long haul, and grain shipments by canal ended in the early 1900s. Yet the southern canal never died. As of 2026, barges loaded with coal, sand and building materials still crowd it south of the Yellow River, and part of it carries Yangtze water north for the South-North Water Transfer Project. In 2014 it was named a UNESCO World Heritage Site.

A road for people and ideas. The canal carried travelers as well as rice: officials going to their posts, scholars going to the examinations in the capital, merchants, monks and, as you will see in Lesson 6.4, the missionary Matteo Ricci on his way to Beijing. Scripture says that “the king’s heart is in the hand of the LORD, as the rivers of water” (Proverbs 21:1). The rulers of China turned water wherever they chose, but they too were in God’s hand.



The Grand Canal links five river systems. The red line shows the older Sui-Song route by way of Kaifeng.



A pound lock. Opening the upper sluice fills the chamber and lifts the boat to the upper level.

PICTURE STUDY



Along the River During the Qingming Festival, Zhang Zeduan, early 12th century (Northern Song dynasty) · Handscroll, ink and color on silk, about 25 cm (10 inches) tall and more than 5 m (17 feet) long · Palace Museum, Beijing

This famous scroll was painted by Zhang Zeduan, an artist of the Northern Song dynasty, probably for the court at Kaifeng. It was meant to be unrolled slowly, a little at a time, from right to left, so the viewer travels from quiet countryside to the busy heart of the city. The water at its center is the Bian River, the section of the Sui and Song canal that brought grain and goods to the capital.

The painting holds more than eight hundred people, along with oxen, donkeys, camels, carts, sedan chairs and some two dozen boats. Its most famous scene is the Rainbow Bridge, a great arched wooden bridge where a barge crew is struggling to lower the mast and steer under the arch while people on the bridge shout and point.

Look closely

- Find the Rainbow Bridge. What is the crew of the big boat doing, and why?
- Find boats being pulled by ropes from the bank. What do you think they are carrying?
- Look at the shops, inns and warehouses along the water. How does the canal help the town make a living?
- Find the camels near the city gate. Where might goods carried by camel have come from?

Talk about it

1. What does this scroll tell you about how important the canal was to Kaifeng?

2. Why might a painter choose a long scroll instead of a single picture to show a canal city?
3. What would a similar picture of a busy port or highway in your own region show?

Safety first. Keep water away from electrical outlets, and use scissors with care when cutting the plastic gates.

PROJECT: A WORKING MODEL CANAL AND POUND LOCK

You will build a canal in a clear plastic box with two gates that divide it into an upper pool, a lock chamber and a lower pool. Then you will float a boat up and down through your lock, measure its lift, and calculate how much water each trip uses. This model becomes part of your unit portfolio.

You will need

- A clear plastic storage box about $40 \times 15 \times 15$ cm ($16 \times 6 \times 6$ inches), or a long loaf pan for a smaller model
- Two gates cut from a stiff plastic lid, each slightly wider than the box and taller than the water will be
- Modeling clay (non-drying) to make slots and seals
- A small toy boat or a piece of cork with a toothpick mast
- A drinking straw and a small ball of clay to plug it (your sluice)
- A ruler, a waterproof marker, a measuring cup, water with a few drops of blue food coloring
- Towels and a tray to catch spills

Steps

1. Mark two lines across the box, dividing it into three equal parts. These are your upper pool, lock chamber and lower pool.
2. At each line, press two thick ribbons of clay up the inside walls and across the floor to make a slot. Slide a plastic gate into each slot and press clay firmly along the bottom and sides to seal it.
3. Make a sluice in each gate: poke a hole near the bottom, push a short piece of straw through, seal around it with clay, and plug the straw with a clay ball.
4. Pour colored water into the upper pool until it is 10 cm (4 inches) deep, and into the chamber and lower pool until they are 5 cm (2 inches) deep. Mark the levels on the box. Your lift is 5 cm.
5. Float the boat in the lower pool. To raise it: lift the lower gate, float the boat into the chamber, and reseal the gate.
6. Pull the plug in the upper sluice. Watch the chamber fill and the boat rise. When the levels match, lift the upper gate and float the boat into the upper pool.
7. Now lock the boat back down: close the upper gate, open the lower sluice to drain the chamber into the lower pool, and float the boat out.

8. Measure the chamber's length and width. Calculate the water used in one lockage: length $\times$ width $\times$ lift. Check by measuring how much water you must add back to the upper pool.

Tips

- Some leaking is normal; real lock gates leak too. Press the clay seals again and keep a towel nearby.
- If your lower pool overflows, scoop a cup out. Real canals use spillways to carry extra water away.

Check your work

- My boat rose and fell through the lock without being lifted by hand.
- I can name the upper pool, chamber, lower pool, gates and sluices and explain what each does.
- I calculated the water used in one lockage and compared it with what I measured.

MAP NOTEBOOK

1. Draw the four steps of raising a boat through a pound lock in a four-box comic strip, with arrows for the water.
2. On your China map from Lesson 6.1, draw the Grand Canal from Hangzhou to Beijing in red and label Suzhou, Yangzhou, Huai'an, Jinan, Linqing, Tianjin and the five rivers it crosses.
3. Make a timeline: Han Gou (486 BC), Sui canals (605–610), Qiao Weiye's lock (984), Yuan route to Beijing (1293), Song Li and the summit (1411), Yellow River shift (1855), UNESCO listing (2014).

From history. The engineer who brought the Grand Canal into the heart of Beijing was Guo Shoujing (1231–1316), who served Kublai Khan. He was also a great astronomer: he built observing instruments and helped prepare the Shoushi calendar of 1281, one of the most accurate calendars of its time. For the capital he found springs in the hills west of the city and led their water by channel to fill the Tonghui River, the last link of the canal, completed in 1293. Grain barges could then sail right into the city, to a lake inside its walls.

WORKED EXAMPLES

Example 1. A lock chamber on the Grand Canal is 60 m long and 10 m wide. The upper pool is 4 m higher than the lower pool. How much water is used to raise one boat? Give the answer in cubic meters and liters, and give the lift in feet.

(Use the map or drawing “The water used in one lockage fills the chamber from the lower level to the upper” shown earlier in this lesson.)

1. The water that fills the chamber is a box 60 m long, 10 m wide and 4 m deep (the lift).
2. Volume = $60 \times 10 \times 4 = 2,400$ cubic meters.
3. One cubic meter holds 1,000 liters, so $2,400 \times 1,000 = 2,400,000$ liters.
4. Lift in feet: $4 \times 3.28 \approx 13.1$ feet.

Answer: 2,400 m³ (2.4 million liters) of water for a lift of 4 m (about 13 feet).

Example 2. The Grand Canal is about 1,794 km long. The Erie Canal in New York, opened in 1825, was about 584 km (363 miles) long. How long is the Grand Canal in miles, and about how many times longer is it than the Erie Canal?

1. Convert: $1,794 \times 0.621 \approx 1,114$ miles.
2. Compare: $1,794 \div 584 \approx 3.07$.
3. Check in miles: $1,114 \div 363 \approx 3.07$.

Answer: About 1,115 miles, roughly three times the length of the Erie Canal.

Example 3. Suppose a loaded grain barge travels about 25 km (15.5 miles) a day on the canal, and it must also wait about half a day at each of 40 locks and crossings. About how long would the trip from Hangzhou to Beijing take? (These are round teaching numbers.)

1. Moving time: $1,794 \text{ km} \div 25 \text{ km per day} \approx 72$ days.
2. Waiting time: $40 \times 0.5 \text{ day} = 20$ days.
3. Total: $72 + 20 = 92$ days.
4. 92 days is about three months.

Answer: About 92 days, roughly three months, which is why grain fleets planned their trips around the seasons.

PRACTICE

1. **EASY** Name the five river systems the Grand Canal links, from south to north.

(Use the map or drawing “Follow the canal north from Hangzhou.” shown earlier in this lesson.)

2. **EASY** Who built the earliest known pound lock, and in what year? What did it replace?
3. **EASY** Name the parts of a pound lock and say what each does.
4. **MEDIUM** A lock lifts boats 3.5 m. How many feet is that?
5. **MEDIUM** A chamber is 50 m long and 8 m wide, with a lift of 3 m. How many cubic meters of water does one lockage use?
6. **MEDIUM** Emperor Yang of the Sui began his great canal network in 605. His dynasty fell in 618. How many years passed? What does this suggest about the cost of the project?
7. **MEDIUM** Hangzhou is at about 30.3°N, 120.2°E and Beijing at about 39.9°N, 116.4°E. At 35°N one degree of longitude is about 91 km. How far apart are they in a straight line? How many times longer is the canal (1,794 km) than the straight line?
(Use the map or drawing “Compare the winding canal with a straight line between its ends.” shown earlier in this lesson.)
8. **HARD** Why did the Yuan dynasty cut a new route for the canal through Shandong instead of using the Sui route by way of Kaifeng and Luoyang?
9. **HARD** Give three reasons why the northern Grand Canal declined after 1855.
10. **CHALLENGE** A boat crossing the summit passes one lock going up and one lock going down, and each lockage takes 2,400 m³ of water out of the summit pool. Suppose the summit pool holds 3,000,000 m³ and gets no new water. How many boats could cross before it ran dry? Use your answer to explain why Song Li dammed the Wen River in 1411.

COMMON MISTAKES

- Thinking a lock uses pumps to lift boats. A pound lock uses gravity: water flows downhill from the upper pool into the chamber.
- Thinking the Grand Canal follows a river. It runs north and south across the eastward-flowing rivers, linking them together.
- Thinking the whole canal was dug at one time. It was built in pieces over about two thousand years, from 486 BC to the Ming rebuilding of the 1400s.

Make it a game • Lock Keeper. Write each lock step on a card: “Lower the chamber,” “Open the lower gate,” “Boat enters,” “Close the lower gate,” “Open the upper sluice,” “Levels match,” “Open the upper gate,” “Boat leaves.” Shuffle and race to lay them in order for a boat going up. Then reverse them for a boat going down. Bonus round: your partner calls out a chamber size and lift, and you have thirty seconds to give the water used.

Scripture. “The king’s heart is in the hand of the LORD, as the rivers of water: he turneth it whithersoever he will.” (Proverbs 21:1, KJV)

Chinese emperors turned rivers and dug a waterway the length of their empire. Solomon pictures God doing the same with the hearts of kings, guiding even the most powerful rulers as easily as a farmer guides water through a channel.

Practice answers

1. The Qiantang, the Yangtze, the Huai, the Yellow River and the Hai.
2. Qiao Weiye, a Song dynasty transport official, in 984. It replaced a double slipway, where boats were dragged up and down stone ramps.
3. Upper gate and lower gate (hold the water in the chamber and open to let boats pass); chamber (holds the boat while the water rises or falls); sluices (let water in from above or out to below).
4. $3.5 \times 3.28 \approx 11.5$ feet.
5. $50 \times 8 \times 3 = 1,200 \text{ m}^3$ (1.2 million liters).
6. $618 - 605 = 13$ years. Forced labor on the canals (and other heavy burdens such as costly wars) helped turn the people against the dynasty, so the canal cost the Sui very dearly even though later dynasties benefited.
7. North-south: $9.6^\circ \times 111 \approx 1,066 \text{ km}$. East-west: $3.8^\circ \times 91 \approx 346 \text{ km}$. Distance = $\sqrt{(1,066^2 + 346^2)} \approx \sqrt{1,256,000} \approx 1,121 \text{ km}$ (about 700 miles). $1,794 \div 1,121 \approx 1.6$ times longer.
8. Kublai Khan made Beijing (Dadu) the capital. The old Sui route bent far west to the old capitals at Luoyang and Kaifeng and then ran northeast, so it was very roundabout for reaching Beijing. A route straight north through Shandong saved hundreds of kilometers, though it had to climb over the Shandong summit with locks.
9. (1) The Yellow River shifted north in 1855, cutting across the canal in Shandong and filling it with silt. (2) Steamships could carry grain faster along the coast. (3) Railways, such as the Tianjin-Pukou line (1912), took over the long north-south haul. Grain shipments by canal ended in the early 1900s.
10. Each boat uses $2 \times 2,400 = 4,800 \text{ m}^3$. $3,000,000 \div 4,800 = 625$ boats. A busy canal with thousands of grain barges a year would drain the summit quickly, so it needed a steady supply of fresh water. Song Li's dam at Daicun led the Wen River to the summit at Nanwang, keeping it full so water could flow down the locks both north and south.

6.3 JAPAN AND KOREA

OBJECTIVES

- Locate Japan's four main islands and the Korean peninsula, and describe their mountains, coastal plains, seas and ocean currents.
- Explain how mountains, seas and currents shaped farming, fishing, trade and the long periods when both lands kept foreigners out, using Hendrick Hamel's shipwreck of 1653.
- Describe the religions of Japan and Korea and the history of Christianity in each, and calculate distances and sun times across the region.

Warm-up. Crumple a sheet of paper into a tight ball, then open it out on the table without flattening it. Imagine it is a country, and the table is the sea. Put a coin anywhere a city could be built on fairly flat ground. How many coins fit? Where are most of them, in the middle or near the edges? You have just made a model of Japan and Korea.

Watch. *Evolution of Japanese SHINKANSEN Trains: Explained* (Railways Explained, 16:52). https://www.youtube.com/watch?v=UIcC-m_cgE4

With On the map: follow the Shinkansen lines along Japan's narrow coastal plains and notice how tunnels and bridges cross its mountains.

Note: Captions were not available to check; preview it first. The description advertises a Japan travel Wi-Fi company, so expect a sponsor message you can skip. It runs about 17 minutes, and the first part may be enough.

Backup video. *How to Draw Korea Outline Map / South Korea Map / North Korea Map / Outline Map Series Easy Tricks* (Outline Map, 8:05). <https://www.youtube.com/watch?v=J355Z4BW8-E>

With On the map: draw the Korean peninsula step by step along with the video, then mark Seoul, Busan and the island of Jeju where Hamel's ship wrecked. Note: Captions were not available to check; preview it first. It seems to be a drawing demonstration with little or no teaching, and the description is padded with unrelated search tags.

KEY TERMS

archipelago

A chain or group of islands. Japan is an archipelago of more than 14,000 islands.

peninsula

A piece of land almost surrounded by water but joined to a larger landmass. Korea is a peninsula joined to Asia in the north.

Ring of Fire

The belt of volcanoes and earthquakes around the edges of the Pacific Ocean, where plates of the earth's crust meet.

Kuroshio

A warm ocean current that flows northeast along Japan's Pacific coast. Where it meets the cold Oyashio current, the sea is rich in fish.

strait

A narrow stretch of sea joining two larger bodies of water. The Korea Strait lies between Korea and Japan.

isolation policy

A government's choice to keep most foreigners and foreign trade out. Japan held such a policy from the 1630s to the 1850s, and Korea's Joseon kingdom did much the same.

CORE IDEAS

The story. In August 1653 the Dutch East India Company ship *Sperwer* ("Sparrowhawk"), bound from Taiwan to Nagasaki, was wrecked in a storm on the island of Jeju, off the southern tip of Korea. Thirty-six of the crew reached shore alive. Korea's Joseon kingdom did not allow foreigners to come and go, so the sailors were taken to Seoul and later sent to live in the southern provinces. For thirteen years they could not leave. In September 1666, Hendrick Hamel and seven companions slipped away in a small boat, crossed the Korea Strait and reached Nagasaki in Japan, where the Dutch kept a small trading post on the man-made island of Dejima. Hamel's journal, printed in 1668, gave Europe its first eyewitness description of Korea.

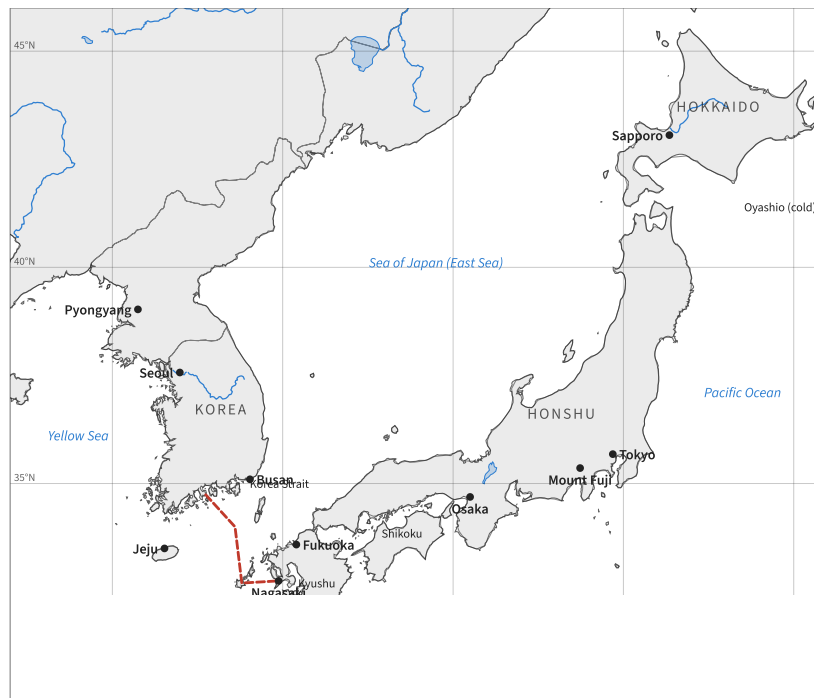
On the map. Hamel's escape crossed the heart of this region. **Korea** is a mountainous **peninsula** about 1,000 km (620 miles) long, between the Yellow Sea and the Sea of Japan (which Koreans call the East Sea). The Taebaek Mountains run close to the east coast, so most rivers, such as the Han at Seoul, flow west, and the larger plains and cities lie on the west and south. In the north the Yalu and Tumen rivers form the border with China. **Japan** is an **archipelago** stretching about 3,000 km (1,900 miles) from north to south. Its four main islands are Hokkaido, Honshu, Kyushu and Shikoku, and a 2023 government survey counted more than 14,000 islands in all. About three-quarters of Japan is mountains. It lies on the **Ring of Fire**, with more than a hundred active volcanoes and frequent earthquakes; the tallest peak, Mount Fuji (3,776 m, 12,388 feet), last erupted in 1707. Most Japanese live on small coastal plains, such as the Kanto Plain around Tokyo and the plains around Osaka and Nagoya.

The big idea. In both lands, mountains crowd people toward the coasts, and the sea feeds them. Rice grows in every flat valley and on terraced hillsides. Offshore, the warm **Kuroshio** current flows northeast along Japan's Pacific coast and meets the cold Oyashio off northeastern Honshu. Where warm and cold water mix, plankton thrive and fish gather, making these some of the richest fishing grounds on earth. With little coal, oil or iron of their own, both Japan and South Korea grew rich in modern times by importing raw materials and exporting ships, cars, steel and electronics through great ports such as Yokohama, Kobe and Busan, one of the busiest container ports in the world.

How geography shaped history. The narrow **Korea Strait**, about 200 km (125 miles) wide with the island of Tsushima in the middle, was both a bridge and a moat. Chinese writing,

Confucian learning and Buddhism passed from China through Korea to Japan. Yet the sea also protected Japan: Mongol fleets sent by Kublai Khan in 1274 and 1281 were turned back, the second wrecked by a typhoon the Japanese called the *kamikaze*, the “divine wind.” From the 1630s Japan’s rulers closed the country to nearly all foreigners except Chinese and Dutch traders at Nagasaki, until the American Commodore Matthew Perry’s ships arrived in 1853 and a treaty opened Japanese ports in 1854. Korea stayed closed until 1876. Japan ruled Korea from 1910 to 1945. In 1945 Korea was divided near the 38th parallel, and after the Korean War (1950–1953) ended in an armistice, two states remain as of 2026: the Republic of Korea (South Korea, capital Seoul) and the Democratic People’s Republic of Korea (North Korea, capital Pyongyang), with no peace treaty yet signed.

Faith. Japan’s native religion is Shinto, the honoring of *kami* (spirits) at shrines, and Buddhism came from Korea in the 500s; most Japanese take part in customs of both. Francis Xavier landed at Kagoshima in 1549, and within fifty years perhaps 300,000 Japanese were Christians. Then the rulers banned the faith. In 1597 twenty-six Christians were crucified at Nagasaki, and many more died in later persecutions. Some families kept their faith in secret for about 250 years; in 1865 a group of these hidden Christians made themselves known to a French priest at Nagasaki’s new Ōura Church. Christians are about one percent of Japan today. In Korea, Buddhism and Confucian teaching shaped the old kingdom. Korean scholars learned of Christianity from books brought from China, and Yi Seung-hun was baptized in Beijing in 1784; thousands of Korean Catholics were martyred in the persecutions that followed. Protestant missionaries Horace Underwood and Henry Appenzeller arrived in 1885, and the Bible spread quickly in Hangul, the simple Korean alphabet created under King Sejong in the 1440s. In the 2015 census about 28 percent of South Koreans were Christians. In North Korea the government strictly controls religion, and open Christian worship is not allowed outside a few state-approved churches.



Korea and Japan face each other across the Korea Strait. The red line shows Hendrick Hamel's escape route in 1666.

PICTURE STUDY



Under the Wave off Kanagawa (The Great Wave), from Thirty-six Views of Mount Fuji, Katsushika Hokusai, about 1830–1832 · Color woodblock print on paper · Many impressions survive; one is in the Metropolitan Museum of Art, New York

Katsushika Hokusai was an artist of Edo (today's Tokyo), working during the long years when Japan was closed to most of the world. When he was about seventy he made a series of prints called *Thirty-six Views of Mount Fuji*. Woodblock prints were carved on blocks of

cherry wood, one block for each color, and printed by hand in large numbers, so ordinary people could buy them.

In this print, three fast boats are caught by a great wave off the coast of Kanagawa, near Edo Bay. Such boats rushed fresh fish to the city markets. Japan's highest mountain looks tiny behind them. Hokusai used a new imported blue pigment, Prussian blue, and the print later became one of the most famous images in the world.

Look closely

- Find Mount Fuji. How has Hokusai made the giant mountain look small?
- Count the boats and look at the rowers. What are they doing to survive the wave?
- Look at the edge of the wave. What does the foam look like?
- Notice how the small wave in front echoes the shape of Mount Fuji. Why might Hokusai have done that?

Talk about it

1. What does this print tell you about how Japanese people lived with the sea and its dangers?
2. Why would fish need to reach the city quickly in a time without refrigerators?
3. How do the mountain and the sea in this picture match what you learned about Japan's geography?

PROJECT: A RELIEF MAP: WHERE CAN PEOPLE LIVE?

You will build a raised relief map of Korea and Japan, then lay a grid over it and count how many squares are flat enough for farms and cities. You will see for yourself why the people of these lands crowd onto the coasts and turn to the sea.

You will need

- Salt dough (2 cups flour, 1 cup salt, about $\frac{3}{4}$ cup water) or modeling clay
- A piece of stiff cardboard about 30 × 40 cm (12 × 16 inches)
- A printed outline map of Korea and Japan, taped to the cardboard
- Poster paints (green, light brown, dark brown, white, blue) and a small brush
- Clear plastic wrap or a transparency sheet, a ruler and a fine marker
- Toothpicks and small paper flags

Steps

1. Using the lesson map and an atlas, lightly pencil the Taebaek Mountains near Korea's east coast, the mountain spine of Honshu, and the Kanto Plain around Tokyo.
2. Cover the land with a thin layer of dough. Build the mountains high and steep, and keep the coastal plains and river valleys low and flat.
3. Carve the Han River flowing west to the Yellow Sea, and mark Mount Fuji as a tall cone southwest of Tokyo.

4. Let the map dry (one to two days, or bake at a very low temperature with a parent's help), then paint plains green, hills light brown, mountains dark brown with white peaks, and the seas blue.
5. Flag Seoul, Busan, Pyongyang, Tokyo, Osaka, Nagasaki, Fukuoka and Sapporo.
6. Draw a grid of 2 cm (about $\frac{3}{4}$ inch) squares on the plastic sheet and lay it over the map. Count the squares that are mostly land, then the squares that are mostly flat green land.
7. Calculate the percent of flat land: $\text{flat squares} \div \text{land squares} \times 100$. Paint a red arrow for the Kuroshio and a blue arrow for the Oyashio offshore.

Tips

- Look at the lesson map carefully: Korea's mountains hug the east coast, so the west side should be lower.
- Your percent will not be exact. Compare it with the real figure: about three-quarters of Japan is mountainous, leaving roughly one-quarter for everything else.

Check your work

- My map shows mountains, coastal plains, the four main islands of Japan and the Korean peninsula.
- I counted flat land with a grid and calculated a percent.
- I can explain why cities and farms crowd along the coasts and why fishing matters so much here.

MAP NOTEBOOK

1. Draw Japan and Korea on one page. Label Hokkaido, Honshu, Kyushu, Shikoku, the Korean peninsula, the Yellow Sea, the Sea of Japan (East Sea), the Korea Strait and the Pacific Ocean.
2. Draw the Kuroshio with a red arrow and the Oyashio with a blue arrow, and shade the area where they meet. Write one sentence explaining why fish gather there.
3. Trace Hamel's journey: Taiwan to the wreck on Jeju (1653), to Seoul, to the south coast, and across the strait to Nagasaki (1666).

From history. Japan's mountains and straits have pushed its engineers to some of the world's greatest tunnels. The Seikan Tunnel, opened in 1988, carries trains under the Tsugaru Strait between Honshu and Hokkaido. It is about 53.9 km (33.5 miles) long, and about 23 km (14 miles) of it runs beneath the seabed. Its builders worked for more than twenty years through soft, broken rock and sudden floods of seawater. For many years it was the longest railway tunnel in the world, until the Gotthard Base Tunnel in Switzerland opened in 2016.

WORKED EXAMPLES

Example 1. Busan, Korea, is at about 35.1°N , 129.0°E , and Fukuoka, Japan, is at about 33.6°N , 130.4°E . At about 34°N one degree of longitude is about 92 km. How far apart are they in km and miles? How long would a ferry take at 30 km/h?

(Use the map or drawing “Busan and Fukuoka face each other across the Korea Strait.” shown earlier in this lesson.)

1. North-south: $35.1^{\circ} - 33.6^{\circ} = 1.5^{\circ}$. $1.5 \times 111 \approx 167$ km.
2. East-west: $130.4^{\circ} - 129.0^{\circ} = 1.4^{\circ}$. $1.4 \times 92 \approx 129$ km.
3. Distance = $\sqrt{(167^2 + 129^2)} = \sqrt{(27,889 + 16,641)} = \sqrt{44,530} \approx 211$ km.
4. Convert: $211 \times 0.621 \approx 131$ miles.
5. Time: $211 \div 30 \approx 7$ hours.

Answer: About 210 km (about 130 miles); about 7 hours at 30 km/h.

Example 2. Japan’s clocks are set by the sun at 135°E , the meridian that passes through the city of Akashi. The sun crosses 1° of longitude every 4 minutes, moving from east to west. Tokyo is at about 139.7°E . At what clock time is the sun highest in Tokyo?

1. Tokyo is east of 135°E by $139.7^{\circ} - 135^{\circ} = 4.7^{\circ}$.
2. The sun reaches places in the east first: 4.7×4 minutes ≈ 19 minutes early.
3. $12:00 - 19$ minutes = 11:41 a.m.

Answer: At about 11:41 a.m. Japan Standard Time.

Example 3. On October 1, 1964, the first Shinkansen (“bullet train”) line opened between Tokyo and Shin-Osaka, a rail distance of about 515 km. The fastest trains then took 4 hours; today’s fastest take about $2\frac{1}{2}$ hours. Find both average speeds in km/h and mph.

1. 1964: $515 \text{ km} \div 4 \text{ h} \approx 129 \text{ km/h}$. $129 \times 0.621 \approx 80 \text{ mph}$.
2. Today: $515 \text{ km} \div 2.5 \text{ h} = 206 \text{ km/h}$. $206 \times 0.621 \approx 128 \text{ mph}$.
3. The line runs along the narrow coastal plains between the mountains and the sea, through many tunnels and over many bridges.

Answer: About 129 km/h (80 mph) in 1964 and about 206 km/h (128 mph) today.

PRACTICE

1. **EASY** Name Japan’s four main islands from north to south.
2. **EASY** Which current is warm, the Kuroshio or the Oyashio? Why are the waters where they meet so good for fishing?

3. **EASY** Mount Fuji is 3,776 m high. How high is it in feet?
4. **MEDIUM** South Korea also keeps its clocks by 135°E, but Seoul is at about 127.0°E. At what clock time is the sun highest in Seoul?
5. **MEDIUM** Seoul is at about 37.6°N. How far south of the 38th parallel is it, in km and miles?
6. **MEDIUM** The Sperwer was wrecked in 1653, Hamel escaped in 1666 and his journal was printed in 1668. How long was he held in Korea, and how long after the shipwreck was his journal printed?
7. **MEDIUM** Japan's land area is about 378,000 km². If about three-quarters is mountainous, about how much land is left for farms, towns and cities? Give km² and square miles (1 km² ≈ 0.386 sq mi).
8. **HARD** Why are most of Korea's large rivers, plains and cities on the west side of the peninsula?
9. **HARD** Explain how the seas around Japan acted both as a moat and as a bridge in its history. Give one example of each.
10. **CHALLENGE** Sapporo is at about 43.1°N, 141.4°E, and Kagoshima at about 31.6°N, 130.6°E. At about 37°N one degree of longitude is about 89 km. How far apart are they in a straight line? Compare this with the distance from Boston to Atlanta, about 1,500 km (940 miles).

(Use the map or drawing "Measure Japan from Sapporo to Kagoshima." shown earlier in this lesson.)

COMMON MISTAKES

- Thinking Japan is one island. It is an archipelago of four main islands and thousands of smaller ones.
- Thinking Korea is an island. It is a peninsula, joined to China (and for a short stretch to Russia) in the north.
- Thinking Japan and Korea have always been closed to the world. Both traded and learned from China for centuries; their isolation policies belong mainly to the 1600s through the 1800s.

Make it a game • Island, Peninsula or Strait?. One player names a place: Honshu, Korea, Tsushima, the Korea Strait, Hokkaido, Jeju, the Tsugaru Strait, Kyushu, the Shandong peninsula. The other has five seconds to say whether it is an island, a peninsula or a strait, and to point to it on the map. A correct answer and point scores two; a correct answer alone scores one. Switch roles after five places. First to fifteen wins.

Scripture. "Sing unto the LORD a new song, and his praise from the end of the earth, ye that go down to the sea, and all that is therein; the isles, and the inhabitants thereof." (Isaiah 42:10, KJV)

Isaiah calls on the far-off islands and the people who work the sea to praise God. The hidden Christians of Nagasaki, who kept their faith in secret for about 250 years, are one example of such praise rising from the islands at the edge of Asia.

Practice answers

1. Hokkaido, Honshu, Shikoku and Kyushu (Shikoku and Kyushu are both south of Honshu; Kyushu is the farthest southwest).
2. The Kuroshio is warm; the Oyashio is cold. Where they mix, nutrients and plankton thrive, and fish gather to feed.
3. $3,776 \times 3.28 \approx 12,385$ feet (the official figure is 12,388 feet).
4. Seoul is 8° west of 135°E . $8 \times 4 = 32$ minutes late, so the sun is highest at about 12:32 p.m.
5. $38.0^\circ - 37.6^\circ = 0.4^\circ$. $0.4 \times 111 \approx 44$ km, about 28 miles. Seoul lies close to the old dividing line.
6. $1666 - 1653 = 13$ years in Korea; $1668 - 1653 = 15$ years after the wreck.
7. One-quarter of $378,000 = 94,500 \text{ km}^2$. $94,500 \times 0.386 \approx 36,500$ square miles.
8. The Taebaek Mountains run close to the east coast, so the land slopes gently down toward the west. Rivers such as the Han flow west to the Yellow Sea, building plains and valleys where farms and cities like Seoul grew. The east coast is steep and narrow.
9. Moat: the sea protected Japan from invasion; the Mongol fleets of 1274 and 1281 failed, the second destroyed by a typhoon. Bridge: across the narrow Korea Strait came Chinese writing, Confucian learning and Buddhism by way of Korea; later Dutch and Chinese ships traded at Nagasaki, and Perry's ships arrived by sea in 1853.
10. North-south: $11.5^\circ \times 111 \approx 1,277$ km. East-west: $10.8^\circ \times 89 \approx 961$ km. Distance = $\sqrt{(1,277^2 + 961^2)} \approx \sqrt{2,554,000} \approx 1,598$ km, about 1,600 km (about 990 miles). Japan's main islands stretch a little farther than Boston to Atlanta.

6.4 RICCI AND TAYLOR IN CHINA

OBJECTIVES

- Tell the stories of Matteo Ricci (in China 1582–1610) and Hudson Taylor (in China from 1854) and trace their journeys on a map of China's rivers and the Grand Canal.
- Explain why both men learned Chinese, dressed as Chinese and studied the land, and why China's many spoken dialects and its shared written characters mattered to their work.
- Weigh their methods fairly, describe the history of Christianity in China, and calculate the distances and travel times of their journeys.

Warm-up. Say the syllable “ma” four ways: high and level, rising like a question, dipping down and up, and falling sharply like a command. In Mandarin Chinese those four tones make four different words: mother, hemp, horse and scold. Now try to say “Mother scolds the horse” without mixing them up. How long do you think it would take you to learn thousands of words like these, plus thousands of written characters?

Watch. *Matteo Ricci and The Forbidden Temple - "Ends of The Earth"* (Drive Thru History with Dave Stotts, 4:24). <https://www.youtube.com/watch?v=JDPN7HehhZA>
After the story: watch Dave Stotts tell how Matteo Ricci became the first European welcomed into Beijing's imperial grounds, and listen for how he shared his faith.

Note: Captions were not available to check; preview it first. It comes from a trusted Christian history series. The title calls it the 'Forbidden Temple'; the lesson says Ricci entered Beijing in 1601 and never met the Wanli Emperor face to face.

KEY TERMS

missionary

A person sent to another people or place to make the gospel of Jesus Christ known, often also teaching, healing or translating.

Jesuit

A member of the Society of Jesus, a Catholic order of priests founded in 1540 and known for its schools, scholars and missionaries.

dialect

A local form of a language. China's spoken forms, such as Mandarin, Cantonese and the Wu speech of Shanghai and Ningbo, differ so much that speakers often cannot understand one another.

tone

The rise or fall of the voice on a syllable. In Chinese, changing the tone changes the meaning of the word.

Chinese characters

The written signs of Chinese, each standing for a word or part of a word. People who speak very different dialects can read the same characters.

China Inland Mission

The mission Hudson Taylor founded in 1865 to send workers into China's interior provinces. It continues today as OMF International.

CORE IDEAS

The story. On January 24, 1601, an Italian Jesuit priest named Matteo Ricci entered Beijing, the capital of Ming China. It had taken him eighteen years to come up from the south coast. He brought gifts for the Wanli Emperor: chiming clocks, a clavichord, glass prisms and religious paintings. The emperor never met him face to face, but the clocks needed someone to keep them running, and Ricci was allowed to stay. He lived in Beijing until his death in 1610, and the emperor granted land for his burial there, a rare honor for a foreigner.

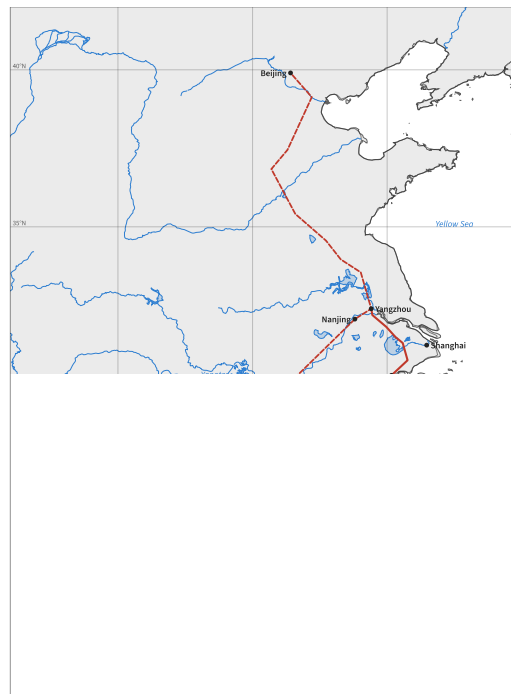
How they figured it out. Ricci (1552–1610) arrived in Portuguese Macau in 1582 and began the hard work of learning Chinese. In 1583 he and another Jesuit, Michele Ruggieri, were allowed to settle at Zhaoqing, west of Guangzhou. Ricci saw that China was ruled by educated scholars, so he studied the Confucian classics, and from 1595 he dressed as a scholar. He wrote books in Chinese, including *The True Meaning of the Lord of Heaven* (1603). He also used geography: he drew world maps that showed Chinese scholars the round earth and the many countries beyond China, and in 1602 he and the scholar Li Zhizao printed a great world map in Beijing. With his friend Xu Guangqi, who was baptized in 1603, he translated the first six books of Euclid's geometry into Chinese (1607). His road north followed China's waterways: up the rivers of the south, over the Meiling Pass, down the Gan River to the Yangtze, and finally up the Grand Canal to Beijing.

A second story. Two and a half centuries later, a young Englishman from Barnsley in Yorkshire, James Hudson Taylor (1832–1905), landed at Shanghai on March 1, 1854, after a voyage of more than five months. China was in the midst of the Taiping Rebellion. Taylor found that his foreign clothes made crowds see him as a stranger, so in 1855 he put on Chinese dress and wore his hair in the Chinese queue, though other foreigners mocked him. He learned the Shanghai and Ningbo dialects and later helped revise the New Testament in the Ningbo dialect. Back in England, he studied maps of China and saw eleven inland provinces with no Protestant missionary at all. On June 25, 1865, on the beach at Brighton, he asked God for twenty-four workers, two for each of those provinces and two for Mongolia. That year he founded the **China Inland Mission**, and in 1866 he sailed with his family and a party of sixteen missionaries on the *Lammermuir*. Its workers, women as well as men, traveled up the Yangtze and its tributaries into province after province. When Taylor died at Changsha in 1905, the mission had more than 800 missionaries.

The big idea. Both men learned the land and the language before they tried to teach. China's geography made that hard. Mountains and rivers had divided its people into many speech regions, so a missionary who learned the speech of Ningbo could not be understood in Guangzhou. Yet one written language of characters tied the country together, so a book printed in characters could be read by scholars everywhere. That is why Ricci wrote for

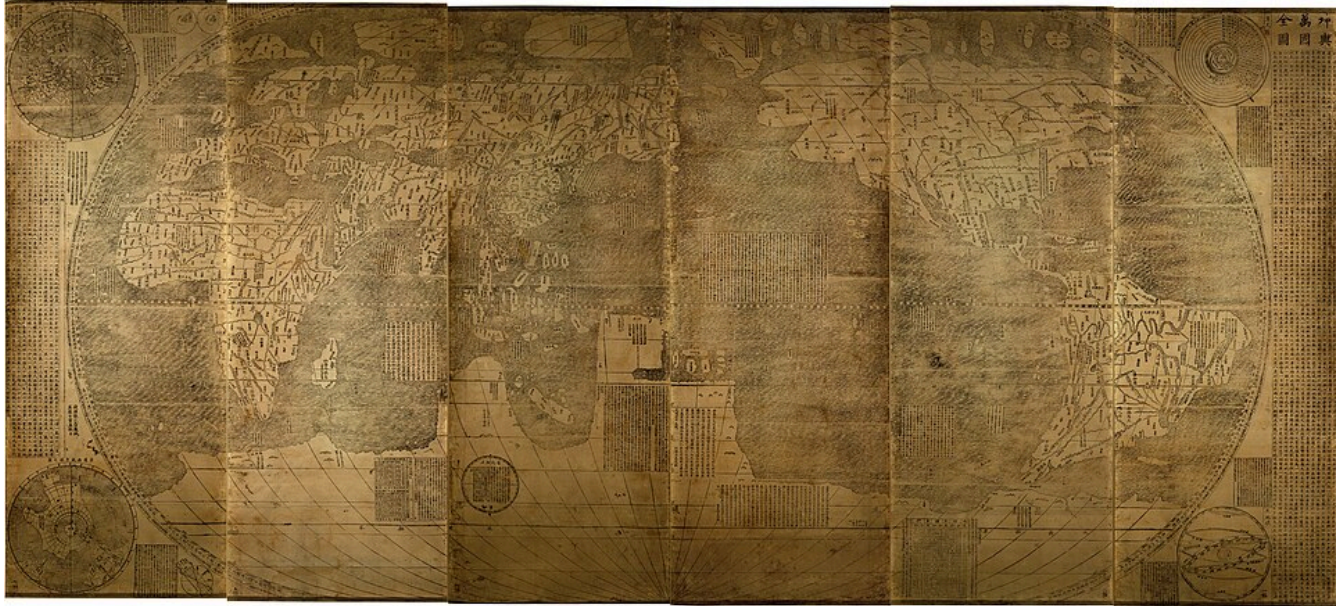
scholars in classical Chinese, while Taylor and other missionaries also printed Bibles in the local speech of ordinary people, sometimes in Roman letters that were easier to learn. Rivers and canals were their highways: Ricci traveled the Grand Canal, and the China Inland Mission planted its stations along the Yangtze. Even the riot that struck Taylor's mission house at Yangzhou in 1868 happened in a canal town.

Weighing the record. Ricci went further than most missionaries of his time in adapting to Chinese ways. He allowed converts to keep honoring their ancestors, which he judged to be a family custom rather than worship. Later missionaries disagreed, and in the 1700s the popes forbade those rites, a ruling Rome relaxed in 1939. Christians still debate where wise adaptation ends and compromise begins. Taylor's workers suffered greatly: in the Boxer Uprising of 1900, fifty-eight China Inland Mission missionaries and twenty-one of their children were killed, and the mission chose not to claim the compensation that foreign governments demanded. Christianity in China is far older than either man, reaching back to the Church of the East in 635 (Lesson 6.1). As of 2026, China's government permits worship in registered Protestant and Catholic churches under state supervision, while many believers meet in unregistered churches that face restrictions. Estimates of the number of Christians vary widely, partly because so many worship outside the registered churches.



Ricci's road north followed rivers, a mountain pass and the Grand Canal (1583–1601). Taylor worked from Shanghai, Ningbo and Hangzhou and died at Changsha in 1905.

PICTURE STUDY



Kunyu Wanguo Quantu (A Map of the Myriad Countries of the World), Matteo Ricci with Li Zhizao, 1602 · Woodblock print in ink on six large panels of paper · One of the few surviving copies is in the James Ford Bell Library, University of Minnesota; others are in the Vatican Library and in Japan

Ricci made his first Chinese world map at Zhaoqing in 1584, and Chinese scholars copied it eagerly. In 1602 in Beijing he and Li Zhizao, a scholar who loved geography and mathematics, printed this much larger version. Ricci's maps were the first in China to show the Americas, and this one put the knowledge of European explorers into Chinese words.

Ricci made one important choice to suit his readers. European maps put the Atlantic in the middle. Ricci split the map through the Atlantic, so that the Pacific lay at the center and China stood near the middle of the world. Notes in Chinese describe many lands and peoples, and some of the Chinese names he helped choose for distant places, such as Ya-xi-ya for Asia, are the roots of names still used today.

Look closely

- Find China. Where is it on this map, compared with where it appears on most maps made in America or Europe?
- Find the Americas. On which side of the map are they? What ocean lies between them and China?
- Look at the oval shape of the whole map. What does that shape tell you about how Ricci showed a round earth on flat paper?
- Notice the blocks of writing. Why would a map for Chinese scholars need so many notes?

Talk about it

1. Why do you think Ricci put the Pacific Ocean in the center? Was that a wise choice?

2. How might a map like this have helped Chinese scholars trust Ricci and listen to him?
3. Is any map “right side up” or “centered” by nature? Who decides?

PROJECT: A PACIFIC-CENTERED MAP AND A MISSIONARY ROUTE MAP

You will remake a world map the way Ricci did, with the Pacific in the middle, and then draw a map of China tracing the journeys of Ricci and Taylor along its rivers, mountain pass and canal.

You will need

- Two identical printed world maps (Atlantic-centered), letter size
- Scissors, clear tape and a glue stick
- A blank outline map of eastern China
- Colored pencils: red, blue and green
- A ruler and a calculator

Steps

1. On both world maps, cut along a north-south line through the middle of the Atlantic Ocean.
2. Take the eastern piece (Europe, Africa and Asia) from one map and the western piece (the Americas) from the other. Tape them together along the Pacific so the Pacific is in the middle.
3. Trim the ends so your new map is the same width as the original. Find China and write 中国 (“Middle Kingdom,” China’s name for itself) beside it if you like.
4. On the China outline map, draw the Yangtze and the Grand Canal in blue.
5. Draw Ricci’s route in red: Macau, Zhaoqing (1583), Shaoguan (1589), over the Meiling Pass, Nanchang (1595), Nanjing (1599), then up the Grand Canal to Beijing (1601).
6. Mark Taylor’s places in green: Shanghai (1854), Ningbo (1857–1860), Hangzhou (1866), Yangzhou (1868) and Changsha (1905).
7. Use the map scale to measure Ricci’s route and Taylor’s Shanghai–Changsha distance in km and miles. Write a caption telling which rivers each man used.

Tips

- Keep the cut lines straight and the edges aligned so the coastlines match where you join the pieces.
- Remember that Ricci took eighteen years for his route because he stopped and lived in each city for years.

Check your work

- My world map has the Pacific in the center, as Ricci’s map did.
- My China map shows Ricci’s route and Taylor’s places in the correct order and position.

- I can explain why both men followed rivers and canals.

MAP NOTEBOOK

1. Draw a two-column chart, “Ricci” and “Taylor,” comparing their home country, church, years in China, the language they learned, how they dressed and the main thing they left behind.
2. Copy the four tones of “ma” with tone marks (mā, má, mǎ, mà) and their meanings (mother, hemp, horse, scold), and draw a little line beside each showing how the voice moves.
3. Sketch a small Pacific-centered world map from memory and label the Pacific, China, Japan, the Americas and Europe.

From history. Ricci’s friend Xu Guangqi (1562–1633), baptized with the name Paul, came from Shanghai and rose to become one of the highest officials of the Ming court. He wrote on farming, water control and astronomy and helped reform the Chinese calendar. His descendants kept the faith, and the district of Shanghai where his family lived is still called Xujiahui, “the Xu family’s meeting place.” In the 1800s and early 1900s Jesuits built a library, an observatory and a large cathedral there, near Xu’s tomb.

WORKED EXAMPLES

Example 1. Macau is at about 22.2°N , 113.6°E , and Beijing at about 39.9°N , 116.4°E . At about 31°N one degree of longitude is about 95 km. How far apart are they in a straight line? Ricci took from 1583 to 1601 to make this journey. On average, how far north did he advance each year?

(Use the map or drawing “Ricci’s eighteen-year road north.” shown earlier in this lesson.)

1. North-south: $39.9^\circ - 22.2^\circ = 17.7^\circ$. $17.7 \times 111 \approx 1,965$ km.
2. East-west: $116.4^\circ - 113.6^\circ = 2.8^\circ$. $2.8 \times 95 = 266$ km.
3. Distance = $\sqrt{(1,965^2 + 266^2)} = \sqrt{(3,861,225 + 70,756)} = \sqrt{3,931,981} \approx 1,983$ km.
Convert: $1,983 \times 0.621 \approx 1,231$ miles.
4. Years: $1601 - 1583 = 18$. Average: $1,983 \div 18 \approx 110$ km (about 68 miles) per year.

Answer: About 1,980 km (about 1,230 miles) in a straight line, an average of only about 110 km (68 miles) a year, because Ricci settled for years in each city along the way.

Example 2. Hudson Taylor sailed from Liverpool on September 19, 1853, and landed at Shanghai on March 1, 1854. How many days was he at sea? Today a flight from London to Shanghai takes about 12 hours. How many times longer was Taylor's voyage?

1. September: $30 - 19 = 11$ days remaining.
2. October 31 + November 30 + December 31 + January 31 + February 28 (1854 was not a leap year) = 151 days.
3. Add March 1: $11 + 151 + 1 = 163$ days.
4. Hours: $163 \times 24 = 3,912$ hours. $3,912 \div 12 = 326$.

Answer: 163 days, about 326 times as long as a modern flight. Ships of Taylor's day sailed around the Cape of Good Hope, since the Suez Canal did not open until 1869.

Example 3. Ricci traveled up the Grand Canal from Yangzhou (about 32.4°N , 119.4°E) toward Beijing (about 39.9°N , 116.4°E). At 36°N one degree of longitude is about 90 km. Find the straight-line distance. If the winding canal route is about 1.3 times as long, and a boat makes about 30 km a day, about how long would the trip take?

1. North-south: $39.9^\circ - 32.4^\circ = 7.5^\circ$. $7.5 \times 111 \approx 833$ km.
2. East-west: $119.4^\circ - 116.4^\circ = 3.0^\circ$. $3.0 \times 90 = 270$ km.
3. Straight line = $\sqrt{(833^2 + 270^2)} = \sqrt{(693,889 + 72,900)} = \sqrt{766,789} \approx 876$ km (about 544 miles).
4. Canal route: $876 \times 1.3 \approx 1,139$ km. Days: $1,139 \div 30 \approx 38$ days.

Answer: About 876 km (544 miles) in a straight line; the canal route is about 1,140 km, so about 38 days (five to six weeks) by canal boat, not counting delays at locks and customs stations.

PRACTICE

1. **EASY** In what year did Ricci enter Beijing? In what year did Taylor first land at Shanghai?
2. **EASY** What was the China Inland Mission, and when and by whom was it founded?
3. **EASY** Why did both Ricci and Taylor wear Chinese clothing?
4. **MEDIUM** Ricci was born in 1552 and died in 1610. Taylor was born in 1832 and died in 1905. About how old was each when he died? How many years passed between Ricci's death and Taylor's arrival in China?
5. **MEDIUM** In 1865 Taylor prayed for 24 workers: two for each inland province without a Protestant missionary, plus two for Mongolia. How many provinces were there? Show your work.
6. **MEDIUM** Ningbo is at about 29.9°N and Shanghai at about 31.2°N , at nearly the same longitude. About how far apart are they, in km and miles?

7. **MEDIUM** Taylor died at Changsha (about 28.2°N, 112.9°E). Shanghai is at about 31.2°N, 121.5°E. At about 30°N one degree of longitude is about 96 km. How far apart are they in a straight line?
(Use the map or drawing “From the coast to the interior: Shanghai to Changsha.” shown earlier in this lesson.)
8. **HARD** The Mandarin syllable “ma” can mean mother, hemp, horse or scold. Explain what makes the difference, and why a missionary preaching with wrong tones might be misunderstood.
9. **HARD** Name two ways Ricci’s and Taylor’s work was alike and two ways it was different.
10. **CHALLENGE** Explain why a book printed in Chinese characters could be read across China even though people in different regions could not understand each other’s speech, and why missionaries such as Taylor still printed some Bibles in local dialects using Roman letters.

COMMON MISTAKES

- Thinking Ricci or Taylor brought Christianity to China for the first time. The Church of the East arrived in 635, and Franciscans worked in Beijing around 1300.
- Thinking all Chinese people speak the same language. They share a written language, but the spoken dialects differ greatly from region to region.
- Thinking the two men worked at the same time. Ricci died in 1610; Taylor arrived in 1854, almost two and a half centuries later.

Make it a game · Tone Telephone. Write mā, má, mǎ and mà on four cards with their meanings (mother, hemp, horse, scold). One player secretly picks a card and says the syllable with its tone. The others must hold up the matching meaning. Then make it harder: the speaker says two in a row (“mā mǎ,” mother’s horse). Score a point for every correct match. Afterward, talk about how patient Ricci and Taylor had to be.

Scripture. “Behold, these shall come from far: and, lo, these from the north and from the west; and these from the land of Sinim.” (Isaiah 49:12, KJV)

Hudson Taylor and many Christians of his day believed “Sinim” meant China, and the verse encouraged them to pray for the Chinese. Many scholars today think Sinim more likely refers to Syene (Aswan) in Egypt. Either way, the verse promises that people will come to God from the farthest corners of the earth, the same hope Paul declared in Athens when he said God “hath made of one blood all nations of men” (Acts 17:26).

Practice answers

1. Ricci entered Beijing in 1601 (January 24). Taylor landed at Shanghai in 1854 (March 1).
2. A Protestant mission that sent workers into China’s interior provinces. Hudson Taylor founded it in 1865. Today it is OMF International.
3. So that Chinese people would not see them as strange outsiders and would be more willing to listen. Ricci dressed as a Confucian scholar to speak with educated officials; Taylor wore ordinary Chinese dress and the queue to live among common people.

4. Ricci was about 57 ($1610 - 1552 = 58$, but he died in May before his October birthday). Taylor was 73 ($1905 - 1832$). Taylor arrived in 1854: $1854 - 1610 = 244$ years after Ricci's death.
5. $24 - 2$ (for Mongolia) $= 22$. $22 \div 2 = 11$ provinces.
6. $31.2^\circ - 29.9^\circ = 1.3^\circ$. $1.3 \times 111 \approx 144$ km, about 90 miles.
7. North-south: $3.0^\circ \times 111 = 333$ km. East-west: $8.6^\circ \times 96 \approx 826$ km. Distance $= \sqrt{(333^2 + 826^2)} \approx \sqrt{793,000} \approx 891$ km, about 890 km (about 550 miles).
8. The tone (the rise or fall of the voice) changes the meaning: mā (high, level) mother, má (rising) hemp, mǎ (dipping) horse, mà (falling) scold. A speaker who uses the wrong tone says a different word, so a sermon full of wrong tones could be confusing or even funny, and listeners might miss the message.
9. Alike: both learned Chinese and dressed as Chinese; both traveled by China's rivers and canals; both studied the land and its people. Different: Ricci was a Catholic Jesuit who worked mainly among scholars and officials at the capital, writing in classical Chinese; Taylor was a Protestant who sent many workers, including women, into the inland provinces to ordinary people, using local dialects.
10. Characters stand mainly for words and meanings rather than exact sounds, so a scholar in Beijing and a scholar in Guangzhou could read the same characters even if they pronounced them very differently. But learning thousands of characters took years, and many ordinary people could not read them. A Bible in a local dialect, spelled in Roman letters, matched the way people actually spoke and could be learned in weeks, so far more people could read it for themselves.

UNIT 6 REVIEW

Answer each question. Show your work for calculations, give distances in both kilometers and miles, and use complete sentences for explanations. Use the unit maps where a question asks for map reading. The review is worth 60 points.

1. (6 pts) Name China's two great rivers, give the length of each in km and miles, and name the plateau where both begin and the sea or seas where each ends today.
2. (6 pts) Explain how silt and dikes turned parts of the lower Yellow River into a "suspended river," and why that made the flood of 1855 change the river's course.
3. (6 pts) Compare farming north and south of the Qinling-Huai line. Give the crops and the reason for the difference.
4. (6 pts) List the four steps for raising a boat through a pound lock. Who built the first known pound lock, and when?
5. (6 pts) A lock chamber is 70 m long and 12 m wide, with a lift of 2.5 m. How much water does one lockage use, in cubic meters and liters? What is the lift in feet?
6. (6 pts) The Grand Canal is about 1,794 km long. Convert to miles. If a barge averages 30 km a day with no delays, how many days would the whole trip take? Name the five river systems the canal links.
7. (6 pts) Explain why China needed the Grand Canal, and give two reasons the northern part declined after 1855.
8. (6 pts) Name Japan's four main islands. Explain why most people in Japan and Korea live near the coasts, and why the waters off northeastern Japan are rich in fish.
9. (6 pts) Japan keeps its clocks by the sun at 135°E. Osaka is at about 135.5°E and Nagasaki at about 129.9°E. At about what clock time is the sun highest in each city?
10. (6 pts) Name two things Matteo Ricci and two things Hudson Taylor did to learn the land and language of China, and explain how China's many dialects and its shared written characters affected their work.

UNIT PROJECT: MY EAST ASIA ATLAS PAGE AND WORKING CANAL LOCK

Draw a large atlas page of East Asia. Show the Tibetan Plateau, the Loess Plateau and the North China Plain; the Yellow River (with its course before and after 1855) and the Yangtze; the Grand Canal from Hangzhou to Beijing; Korea and Japan's four main islands; and the Kuroshio and Oyashio currents. Mark at least twelve cities, and add Ricci's route and Hamel's escape. Use a map scale and show at least three distances you calculated in this unit in both km and miles.

Beside the atlas page, present your working model pound lock. Demonstrate it raising and lowering a boat, label its parts, and write a short paragraph explaining how a pound lock overcomes a change in water level and why the Grand Canal mattered to China.

- **Accuracy:** Rivers, canal, landforms, islands, currents and cities are placed and labeled correctly, and the calculated distances are correct in km and miles.

- **Working model:** The lock raises and lowers a boat without lifting it by hand; gates, chamber, pools and sluices are labeled; the water used per lockage is calculated.
- **Explanation:** The paragraph explains how a pound lock works and how the canal linked the rice-growing south with the capitals of the north.
- **Care:** The atlas page is neat, colorful, has a title, key, scale and compass rose, and is easy to read.

Answer key

1. The Yellow River, about 5,460 km (3,395 miles), ends in the Bohai Sea. The Yangtze, about 6,300 km (3,900 miles), ends in the East China Sea at Shanghai. Both begin on the Tibetan Plateau in Qinghai.
2. The river picks up loess silt on the Loess Plateau and drops it on its bed when it slows on the flat plain. People raised the dikes, the silt raised the bed again, and over centuries the river came to flow above the surrounding land. When the dikes broke near Lankao in 1855, the water ran downhill away from the old channel and found a new path north of the Shandong hills to the Bohai Sea, about 400 km (250 miles) from the old mouth.
3. North: colder, drier winters and less rain (under about 800 mm or 31 inches a year), so farmers grow wheat and millet. South: warmer, with heavy summer monsoon rain, so farmers grow rice in flooded paddies, often two crops a year, and tea on the hills.
4. (1) Empty the chamber to the lower level and open the lower gate. (2) The boat enters and the lower gate closes. (3) Open the upper sluice so water fills the chamber and lifts the boat. (4) When the levels match, open the upper gate and the boat leaves. Qiao Weiyue built the first known pound lock in 984, during the Song dynasty.
5. $70 \times 12 \times 2.5 = 2,100 \text{ m}^3 = 2,100,000 \text{ liters}$. $2.5 \times 3.28 \approx 8.2 \text{ feet}$.
6. $1,794 \times 0.621 \approx 1,114 \text{ miles}$. $1,794 \div 30 \approx 60 \text{ days}$. It links the Qiantang, the Yangtze, the Huai, the Yellow River and the Hai.
7. The rice surplus grew in the south, while the capitals and armies were in the north, and China's great rivers all flow east, so a north-south waterway was needed to carry grain tribute. After 1855 the Yellow River shifted north and cut across and silted the canal in Shandong; steamships along the coast and railways such as the Tianjin-Pukou line (1912) took over the long haul.
8. Hokkaido, Honshu, Shikoku and Kyushu. Both lands are mostly mountains (about three-quarters of Japan), so farms and cities crowd onto small coastal plains and river valleys. Off northeastern Japan the warm Kuroshio meets the cold Oyashio; the mixing water feeds plankton, and fish gather to feed.
9. Osaka: $0.5^\circ \text{ east} \times 4 \text{ min} = 2 \text{ minutes early}$, about 11:58 a.m. Nagasaki: $135^\circ - 129.9^\circ = 5.1^\circ \text{ west}$; $5.1 \times 4 \approx 20 \text{ minutes late}$, about 12:20 p.m.
10. Ricci: studied Chinese and the Confucian classics, dressed as a scholar, wrote books in Chinese, drew world maps (1584, 1602), translated Euclid with Xu Guangqi. Taylor: wore Chinese dress and the queue, learned the Shanghai and Ningbo dialects, revised the Ningbo New Testament, studied maps of the inland provinces and founded the China Inland Mission (1865). Characters could be read across China, so Ricci wrote for scholars everywhere; but spoken dialects differ greatly, so missionaries working among ordinary people had to learn the local speech and sometimes printed Bibles in local dialects using Roman letters.

SOUTHEAST ASIA AND OCEANIA

Between mainland Asia and the Americas lies a world made mostly of water: the thousands of islands of Indonesia and the Philippines, the narrow straits that join the Indian Ocean to the Pacific, the dry island continent of Australia, the mountains of New Zealand, and the scattered high islands and coral atolls of the Pacific. In this unit you will study each the same way: first the land and the sea, the volcanoes, monsoons, deserts and swells; then how that geography shaped the history, farming, trade and faith of the people who live there. God “hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation” (Acts 17:26), and here the bounds of habitation are often the shores of an island.

You will sail with Magellan’s men to the Philippines in 1521 and follow the spice trade to the Moluccas. You will stand with Stamford Raffles at the mouth of the Singapore River in 1819 and watch a tiny island become one of the busiest ports on earth, our technology story for this region. You will land with the First Fleet at Sydney Cove in 1788, cross the Blue Mountains, and see why New Zealand’s west coast is soaked while its east lies in a rain shadow. Finally you will learn how Polynesian and Marshallese navigators found specks of land in the largest ocean without instruments, and how John Williams and many Pacific Islander teachers carried the gospel from island to island.

Your map for this unit is the Strait of Malacca and the islands around it. Your project is a Marshall Islands stick chart, and the unit ends with an atlas page for Southeast Asia and Oceania and a short map quiz.

BEFORE YOU BEGIN

- Can read latitude and longitude and convert between kilometers and miles
- Knows what a monsoon is and how mountains make a rain shadow (Unit 5 and Grade 6)
- Can use the Pythagorean theorem to estimate a straight-line distance from north-south and east-west distances
- Has begun a regional atlas notebook in earlier units

MASTERY CHECKLIST

- I can locate Indonesia, the Philippines, Singapore, Australia, New Zealand and the three Pacific island regions, and the Strait of Malacca, Sunda Strait and Lombok Strait.
- I can explain how straits, monsoon winds and spices shaped the history and faiths of the islands of Southeast Asia.
- I can explain what a choke point is and how Singapore used technology to overcome being a small island with few resources.
- I can explain, using climate, why most Australians live near the coast and why New Zealand’s Canterbury Plains lie in a rain shadow.

- I can describe how Pacific navigators found islands with stars, swells and birds, and read a Marshall Islands stick chart.
- I can tell how the gospel came to these regions, naming Francis Xavier, Richard Johnson, Samuel Marsden, John Williams and the Pacific Islander teachers.

OPTIONAL BOOKS AND RESOURCES

- **Alfred Russel Wallace, *The Malay Archipelago* (free at Project Gutenberg)** (<https://www.gutenberg.org/ebooks/search/?query=the+malay+archipelago+wallace>): Free. Wallace's own account of eight years among the islands (1854-1862). Read aloud his chapters on Bali and Lombok (Lesson 7.1). Long and detailed, so a parent may choose passages.
- **Polynesian Voyaging Society** (<https://www.hokulea.com/>): Free. Photographs, maps and explanations of the voyaging canoe Hōkūle'a, the Hawaiian star compass and modern wayfinding (Lesson 7.4).
- **Royal Museums Greenwich** (<https://www.rmg.co.uk/>): Free. Search the collections for William Hodges's paintings from Cook's second voyage, including *Tahiti Revisited* (Lesson 7.4 picture study).

7.1 ISLANDS AND STRAITS ★

OBJECTIVES

- Locate Indonesia, the Philippines, their largest islands and the Strait of Malacca, Sunda Strait and Lombok Strait on a map.
- Explain how volcanoes, monsoon winds, straits and spices shaped the history, farming, trade and faiths of the islands, using Magellan's arrival in 1521 and Wallace's line.
- Measure distances and travel times across the islands in kilometers and miles, and read the three time zones of Indonesia.

Warm-up. Fill a sink or baking pan with water and drop in a handful of small stones or bottle caps so they make a scattered chain of "islands." Float a paper boat from one end to the other. Where must it squeeze between islands? Where could a person who controlled one narrow gap stop or tax every boat? Now blow gently from one side to make a "wind." Is it easier to sail with the wind or against it?

Watch. *27th August 1883: The eruption of Krakatoa* (HistoryPod, 2:48).

<https://www.youtube.com/watch?v=2Pp-W1Va5gE>

With On the map: find the Sunda Strait between Java and Sumatra, then watch how Krakatoa's 1883 eruption was heard thousands of miles away.

Note: Captions were not available to check; preview it first. The eruption and its tsunamis killed more than 36,000 people, a hard moment to discuss.

KEY TERMS

archipelago

A large group or chain of islands. Indonesia and the Philippines together make up most of the Malay Archipelago, the largest island group on earth.

strait

A narrow passage of sea that connects two larger bodies of water, such as the Strait of Malacca between the Indian Ocean and the South China Sea.

monsoon

A seasonal wind that reverses direction during the year, bringing a wet season and a drier season. Sailing ships in Asia timed their voyages by it.

Ring of Fire

The belt of volcanoes and earthquakes around the edges of the Pacific Ocean, where plates of the earth's crust meet.

Wallace Line

A boundary through the Lombok Strait and the Makassar Strait, traced by Alfred Russel Wallace, that separates mostly Asian animals to the west from mostly Australian kinds to the east.

Spice Islands

The Moluccas (Maluku) of eastern Indonesia, where cloves, nutmeg and mace once grew and nowhere else.

CORE IDEAS

The story. In March 1521, three battered Spanish ships under Ferdinand Magellan came out of the empty Pacific and sighted the islands of the eastern Philippines, after more than three months crossing the ocean. On Easter Sunday, March 31, a priest said Mass on the small island of Limasawa, the first known Mass in the Philippines. At Cebu, a busy harbor town, Rajah Humabon and hundreds of his people were baptized in April. Then Magellan tried to force a neighboring chief, Lapulapu of Mactan, to submit, and on April 27, 1521, Magellan was killed in the shallows of Mactan. The survivors sailed south to Tidore, one of the Spice Islands, and filled their last ship, the *Victoria*, with cloves. In September 1522 the *Victoria* limped into Spain with only 18 men of the five crews that had set out in 1519. Why risk so much? Because these islands sat on the richest sea roads in the world.

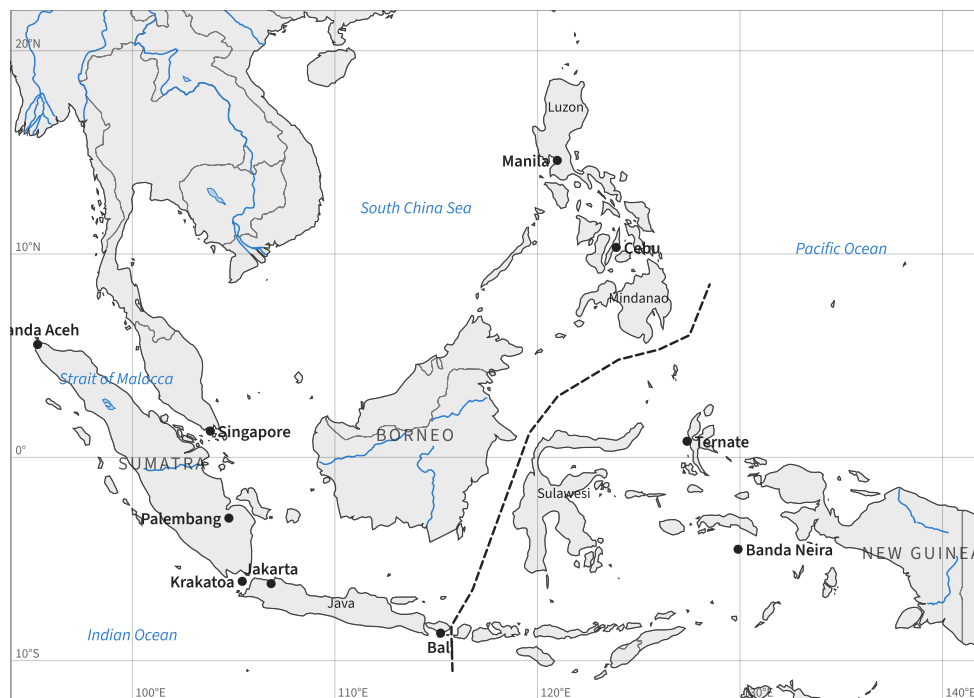
On the map. Between mainland Asia and Australia lies the largest group of islands on earth. Indonesia counts about 17,000 islands spread across some 5,000 km (3,100 miles) of sea, and the Philippines more than 7,000. The great islands are Sumatra, Java, Borneo (shared by Indonesia, Malaysia and Brunei), Sulawesi and New Guinea, and in the Philippines, Luzon and Mindanao. The islands lie on the **Ring of Fire**, and Indonesia has more active volcanoes than any other country. Volcanic ash weathers into rich soil, one reason crowded Java can feed so many people, but eruptions can be terrible, as at Tambora in 1815 and Krakatoa in 1883. The western islands rise from a shallow shelf, but east of Bali the water plunges deep. The naturalist **Alfred Russel Wallace**, collecting here from 1854 to 1862, noticed that the birds of Bali and Lombok were strikingly different, though the strait between them is only about 25 km (15 miles) wide. West of his line live Asian animals such as tigers and orangutans; east of it, Australian kinds such as cockatoos and marsupials.

The big idea. Islands make sea travel necessary, and the narrow passages between them, the **straits**, become the gates of trade. The most important is the **Strait of Malacca**, about 800 km (500 miles) long between Sumatra and the Malay Peninsula, the shortest sea road between the Indian Ocean and the Pacific. Sailors also lived by the **monsoon**: roughly from December to March the wind blows from the northeast, and from June to September from the southwest. Merchants from India, Arabia and China sailed with one monsoon and waited in port for the next, so harbor towns on the straits grew rich. Srivijaya, based at Palembang on Sumatra, ruled the straits from about the 600s to the 1200s, and later Malacca did. The great prize was spice. Cloves grew only on a few small islands of the northern Moluccas, such as Ternate and Tidore, and nutmeg only on the tiny Banda Islands. Portugal seized Malacca in 1511. The Dutch East India Company, based at Batavia (today's Jakarta) from 1619, conquered the Banda Islands in 1621 with great cruelty, killing, driving out or enslaving most of the Bandanese to control the nutmeg trade.

Peoples, faith and farming. Near the equator, sun and rain come all year, so rice is the staple. Farmers flood terraced paddies, from Bali to northern Luzon, where the Ifugao people carved terraces up whole mountainsides. The faiths of the islands came by sea along the

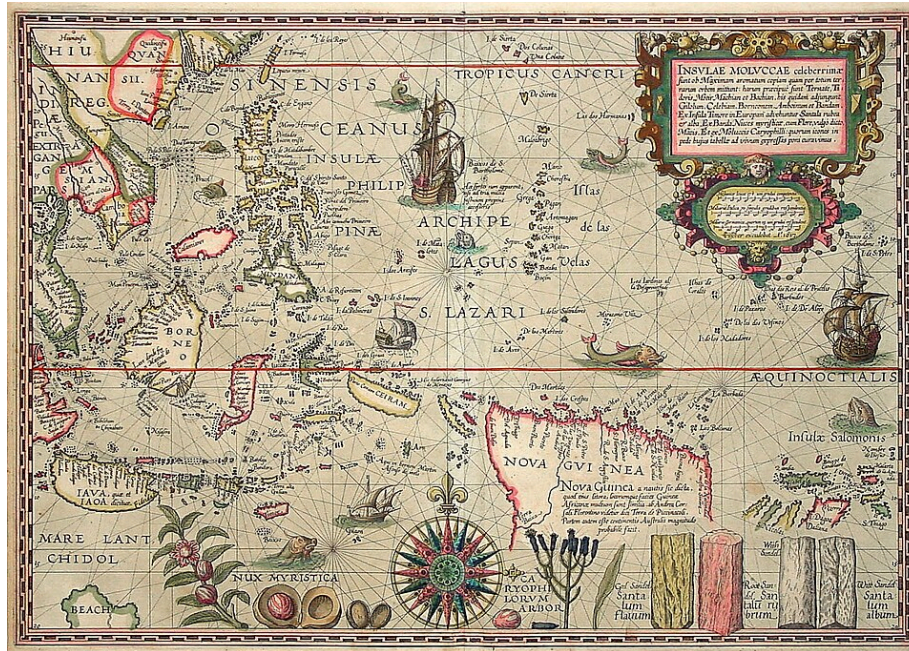
trade routes. Hindu and Buddhist kingdoms came first, building temples such as the great Buddhist monument of Borobudur on Java about 800. Islam came with Muslim merchants, taking root in northern Sumatra by the late 1200s and spreading from port to port. Today nearly nine Indonesians in ten are Muslim, so Indonesia has more Muslims than any other country, while Bali remains mostly Hindu. Christianity came by sea too. Francis Xavier preached in Ambon and the Moluccas in 1546–1547, and from the 1860s the German missionary Ludwig Nommensen worked among the Batak of northern Sumatra, where a large Protestant church grew. About one Indonesian in ten is Christian. Spain ruled the Philippines from 1565, founded Manila in 1571, and sent Catholic friars across the islands; at the 2020 census nearly four Filipinos in five were Roman Catholic, with a Muslim minority in Mindanao and Sulu, where Islam had arrived before the Spanish.

The islands today. Indonesia declared independence on August 17, 1945, and the Netherlands recognized it in 1949. It counted about 270 million people in 2020, the fourth most of any country, and more than half live on Java. The national language, Bahasa Indonesia, links speakers of more than 700 local languages. In 2022 Indonesia passed a law to move its capital from Jakarta to a new city, Nusantara, on Borneo; as of 2026 the move was not complete. The Philippines passed from Spain to the United States in 1898 and became independent on July 4, 1946; it counted about 109 million people in 2020. Both nations still depend on the sea, and God, who “hath determined ... the bounds of their habitation” (Acts 17:26), set these peoples among the islands and the straits.



The islands and straits of Southeast Asia. The dashed Wallace Line runs through the Lombok Strait and the Makassar Strait.

PICTURE STUDY



Insulae Moluccae (The Molucca Islands), Petrus Plancius, 1592 (this impression printed 1617) · Engraved map, hand-colored in many copies · Published in Amsterdam by Cornelis Claesz; copies survive in many map libraries

Petrus Plancius was a Reformed minister in Amsterdam who was also one of the best mapmakers of his day. In the 1590s Dutch merchants were planning their first voyages to the East Indies, and they needed to know where the spices grew. Plancius drew this map largely from Portuguese charts, which the Portuguese had tried to keep secret.

Along the bottom of the map he drew the treasures that made the islands famous: nutmeg, cloves and sandalwood. A few years later Dutch fleets followed maps like this one to the Moluccas, and in 1602 the merchants joined together as the Dutch East India Company.

Look closely

- Find the spice plants drawn along the bottom edge. Which can you name?
- Find the large island of Borneo. Compare its shape with a modern map. Where did Plancius go wrong?
- Look for the small islands of the Moluccas. Why do you think the mapmaker drew them so carefully?
- Find the ships and sea creatures. What do they tell you about how people felt about these seas?

Talk about it

1. Why would a map like this be worth a great deal of money to merchants in 1592?
2. Why might the Portuguese have wanted to keep their charts secret?

3. What does this map tell you about how geography (spices growing in only a few places) shaped history?

Safety first. Use a battery-powered or plug-in fan kept well away from the water tray. Never use a hair dryer or other plug-in appliance near water. Wipe up spills right away so no one slips.

PROJECT: ISLANDS AND STRAITS IN A BAKING PAN

You will build the western islands of Southeast Asia in a tray of water and sail paper boats through the straits with a fan as your monsoon wind. You will discover why ships crowded into the Strait of Malacca, why sailors waited for the wind to change, and why whoever held the narrow gates could grow rich.

You will need

- A large baking pan or plastic storage tub, about 12 × 18 inches (30 × 45 cm)
- Modeling clay or salt dough in two colors
- Water with a few drops of blue food coloring
- A printed outline map of Southeast Asia, or the lesson map
- Paper boats or bottle-cap boats with toothpick-and-paper sails
- A small fan
- A ruler, tape and a marker

Steps

1. Tape the outline map under a clear tub, or study it beside the pan. Decide which way is north and mark it on the pan's rim with tape.
2. Shape the Malay Peninsula from clay along one side so it reaches toward the middle of the pan. Shape Sumatra beside it, leaving a long narrow channel between them: the Strait of Malacca.
3. Add Java south of Sumatra, leaving a small gap (the Sunda Strait), and then Bali and Lombok with a narrow gap between (the Lombok Strait). Add Borneo to the east.
4. Press a tiny ball of clay at the tip of the Malay Peninsula for Singapore. Pour in water about 1 inch (2.5 cm) deep.
5. Place a boat in the "Indian Ocean" west of Sumatra. Set the fan to blow from the southwest, as in June to September, and let the boat sail toward the "South China Sea." Record which gap it goes through and how long it takes.
6. Turn the fan to blow from the northeast, as in December to March. Try to sail the same way. What happens? Now sail the other way.
7. Try a second route, around the south of Sumatra through the Sunda Strait. Measure both routes with a string and ruler and compare.
8. Put a coin "toll" at the narrowest gap. Count how many boats would have to pay it if every boat used the shortest route.

Tips

- Keep the Strait of Malacca long and narrow; it is the heart of the model.
- On a real map Sumatra runs from northwest to southeast. Check your angle before the clay sets.

Check your work

- My model shows Sumatra, the Malay Peninsula, Java, Bali, Lombok and Borneo with the right straits between them.
- I can explain why sailors waited for the monsoon to change direction.
- I can explain, using my toll coin, why the kingdoms and ports on a strait grew rich.

MAP NOTEBOOK

1. On a blank map, draw and label Sumatra, Java, Borneo, Sulawesi, New Guinea, Luzon and Mindanao, and shade the Strait of Malacca, the Sunda Strait and the Lombok Strait blue.
2. Draw the Wallace Line in red. On its west side sketch a tiger or an orangutan; on its east side, a cockatoo.
3. Make a two-column chart, "Northeast monsoon" and "Southwest monsoon," with the months each blows and the direction a ship from India could sail in each.

From history. In April 1815 Mount Tambora, on the island of Sumbawa in Indonesia, erupted in the largest volcanic explosion in recorded history. Tens of thousands of people on Sumbawa and nearby islands died from the blast, the ash and the hunger that followed. The eruption threw so much fine ash and gas high into the sky that the next year, 1816, became known in Europe and New England as "the Year Without a Summer," with snow in June in parts of New England and failed harvests across Europe. A volcano on a small island halfway around the world changed the weather of farms in Vermont and Switzerland.

WORKED EXAMPLES

Example 1. Indonesia stretches from about 95°E in northern Sumatra to about 141°E at its border on New Guinea. Near the equator, one degree of longitude is about 111 km. About how wide is Indonesia from west to east, in kilometers and miles?

(Use the map or drawing “Indonesia stretches across more than 45 degrees of longitude.” shown earlier in this lesson.)

1. Find the difference in longitude: $141^{\circ} - 95^{\circ} = 46^{\circ}$.
2. Multiply by the length of a degree near the equator: $46 \times 111 \text{ km} = 5,106 \text{ km}$.
3. Round to about 5,100 km.
4. Convert to miles ($1 \text{ km} \approx 0.621 \text{ mi}$): $5,100 \times 0.621 \approx 3,170 \text{ miles}$.

Answer: About 5,100 km (about 3,200 miles), wider than the United States from coast to coast.

Example 2. A merchant ship of the 1500s sails the length of the Strait of Malacca, about 800 km (500 miles), at a steady 5 knots. One knot is 1 nautical mile per hour, or 1.852 km per hour. How long does the passage take?

1. Change the speed to km per hour: $5 \times 1.852 = 9.26 \text{ km/h}$.
2. Divide distance by speed: $800 \div 9.26 \approx 86 \text{ hours}$.
3. Change hours to days: $86 \div 24 \approx 3.6 \text{ days}$.
4. Check in miles: 5 knots $\approx 5.75 \text{ mph}$, and $500 \div 5.75 \approx 87 \text{ hours}$. The answers agree.

Answer: About 86 hours, or about $3\frac{1}{2}$ days, if the wind held steady all the way.

Example 3. When Krakatoa exploded on August 27, 1883, the roar was heard on Rodrigues Island in the Indian Ocean, about 4,800 km (3,000 miles) away. Sound travels about 343 meters per second in air. About how long did the sound take to reach Rodrigues?

1. Change the speed of sound to km per hour: $343 \text{ m/s} \times 3,600 \text{ s} = 1,234,800 \text{ m per hour}$, or about 1,235 km/h.
2. Divide the distance by the speed: $4,800 \div 1,235 \approx 3.9 \text{ hours}$.
3. So the sound arrived a little under 4 hours after the explosion.

Answer: About 4 hours. People on Rodrigues heard what they thought was distant gunfire hours after Krakatoa had already exploded.

PRACTICE

1. **EASY** About how many islands does Indonesia count? About how many does the Philippines have?
2. **EASY** Which strait lies between Sumatra and the Malay Peninsula, and which two bodies of water does it connect?
(Use the map or drawing “Find the strait between Sumatra and the Malay Peninsula.” shown earlier in this lesson.)
3. **EASY** Which spices once grew only in the Moluccas, and on which islands?
4. **EASY** Wallace wrote that Bali and Lombok are separated by a strait only about 15 miles wide. How many kilometers is that? (1 mile $\approx$ 1.609 km)
5. **MEDIUM** A merchant in India wants to sail east to Malacca. In which season should he leave, and why?
6. **MEDIUM** The Philippines counted about 109 million people in 2020, and nearly four in five were Roman Catholic. About how many Catholics is that?
7. **MEDIUM** Manila is at about 14.6°N, 121.0°E, and Jakarta at about 6.2°S, 106.8°E. One degree of latitude is about 111 km, and in this band one degree of longitude is also about 111 km. Find the north-south and east-west distances, then the straight-line distance, in km and miles.
(Use the map or drawing “Manila and Jakarta lie on opposite sides of the equator.” shown earlier in this lesson.)
8. **MEDIUM** Indonesia uses three time zones: Western (UTC+7) for Sumatra and Java, Central (UTC+8) for Bali and Sulawesi, and Eastern (UTC+9) for the Moluccas and Papua. Manila uses UTC+8. When it is noon in Jakarta, what time is it in Banda Neira and in Manila?
9. **HARD** Hinduism, Buddhism, Islam and Christianity all reached the islands from far away. Explain how geography helped bring them.
10. **CHALLENGE** Geography made nutmeg rare, because it grew only on the Banda Islands. Write a short paragraph explaining how that rarity shaped what the Dutch did in 1621, and why geography does not excuse their actions.

COMMON MISTAKES

- Thinking Indonesia is one big island. It is a nation of thousands of islands, and most people live on a few large ones, especially Java.
- Mixing up the Strait of Malacca (between Sumatra and the Malay Peninsula) with the Sunda Strait (between Sumatra and Java).
- Thinking the monsoon is only rain. A monsoon is a seasonal wind that reverses; the rains come with it.

Make it a game • Strait or Island?. A parent or partner calls out a name: Sumatra, Malacca, Java, Sunda, Lombok, Borneo, Luzon, Makassar, Mindanao, Sulawesi. You answer “Strait!” or “Island!” and point to it on the lesson map within ten seconds. For a bonus point, name the two islands or lands on either side of each strait. Play to ten points, then switch roles.

Scripture. “Sing unto the LORD a new song, and his praise from the end of the earth, ye that go down to the sea, and all that is therein; the isles, and the inhabitants thereof.” (Isaiah 42:10, KJV)

Isaiah calls the isles and the people who live on them to praise God. The islands of Southeast Asia, once known to Europe only for their spices, are home to many millions of people for whom Christ died, and churches there today sing in hundreds of languages.

Practice answers

1. Indonesia counts about 17,000 islands; the Philippines has more than 7,000.
2. The Strait of Malacca. It connects the Indian Ocean (by way of the Andaman Sea) with the South China Sea and the Pacific.
3. Cloves grew only on a few small islands of the northern Moluccas, such as Ternate and Tidore. Nutmeg and mace grew only on the Banda Islands.
4. $15 \times 1.609 \approx 24$ km, about 25 km.
5. During the southwest monsoon, roughly June to September, because the wind then blows from the southwest toward the northeast and east, carrying ships from India toward the straits. He would sail home with the northeast monsoon, roughly December to March.
6. $4/5 \times 109$ million ≈ 87 million people.
7. North-south: $14.6 + 6.2 = 20.8^\circ$, $\times 111 \approx 2,310$ km. East-west: $121.0 - 106.8 = 14.2^\circ$, $\times 111 \approx 1,580$ km. Straight line (Pythagorean theorem): $\sqrt{(2,310^2 + 1,580^2)} \approx 2,800$ km, about 1,740 miles.
8. Banda Neira (UTC+9) is 2 hours ahead: 2:00 p.m. Manila (UTC+8) is 1 hour ahead: 1:00 p.m.
9. The islands sit on the sea roads between India, Arabia and China, and the monsoon made merchants stop for months in island ports while waiting for the wind. Traders, teachers and later missionaries traveled on the same ships and routes, so each faith arrived by sea and took root first in the port towns (for example, Islam in northern Sumatra by the late 1200s, and Christianity with Xavier in the Moluccas and the Spanish in the Philippines).
10. Because nutmeg grew in only one tiny group of islands, whoever controlled Banda could control the world supply and set the price, so the Dutch East India Company wanted the islands for itself. In 1621 it conquered Banda, and most of the Bandanese were killed, driven away or enslaved, and the land was given to Dutch planters worked by slaves. Geography created the temptation, but people chose the cruelty; a good answer names both the geographic cause and the moral wrong.

7.2 SINGAPORE: A PORT AT A CHOKE POINT

OBJECTIVES

- Explain what a choke point is and why Stamford Raffles chose the island of Singapore for a British port in 1819.
- Describe how Singapore has used technology (a free port, steamships, container cranes, land reclamation and water recycling) to overcome being a tiny island with few resources.
- Compare sea routes through the Strait of Malacca and around it, computing the extra distance and time in kilometers, miles and knots.

Warm-up. Set up a “hallway port.” Ask everyone in the house to carry a book from one room to another, but only through one doorway. Stand in the doorway with a basket and offer each person a cup of water or a snack as they pass. How many people did you meet? Now imagine there were three other doors farther away. Would people still choose yours? What would make them choose it?

Watch. *The Bicentennial Trilogy - 1819* (Singapore Bicentennial, 4:31).

https://www.youtube.com/watch?v=RsI6gPYY_Vw

After the story: watch this short animated film about Singapore's founding in 1819 and look for why the spot at the tip of the Malay Peninsula mattered to ships.

Note: Captions were not available to check; preview it first. It is an official Singapore government animation that describes 'colonial Singapore', so check its framing. The story is told through William Farquhar, the first British Resident, while the lesson centers on Stamford Raffles.

Backup video. *Time-lapse: transit W-Singapore Strait and arrival at Singapore [4K / UHD, 60fps]* (SeaTube, 3:04). <https://www.youtube.com/watch?v=IQOBJPFsGBM>

With the big idea: ride along in this time-lapse as a ship passes through the busy Singapore Strait and docks at a container terminal, and count how many other ships you see.

KEY TERMS

choke point

A narrow place on a trade route, such as a strait or canal, through which a great deal of traffic must pass, and which can easily be blocked or controlled.

free port

A port where merchants may land, store and ship goods without paying customs duties (taxes on imports and exports).

entrepôt

A trading port where goods from many places are brought, stored, sorted and shipped on to other places.

transshipment

Moving cargo from one ship to another at a port partway through its journey, instead of unloading it for local use.

TEU

Twenty-foot equivalent unit: the standard measure of container cargo, equal to one container 20 feet (about 6.1 m) long.

land reclamation

Making new land by filling in shallow sea, swamp or river edges with sand, soil or rock.

CORE IDEAS

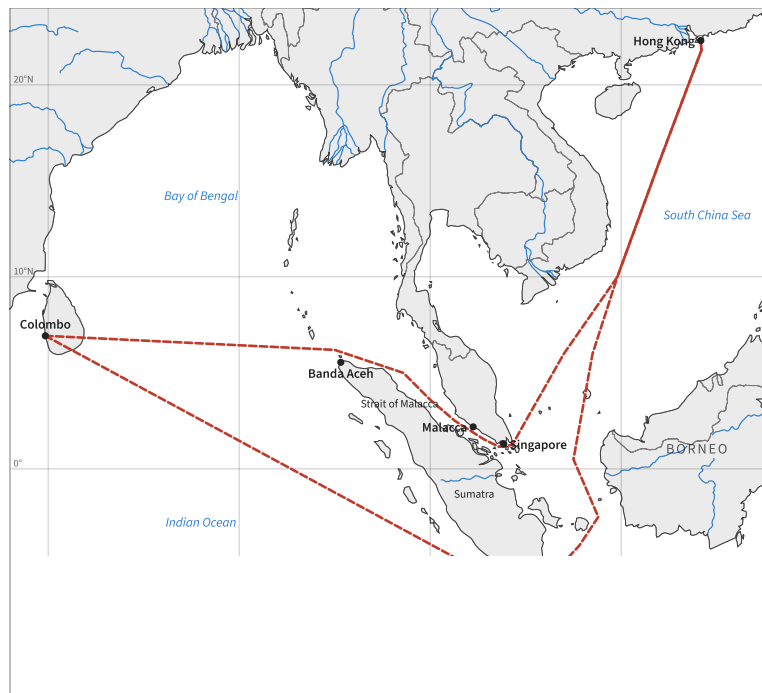
The story. In late January 1819, a small British squadron anchored off the mouth of a muddy river at the southern tip of the Malay Peninsula. On board was Sir Thomas Stamford Raffles, an officer of the British East India Company who had governed Java during the Napoleonic Wars. After the wars the Dutch took back Java and the ports around the straits, and Raffles feared they could shut British ships out of the road to China. On the island of Singapore he found a small Malay settlement under a local chief, the Temenggong. On February 6, 1819, Raffles signed a treaty with the Temenggong and with Hussein Shah, whom he recognized as Sultan of Johor, allowing the Company to build a trading post. Raffles declared it a **free port**, where ships paid no customs duties. Merchants came quickly: Chinese, Malays, Bugis, Indians, Arabs and Europeans. By 1824 the town held more than 10,000 people.

On the map. Singapore is a small island, about 140 km (90 miles) north of the equator, at the bottom of the Malay Peninsula. A narrow strait, the Johor Strait, separates it from the mainland, and the Singapore Strait runs along its south side. Every ship using the **Strait of Malacca** between the Indian Ocean and the South China Sea must pass Singapore. In the Phillips Channel, the narrowest part of the Singapore Strait, the shipping lane squeezes to about 2.8 km (1.7 miles) wide. That makes this one of the world's great **choke points**. Ships could go around, through the Sunda Strait between Sumatra and Java or the deeper Lombok Strait east of Bali, but those routes add hundreds of kilometers. Singapore also offered a deep, sheltered harbor.

The big idea. Ports grow at choke points because ships must pass and are glad to stop. Long before Raffles, a town called Temasek stood here, and the straits made Srivijaya and then Malacca rich. Portugal took Malacca in 1511 and the Dutch took it in 1641. In the Anglo-Dutch Treaty of 1824 the two powers divided the region: the Dutch kept the islands south of the Singapore Strait, and Britain the peninsula to the north, a line that still runs between Indonesia and Malaysia today. Singapore became an **entrepôt**, where pepper, tin, tea, silk, cotton cloth and opium were stored and shipped on. The opening of the Suez Canal in 1869 and the coming of steamships, which needed coal, made Singapore a key coaling station on the route from Europe to China.

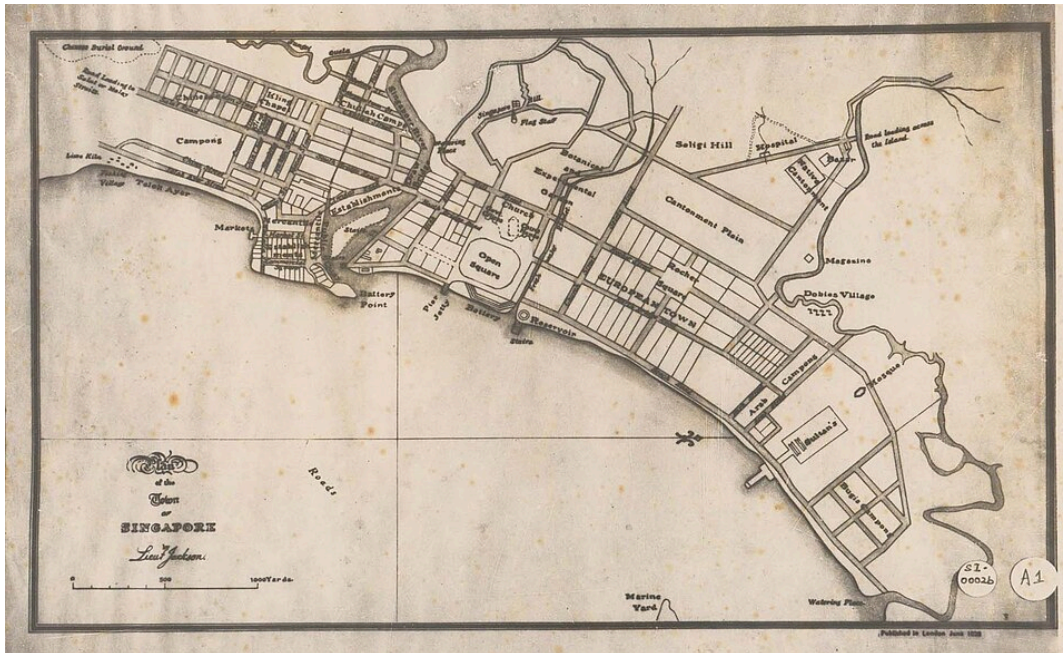
Technology overcoming geography. Singapore has almost no farmland, no oil or minerals, and few natural sources of fresh water. Its people overcame those limits with engineering. A causeway opened in 1924 linked the island to the mainland by road and rail. In 1972 Singapore opened its first container terminal at Tanjong Pagar. In 2023 the port handled about 39 million **TEU**, second only to Shanghai, much of it **transshipment** from one ship to another. By **land reclamation**, Singapore has grown about a quarter larger since the 1960s, and it is building a new automated port at Tuas, planned to handle about 65 million TEU when finished in the 2040s. For water, Singapore buys water from Malaysia's Johor under a 1962 agreement that runs to 2061, catches rain in reservoirs, removes salt from seawater, and since 2003 has purified used water into very clean drinking-grade water called NEWater.

People, faith and government. Singapore was taken by Japan in February 1942 and returned to British rule in 1945. It gained self-government in 1959 under Lee Kuan Yew, joined Malaysia in 1963, and became an independent republic on August 9, 1965. As of 2026 it is a parliamentary republic in which the People's Action Party has governed since 1959. About three-quarters of its roughly 6 million people are of Chinese descent, with large Malay and Indian communities. At the 2020 census Buddhism was the largest religion, about one in five people said they had no religion, and nearly one in five was Christian, with Muslims, Taoists and Hindus as well. The Armenian Church of Saint Gregory, built in 1835, is the island's oldest church, and the Methodist missionary William Oldham founded the Anglo-Chinese School in 1886. In a port where every ship must pass, people of many nations meet.



Ships between the Indian Ocean and East Asia can pass Singapore through the Strait of Malacca or go the long way around through the Sunda or Lombok Strait.

PICTURE STUDY



Plan of the Town of Singapore (the "Jackson Plan"), Lieutenant Philip Jackson, following Stamford Raffles's instructions, drawn 1822; printed 1828 · Engraved map · Printed in London in 1828 in John Crawford's account of his embassy to Siam and Cochin China; copies are held in libraries and archives in Singapore and Britain

When Raffles returned to Singapore in 1822, he found the young town growing in a jumble. He set up a committee to plan it, and Lieutenant Philip Jackson, a surveyor, drew this plan. It lays out straight streets, a waterfront for warehouses along the Singapore River, a public square, and the hill where the government stood.

Raffles also divided the town into separate quarters, called *kampongs*, for different peoples: Europeans, Chinese, Malays, Bugis, Arabs and Indians. This kept order as he saw it, though it also kept peoples apart. Many of these quarters, such as Chinatown and Kampong Glam, can still be traced in Singapore today.

Look closely

- Find the Singapore River. Why do you think the warehouses and markets were placed along its banks?
- Find the high ground set aside for the government. Why might rulers want to be on a hill?
- Look for the labels of the different peoples' quarters. How many can you find?
- Notice the straight streets. How is this town different from a town that grew without a plan?

Talk about it

1. What does this plan tell you about what Raffles thought mattered most in his new port?

2. Why would a planned grid of streets help a port town grow?
3. Raffles separated the peoples of the town into quarters. What might be good and what might be harmful about that?

PROJECT: THE SHORTCUT TEST: SEA ROUTES ON A GLOBE

You will measure real sea routes on a globe with string, turn your measurements into kilometers and miles, and find out how much farther a ship must go if it avoids the Strait of Malacca. Then you will build a small container yard to see why stacking boxes changed shipping.

You will need

- A globe (or a large world map)
- Thin string or yarn, a ruler and a fine marker
- A calculator
- About 30 small rectangular blocks, dominoes or LEGO bricks to be containers
- A shoebox lid to be a container ship

Steps

1. Lay the string around the globe's equator, mark where it meets itself, and measure that length with the ruler. The equator is about 40,075 km (24,900 miles) long. Divide to find how many kilometers each centimeter (or inch) of string stands for on your globe.
2. Route A: lay the string by sea from Colombo, Sri Lanka, past the northern tip of Sumatra, down the Strait of Malacca to Singapore, then north across the South China Sea to Hong Kong. Measure it and convert to km and miles.
3. Route B: from Colombo, run the string southeast around the west coast of Sumatra, through the Sunda Strait, across the Java Sea, and north to Hong Kong. Measure and convert.
4. Route C: try going around even farther, through the Lombok Strait east of Bali and north through the Makassar Strait. Measure and convert.
5. Make a table of the three routes and the extra distance of B and C compared with A. Use 37 km/h (20 knots) to find how many extra hours each detour adds.
6. Now load your shoebox ship with block containers in tidy stacks. Time how long it takes to unload them all. Then try unloading the same number of loose, odd-shaped items (socks, spoons, toy cars). Which is faster? That is the idea behind the container.

Tips

- Keep the string on the sea; ships cannot cross land.
- Your globe answers will not exactly match the numbers in the lesson. Within 10 percent is very good for string on a globe.

Check your work

- I measured three routes and converted each to kilometers and miles.

- I can explain why most ships choose the Strait of Malacca and pass Singapore.
- I can explain why containers made loading and unloading ships much faster.

MAP NOTEBOOK

1. Draw the tip of the Malay Peninsula, the island of Singapore, the Johor Strait and the Singapore Strait. Mark the Causeway and the Tuas port area in the west.
2. Make a timeline of Singapore: 1819, 1824, 1869, 1942, 1965, 1972 and 2003, with one line about each.
3. Sketch a container ship and a container crane, and label one 20-foot container (1 TEU) and one 40-foot container (2 TEU).

From history. In February 1942, during the Second World War, Japanese forces captured Singapore after advancing down the Malay Peninsula from the north, the land side of the island, rather than attacking from the sea. On February 15, 1942, the British commander surrendered, and tens of thousands of British, Australian and Indian soldiers became prisoners. Winston Churchill called it the worst disaster and largest surrender in British history. Singapore was occupied until 1945. The fortress had been built mainly to guard the sea approaches of the strait, and the attack came through the back door.

WORKED EXAMPLES

Example 1. Singapore lies at about 1.3°N . One degree of latitude is about 111 km. How far is Singapore from the equator, in kilometers and miles?

1. Multiply the latitude by the length of one degree: $1.3 \times 111 \text{ km} \approx 144 \text{ km}$.
2. Round to about 140 km.
3. Convert to miles: $144 \times 0.621 \approx 89 \text{ miles}$, about 90 miles.

Answer: About 140 km (about 90 miles). Singapore is one of the closest major cities to the equator, so it is warm and rainy all year.

Example 2. Rounded sea distances: from Colombo to Hong Kong through the Strait of Malacca is about 2,900 km to Singapore plus 2,700 km from Singapore to Hong Kong. Around Sumatra through the Sunda Strait it is about 3,300 km from Colombo to the Sunda Strait plus 3,400 km from there to Hong Kong. How much longer is the Sunda route, and how many extra hours does it add for a ship sailing at 20 knots (37 km/h)?

(Use the map or drawing “The Sunda Strait detour is about 1,100 km longer.” shown earlier in this lesson.)

1. Malacca route: $2,900 + 2,700 = 5,600$ km.
2. Sunda route: $3,300 + 3,400 = 6,700$ km.
3. Extra distance: $6,700 - 5,600 = 1,100$ km, which is $1,100 \times 0.621 \approx 680$ miles.
4. Extra time: $1,100 \div 37 \approx 30$ hours.

Answer: About 1,100 km (about 680 miles) longer, adding about 30 hours, more than a day of fuel, wages and time for every ship.

Example 3. In 2023 Singapore handled about 39 million TEU. One TEU is a container 20 feet (about 6.1 m) long. If all those containers were laid end to end, how far would they reach? How many times around the equator (about 40,075 km) is that?

1. Multiply: $39,000,000 \times 6.1 \text{ m} = 237,900,000 \text{ m}$.
2. Change to kilometers: $237,900,000 \div 1,000 = 237,900 \text{ km}$.
3. Divide by the equator: $237,900 \div 40,075 \approx 5.9$.
4. In miles: $237,900 \times 0.621 \approx 147,700$ miles.

Answer: About 238,000 km (about 148,000 miles), nearly six times around the equator in one year.

PRACTICE

1. **EASY** Who founded the British port of Singapore, and in what year? What made it a “free port”?
2. **EASY** What is a choke point? Name two straits a ship could use to avoid the Strait of Malacca.
3. **EASY** The Phillips Channel shipping lane is about 2.8 km wide. How many miles is that?
4. **MEDIUM** The old port of Malacca is at about 2.2°N, 102.3°E, and Singapore at about 1.3°N, 103.9°E. Near the equator one degree of latitude or longitude is about 111 km. Find the straight-line distance between them in km and miles.
(Use the map or drawing “Malacca and Singapore both guard the same strait.” shown earlier in this lesson.)
5. **MEDIUM** Singapore’s land area grew from about 580 km² in the 1960s to about 730 km² by the 2020s. By what percent did it grow?

6. **MEDIUM** Singapore uses UTC+8. London uses UTC+0 in winter. When it is noon on a January day in Singapore, what time is it in London?
7. **MEDIUM** A container ship sails the whole Strait of Malacca, about 800 km (500 miles), at 20 knots (about 37 km/h). How long does the passage take? Compare it with the sailing ship of Lesson 7.1, which took about 86 hours.
8. **HARD** Put these in order and find how many years passed between the first and the last: independence (1965), the first container terminal (1972), Raffles's treaty (1819), the Suez Canal opens (1869), the Anglo-Dutch Treaty (1824).
9. **HARD** Singapore has very little fresh water of its own. Name three ways it supplies its people with water, and explain which ones are "technology overcoming geography."
10. **CHALLENGE** Suppose a very large container ship carries 20,000 TEU. How many full loads of such ships would equal Singapore's 39 million TEU in 2023? Then explain why the real number of ship visits is much larger.

COMMON MISTAKES

- Thinking Singapore grew rich from its own resources. It has almost none; it grew rich from its position on the sea road and from trade.
- Thinking the Strait of Malacca is the only way between the oceans. Ships can go around through the Sunda or Lombok Strait, but it costs extra distance and time.
- Confusing a TEU with a ship. A TEU is one 20-foot container; a large ship may carry many thousands of them.

Make it a game · Choke Point Toll. Set out three "straits" on the floor with tape: a short one (Malacca), a long one (Sunda) and a longer one (Lombok). Each player is a ship and rolls a die to move. A player who uses Malacca must pay one bean as a toll to the port keeper, but saves three spaces. Players decide on each turn which route to take. The first ship to reach "Hong Kong" wins, and the port keeper counts the beans collected. Talk about it afterward: why did most ships still choose the shortcut?

Scripture. "They that go down to the sea in ships, that do business in great waters; These see the works of the LORD, and his wonders in the deep." (Psalm 107:23-24, KJV)

The sailors and merchants who pass through the straits do "business in great waters." The seas and the narrow passages between islands are God's works, and the skill of the people who build ports and guide ships through them is one of His gifts.

Practice answers

1. Sir Stamford Raffles, in 1819. It was a free port because merchants paid no customs duties on goods they landed or shipped.
2. A narrow place on a trade route through which much traffic must pass and which can be blocked or controlled. Ships could use the Sunda Strait (between Sumatra and Java) or the Lombok Strait (east of Bali).
3. $2.8 \times 0.621 \approx 1.7$ miles.

4. North-south: $0.9^\circ \times 111 \approx 100$ km. East-west: $1.6^\circ \times 111 \approx 178$ km. Straight line: $\sqrt{(100^2 + 178^2)} \approx 204$ km, about 127 miles.
5. Increase: $730 - 580 = 150$ km². $150 \div 580 \approx 0.26$, so about 26 percent, roughly a quarter larger.
6. London is 8 hours behind: 4:00 a.m. the same day.
7. $800 \div 37 \approx 21.6$ hours, a little under a day. It is about four times faster than the 5-knot sailing ship, and it does not have to wait for the monsoon.
8. 1819 Raffles's treaty; 1824 Anglo-Dutch Treaty; 1869 Suez Canal; 1965 independence; 1972 container terminal. $1972 - 1819 = 153$ years.
9. It buys water from Johor in Malaysia, collects rain in reservoirs, removes salt from seawater (desalination), and purifies used water into NEWater. Desalination and NEWater are technology overcoming geography, because they make drinking water where nature provides too little.
10. $39,000,000 \div 20,000 = 1,950$ full loads. Real ship visits are far more numerous because most ships are smaller than 20,000 TEU, most do not load or unload their whole cargo at Singapore, and transshipped boxes are counted when they come off one ship and again when they go onto another.

7.3 AUSTRALIA AND NEW ZEALAND

OBJECTIVES

- Describe the physical geography of Australia (the Great Dividing Range, the dry interior, the Murray-Darling basin) and of New Zealand (two mountainous islands under the westerly winds).
- Explain why most Australians live in a few coastal cities, using climate, rainfall and the story of the First Fleet and the crossing of the Blue Mountains.
- Compute distances, population densities and time differences across Australia and New Zealand in kilometers and miles.

Warm-up. Take a dinner plate and a spray bottle of water. Tilt the plate and spray only along one edge, the “east coast,” and a little at the bottom corners. Leave the middle dry. Now set ten coins on the plate where you think people would want to live. Where did you put them? Look at a map of Australia’s cities and see whether the real people chose as you did.

Watch. *Captain Phillip and Reverend Johnson in Australia - "Ends of the Earth"* (Drive Thru History with Dave Stotts, 4:05). <https://www.youtube.com/watch?v=oFtt9ZitOBw>
After the story: watch Dave Stotts tell how Captain Arthur Phillip brought the First Fleet to Sydney Cove and how Reverend Richard Johnson, the colony's chaplain, preached the first Christian service in Australia.

Note: Captions were not available to check; preview it first. This is a short clip from a trusted Christian history series, and it centers on the colony's chaplain as well as on Phillip.

Backup video. *Greater Blue Mountains Area - UNESCO World Heritage Site* (World Heritage Journey, 6:52). <https://www.youtube.com/watch?v=fZzqAXKMw>
With On the map: watch the tour of the Blue Mountains west of Sydney, including the Three Sisters, Wentworth Falls and the Grose Valley, and notice the steep cliffs and deep valleys that kept settlers near the coast until 1813. Note: Captions were not available to check; preview it first. The description says Australia was isolated 'for millions of years' and the video looks at recovery after the 2019-2020 bushfires; the lesson gives no ages. The video is a nature and travel tour; it probably does not tell the story of the 1813 crossing.

KEY TERMS

island continent

Australia, the only continent occupied by a single country and surrounded entirely by ocean.

Great Dividing Range

The long belt of mountains and high plateaus, about 3,500 km (2,200 miles) long, that runs down eastern Australia near the coast.

outback

The dry, thinly settled interior of Australia, with desert, scrub and grassland used mainly for grazing and mining.

subtropical high

A belt of sinking, dry air near 20° to 30° latitude north and south of the equator, which makes many of the world's great deserts, including Australia's.

rain shadow

The dry land on the downwind side of a mountain range, where air that has already dropped its rain on the windward side sinks and warms.

population density

The number of people per unit of land, such as people per square kilometer or per square mile.

CORE IDEAS

The story. In January 1788, eleven ships of the First Fleet, under Captain Arthur Phillip of the Royal Navy, reached Botany Bay on the east coast of Australia. They carried about 1,400 people, more than 750 of them convicts sent to a new penal colony. Botany Bay disappointed Phillip: it was open to the sea, shallow, and short of fresh water. So he rowed a few miles north into Port Jackson and found what he called "the finest harbour in the world." On January 26, 1788, the fleet anchored in a cove with a stream of fresh water, and he named it Sydney Cove. On February 3 the chaplain, Richard Johnson, held the first Christian service in the colony under a tree, preaching from Psalm 116:12. For twenty-five years the colony clung to the coast, because a wall of steep sandstone cliffs and gorges, the Blue Mountains, blocked the way west. In 1813 Gregory Blaxland, William Lawson and William Wentworth crossed them by following the ridges instead of the valleys and looked down on wide grasslands beyond.

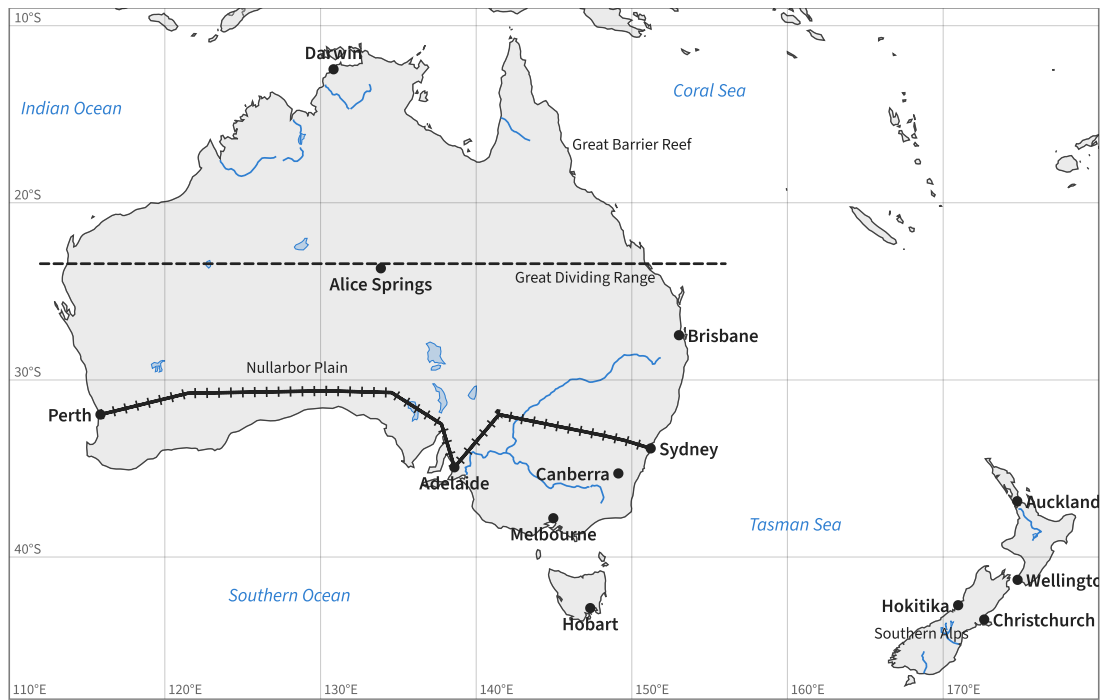
On the map. Australia is the smallest continent and the only one that is a single country, covering about 7.7 million km² (3.0 million square miles), a little less than the 48 contiguous United States. It is the lowest, flattest and driest inhabited continent. The **Great Dividing Range** runs down the east side, rising to Mount Kosciuszko, 2,228 m (7,310 feet). West of the range lies the vast **outback**: plains, stony deserts, salt lakes and the red rock of Uluru. The Murray River, 2,508 km (1,558 miles) long, and its tributary the Darling drain the southeast. Off the northeast coast stretches the Great Barrier Reef, the largest coral reef system on earth, about 2,300 km (1,400 miles) long. Across the Tasman Sea, about 2,000 km (1,250 miles) to the southeast, lies New Zealand: two main islands, the North Island with its volcanoes and the South Island with the snowy Southern Alps, crowned by Aoraki/Mount Cook, 3,724 m (12,218 feet).

The big idea. Australia straddles the **Tropic of Capricorn**, in the belt of the **subtropical high**, where sinking air makes deserts. Roughly 70 percent of the land is arid or semi-arid. Moist winds from the Pacific drop their rain on the eastern slopes of the Great Dividing

Range, the tropical north gets a summer monsoon, and the southwest and south have a Mediterranean climate of wet winters and dry summers. So people settled where the rain falls: more than four Australians in five live within about 50 km (30 miles) of the sea, most of them in the state capitals of Sydney, Melbourne, Brisbane, Perth and Adelaide. The interior became sheep and cattle country. Merino wool became the great export, and gold, found in 1851, brought a rush of settlers. The six colonies united as the Commonwealth of Australia on January 1, 1901, and built a new capital, Canberra, between Sydney and Melbourne. Australia counted about 25.4 million people at the 2021 census.

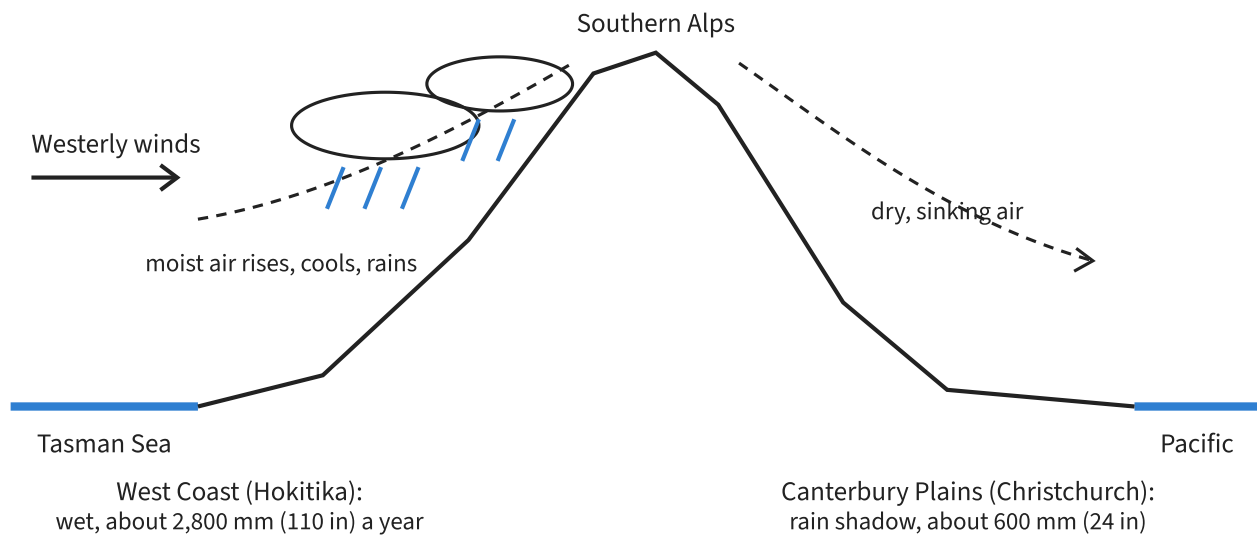
Peoples and faith. Long before 1788, Aboriginal peoples lived across the whole continent, and Torres Strait Islanders in the islands to the north, speaking more than 250 languages. British settlement brought them great suffering: smallpox and other diseases, the loss of their lands, and frontier killings; at Myall Creek in 1838 settlers murdered some twenty-eight Aboriginal people, and seven of the killers were hanged. In the 1900s many Aboriginal children were taken from their families by government policy, and in 2008 the Australian Prime Minister formally apologized. Missionaries such as Lancelot Threlkeld, who studied and wrote down the Awabakal language in the 1820s and 1830s, and the Lutherans of Hermannsburg in central Australia (founded 1877) brought the gospel and often defended Aboriginal people. At the 2021 census about 44 percent of Australians called themselves Christian, and about 39 percent said they had no religion.

New Zealand. The Māori, sailing from eastern Polynesia, settled New Zealand about 1300 and called it Aotearoa. The Dutch navigator Abel Tasman saw it in 1642. On Christmas Day 1814 the chaplain Samuel Marsden preached the first Christian sermon in New Zealand at the Bay of Islands, with the Māori chief Ruatara explaining his words, and in 1840 British officials and Māori chiefs signed the Treaty of Waitangi. New Zealand lies in the path of strong westerly winds, which pour rain on the western side of the Southern Alps and leave a **rain shadow** on the drier Canterbury Plains to the east. Grass grows well, so sheep and dairy farming became the backbone of the economy, and refrigerated ships, beginning with the *Dunedin* in 1882, carried frozen meat halfway around the world to Britain. New Zealand counted about 5 million people at the 2023 census.



Australia's cities cling to the coast, especially in the wetter southeast. The red line is the Indian Pacific railway across the Nullarbor Plain.

New Zealand's South Island, west to east



The westerlies drop their rain on the West Coast and leave the Canterbury Plains in a rain shadow.

PICTURE STUDY



Shearing the Rams, Tom Roberts, 1890 · Oil on canvas · National Gallery of Victoria, Melbourne

Tom Roberts, born in England and raised in Melbourne, wanted to paint the real working life of Australia. He spent the shearing seasons of 1888 and 1889 at Brocklesby, a sheep station in the Riverina district of New South Wales, sketching in the shed, and finished this large painting in his Melbourne studio in 1890.

In the 1800s Australia's wealth rode on the sheep's back. Fine merino wool grew on dry grassland where crops struggled, and it could survive the long voyage to the mills of England. Roberts shows the shearers at work in the heat and dust, using hand shears, before machines replaced them.

Look closely

- Find the shearers bent over the sheep. How are they holding the animals?
- Find a fleece coming off a sheep in one piece. Where does the wool go next?
- Look at the light coming through the gaps in the wooden walls. How does it make the shed feel?
- Find the smiling young helper near the middle. What do you think that child's job was?

Talk about it

1. Why was wool a good thing for a dry land far from Europe to sell?
2. What does this painting tell you about the work that built Australia's farms?
3. Roberts painted ordinary workers instead of famous people. Why might he have thought their work worth a great painting?

PROJECT: WHERE DO AUSTRALIANS LIVE? A DOT-AND-RAIN MAP

You will make a thematic map, a map that shows one theme, of where Australians live. Then you will lay a second map of rainfall over it on tracing paper and see how closely people follow the rain. This is the kind of reasoning a geographer uses to explain a pattern.

You will need

- A printed outline map of Australia, about letter size
- Tracing paper or baking paper the same size
- Small round stickers or a marker for dots; blue and yellow colored pencils
- This table of approximate populations of the capital-city areas at the 2021 census:
Sydney 5.2 million; Melbourne 4.9 million; Brisbane 2.5 million; Perth 2.1 million; Adelaide 1.4 million; Canberra 0.45 million; Hobart 0.25 million; Darwin 0.14 million
- An atlas or online rainfall map of Australia

Steps

1. Choose your key: one dot stands for 250,000 people. Write the key in a corner of the outline map.
2. Work out the number of dots for each city: for example, Sydney $5.2 \text{ million} \div 250,000 \approx 21$ dots. Round to whole dots, and give Darwin and Hobart one dot each.
3. Place the dots in a cluster at each city's location. Label each city.
4. Australia counted about 25.4 million people in 2021. Add up your city dots, find how many people are left over for the rest of the country, and scatter those dots along the coasts and inland towns, keeping most in the southeast.
5. On the tracing paper, trace the coast. Using the rainfall map, shade blue where more than about 600 mm (24 inches) of rain falls in a year, and yellow where less than about 250 mm (10 inches) falls.
6. Lay the rainfall sheet over the dot map. Write three sentences explaining the pattern you see.

Tips

- Keep the dots the same size, so the map is fair.
- A thematic map shows one idea clearly. Leave off details that do not help the theme.

Check your work

- My dot map uses a key and the right number of dots for each city.
- My rainfall overlay shows the wet coasts and the dry interior.
- I can explain in my own words why most Australians live near the coast.

MAP NOTEBOOK

1. Draw Australia and label the Great Dividing Range, the Murray River, the Great Barrier Reef, Uluru, the Nullarbor Plain and the Tropic of Capricorn.

2. Draw New Zealand's two main islands. Label the Southern Alps, Aoraki/Mount Cook, the Canterbury Plains, Auckland, Wellington and Christchurch, and draw arrows for the westerly winds.
3. Sketch the First Fleet's path from Botany Bay into Port Jackson and Sydney Cove, and write one sentence on why Phillip moved.

From history. After Blaxland, Lawson and Wentworth crossed the Blue Mountains in 1813, Governor Lachlan Macquarie sent William Cox to build a road. Cox and a gang of about thirty convicts and eight guards built a road more than 160 km (100 miles) long over the mountains in about six months, finishing in January 1815. Later that year the town of Bathurst was founded on the plains beyond, the first inland town in Australia. The convicts who built the road were promised their freedom as a reward.

WORKED EXAMPLES

Example 1. Sydney is at about 33.9°S , 151.2°E , and Perth at about 32.0°S , 115.9°E . At this latitude one degree of longitude is about 93 km, and one degree of latitude is about 111 km. About how far apart are they in a straight line, in kilometers and miles?

(Use the map or drawing "Sydney and Perth lie at nearly the same latitude on opposite coasts." shown earlier in this lesson.)

1. East-west: $151.2^{\circ} - 115.9^{\circ} = 35.3^{\circ}$. $35.3 \times 93 \text{ km} \approx 3,283 \text{ km}$.
2. North-south: $33.9^{\circ} - 32.0^{\circ} = 1.9^{\circ}$. $1.9 \times 111 \text{ km} \approx 211 \text{ km}$.
3. Straight line: $\sqrt{(3,283^2 + 211^2)} \approx \sqrt{(10,778,000 + 44,500)} \approx 3,290 \text{ km}$.
4. In miles: $3,290 \times 0.621 \approx 2,040 \text{ miles}$.

Answer: About 3,300 km (about 2,000 miles), a little more than the distance from Atlanta to Los Angeles, all within one country.

Example 2. In standard time, Perth uses UTC+8, Sydney uses UTC+10, and New Zealand uses UTC+12. When it is noon in Sydney, what time is it in Perth and in Auckland?

1. Perth is $10 - 8 = 2$ hours behind Sydney: noon $- 2$ hours = 10:00 a.m.
2. Auckland is $12 - 10 = 2$ hours ahead of Sydney: noon $+ 2$ hours = 2:00 p.m.
3. So from Perth to Auckland spans 4 hours.

Answer: 10:00 a.m. in Perth and 2:00 p.m. in Auckland. (In summer, daylight saving time in some states and in New Zealand changes these differences.)

Example 3. Australia had about 25.4 million people on about 7.69 million km² (2.97 million square miles). New Zealand had about 5.0 million people on about 268,000 km² (103,500 square miles). Find each country's population density in people per km² and per square mile.

1. Australia per km²: $25,400,000 \div 7,690,000 \approx 3.3$ people per km².
2. Australia per square mile: $25,400,000 \div 2,970,000 \approx 8.6$ people per square mile.
3. New Zealand per km²: $5,000,000 \div 268,000 \approx 18.7$ people per km².
4. New Zealand per square mile: $5,000,000 \div 103,500 \approx 48$ people per square mile.

Answer: Australia about 3.3 per km² (8.6 per square mile); New Zealand about 19 per km² (48 per square mile). Both are thinly peopled overall, but Australia's people are packed into a few coastal cities, so the average hides an empty interior.

PRACTICE

1. **EASY** Mount Kosciuszko is 2,228 m high. How many feet is that? (1 m $\approx$ 3.28 ft)
2. **EASY** Why did Arthur Phillip move the First Fleet from Botany Bay to Sydney Cove?
3. **EASY** Name the mountain range along Australia's east coast and the three men who crossed its Blue Mountains in 1813.
4. **MEDIUM** Sydney is at about 33.9°S, 151.2°E and Auckland at about 36.8°S, 174.8°E. At this latitude a degree of longitude is about 91 km and a degree of latitude about 111 km. Find the straight-line distance across the Tasman Sea in km and miles.
5. **MEDIUM** Hokitika, on the West Coast of New Zealand's South Island, gets about 2,800 mm of rain a year. Christchurch, on the Canterbury Plains, gets about 600 mm. How many times wetter is Hokitika? Give both amounts in inches (1 inch = 25.4 mm).
(Use the map or drawing "The rain shadow of the Southern Alps." shown earlier in this lesson.)
6. **MEDIUM** The Indian Pacific railway crosses the Nullarbor Plain on a perfectly straight stretch of track 478 km long, the longest in the world. How many miles is that? At 80 km/h, how long does a train take to cross it?
7. **MEDIUM** Use the map. Which of Australia's state and territory capitals lies north of the Tropic of Capricorn (23.4°S)? Brisbane is at 27.5°S. Is it north or south of the Tropic?
(Use the map or drawing "Find the Tropic of Capricorn." shown earlier in this lesson.)
8. **HARD** Perth and Adelaide have hot, dry summers and mild, wet winters. Explain why, using the subtropical high and the westerly winds.
9. **HARD** The Murray River is 2,508 km long. How many miles is that? Explain why rivers like the Murray matter so much more in Australia than in a wet country.
10. **CHALLENGE** In 1882 the sailing ship *Dunedin*, fitted with a steam-driven freezing machine, carried frozen mutton from New Zealand to London in 98 days. Write a short paragraph explaining how this was "technology overcoming geography."

COMMON MISTAKES

- Thinking Australia's interior is empty of people because the land is useless. It is mostly dry, but it supports grazing and mining, and Aboriginal peoples lived across all of it for many generations.
- Thinking Sydney is Australia's capital. The capital is Canberra, chosen in 1908 as a compromise between Sydney and Melbourne.
- Forgetting that the rain shadow is on the downwind side. In New Zealand the westerlies blow from the west, so the dry side is the east.

Make it a game · Coast or Outback? A parent reads a clue, such as "I am Australia's largest city," "I am a red rock in the middle of the desert," "I am a 478-km straight railway," "I am a reef about 2,300 km (1,400 miles) long," or "I am a city in the rain shadow of the Southern Alps." The player names the place and says "Coast!" or "Inland!" and points to it on the lesson map. Score one point for the name and one for the right answer. Play to fifteen.

Scripture. "What shall I render unto the LORD for all his benefits toward me?" (Psalm 116:12, KJV)

This was the verse Richard Johnson preached on at the first Christian service in Australia on February 3, 1788, to a crowd of convicts, sailors and marines far from home. Even at the end of the earth, on a hard and strange coast, there was reason to thank God.

Practice answers

1. $2,228 \times 3.28 \approx 7,308$ feet, about 7,310 feet.
2. Botany Bay was open to the sea, shallow and short of fresh water. Port Jackson was a deep, sheltered harbor, and Sydney Cove had a stream of fresh water.
3. The Great Dividing Range. Gregory Blaxland, William Lawson and William Wentworth crossed the Blue Mountains.
4. East-west: $23.6^\circ \times 91 \approx 2,148$ km. North-south: $2.9^\circ \times 111 \approx 322$ km. Straight line: $\sqrt{(2,148^2 + 322^2)} \approx 2,170$ km, about 1,350 miles.
5. $2,800 \div 600 \approx 4.7$ times wetter. Hokitika: $2,800 \div 25.4 \approx 110$ inches. Christchurch: $600 \div 25.4 \approx 24$ inches.
6. $478 \times 0.621 \approx 297$ miles. $478 \div 80 \approx 6$ hours.
7. Darwin (about 12.5°S) is the only capital north of the Tropic. Brisbane, at 27.5°S , is about 4° south of it.
8. In summer the belt of the subtropical high shifts south over southern Australia, and its sinking, dry air blocks rain, so summers are hot and dry. In winter the belt moves north, and the westerly winds and their storms from the Southern Ocean reach the south coast, bringing rain. This is a Mediterranean climate, like that of southern Europe or California.
9. $2,508 \times 0.621 \approx 1,558$ miles. In a dry continent with little rain inland, the Murray-Darling rivers supply water for towns and for irrigating crops and pasture, so a large share of Australia's farming depends on them. In a wet country, rain alone waters most farms.

10. New Zealand had excellent grass for sheep but lay on the opposite side of the world from its main buyers in Britain, and fresh meat would spoil long before it arrived, so farmers could sell only wool and a little tallow. Refrigeration kept the meat frozen across the tropics for more than three months. Distance no longer blocked the trade, and frozen meat and later butter and cheese became great exports, shaping New Zealand's farms for a century.

7.4 THE PACIFIC ISLANDS

OBJECTIVES

- Name the three island regions of the Pacific (Melanesia, Micronesia and Polynesia) and explain the difference between high volcanic islands and low coral atolls.
- Explain how Polynesian and Micronesian navigators found islands without instruments, using stars, swells, birds and Marshall Islands stick charts.
- Tell the story of John Williams and the Pacific Islander teachers who carried the gospel across the ocean, and weigh honestly the good and the harm that came with outside contact.

Warm-up. Lie on your back on the floor with your eyes closed while a partner gently rocks a large pillow or cushion under you, first in long, slow rolls from one direction, then adding short, quick bumps from another. Can you tell the two motions apart without looking? Can you tell which way each comes from? Pacific navigators felt the ocean swells this way, lying in the hulls of their canoes, and used them to steer at night.

Video. Coming soon. Polynesian wayfinding and the voyaging canoe Hōkūleʻa (1976), Marshall Islands stick charts, coral atolls, and the missionary John Williams: search Smithsonian, The History Guy, NASA (stars and navigation), Library of Congress; Homeschool Pop (Alternate); candidates needing vetting: Polynesian Voyaging Society, Geography Now (Fiji, Samoa, Tonga, Marshall Islands).

KEY TERMS

Polynesia, Micronesia, Melanesia

The three island regions of the Pacific. Polynesia means “many islands” (a great triangle from Hawai‘i to New Zealand to Rapa Nui); Micronesia means “small islands” (north of the equator in the west); Melanesia means “black islands” (from New Guinea to Fiji).

high island

A Pacific island made by a volcano, with mountains, streams and rich soil, such as Tahiti or the islands of Hawai‘i.

atoll

A ring of coral reef and low sandy islets around a lagoon, usually only a few meters above the sea, such as Majuro or Bikini in the Marshall Islands.

wayfinding

Finding the way across the ocean without instruments, by reading the stars, sun, swells, winds, birds and clouds.

swell

A long, steady ocean wave raised by winds far away, which keeps its direction for days and bends around islands.

stick chart

A Marshall Islands teaching chart made of tied sticks and shells, showing islands and the ways swells move and bend around them.

CORE IDEAS

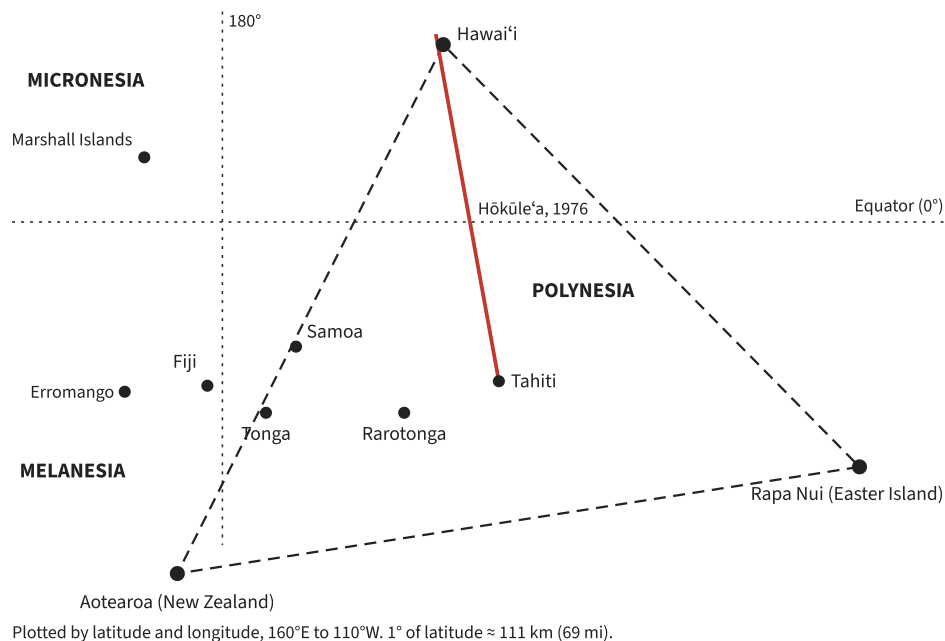
The story. On November 20, 1839, the missionary ship *Camden* anchored in Dillon's Bay on the island of Erromango, in the islands then called the New Hebrides (today Vanuatu). John Williams of the London Missionary Society rowed ashore, hoping to leave Christian teachers on the island. Within minutes men of the island attacked, and Williams and a young companion, James Harris, were killed at the water's edge. The people of Erromango had suffered violence from European sandalwood traders, and they may have taken the strangers for more of the same. Williams had come to the Pacific in 1817. From the Society Islands he sent Polynesian teachers to new islands; one of them, Papeiha, landed on Rarotonga in 1823. On Rarotonga Williams built his own ship, the *Messenger of Peace*, and in 1830 he sailed it to Samoa, where the chief Malietoa welcomed the teachers he brought. Erromango later became a Christian island.

On the map. The Pacific is the largest feature on the face of the earth. It covers about 165 million km² (64 million square miles), about a third of the globe and more than all the land on earth put together. Geographers group its islands into three regions: **Melanesia** (New Guinea, the Solomon Islands, Vanuatu, New Caledonia and Fiji), **Micronesia** (the Marianas, Carolines, Marshalls and Gilberts) and **Polynesia**, a vast triangle with Hawai'i, New Zealand and Rapa Nui (Easter Island) at its corners. There are two kinds of islands. **High islands** are volcanoes, with mountains, streams and rich soil for taro and breadfruit. **Atolls** are rings of coral islets around a lagoon, only a few meters above the sea, with thin soil, little fresh water, coconut palms and plenty of fish. In 1842 Charles Darwin suggested that an atoll forms when coral keeps growing upward around a volcanic island that slowly sinks. In 1952 drillers on Enewetak atoll found volcanic rock more than 1,200 m (about 4,000 feet) beneath the coral.

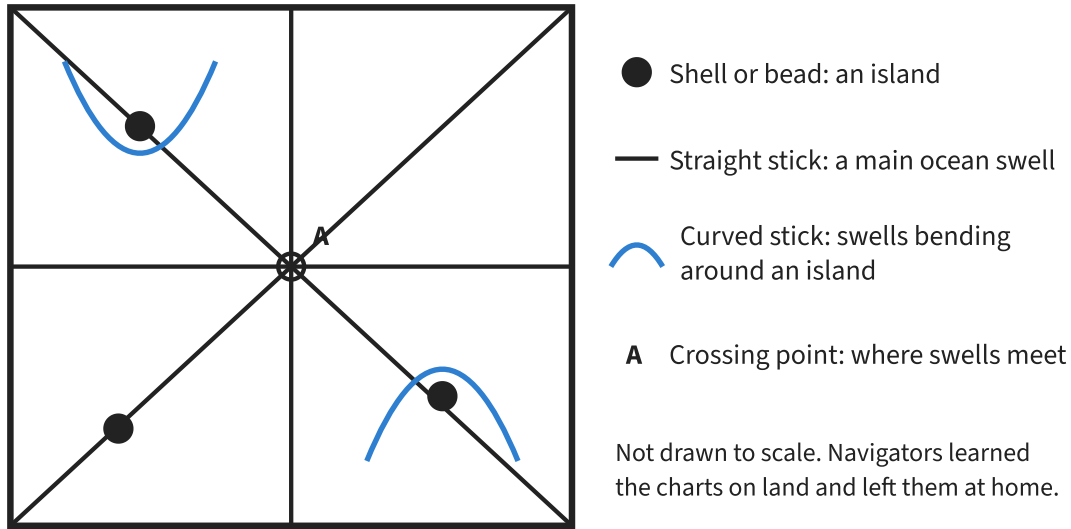
How they found the islands. No people in history crossed more open ocean than the ancestors of the Polynesians. About 3,000 years ago, people who made a decorated pottery called Lapita sailed from the islands near New Guinea to Fiji, Tonga and Samoa. Many centuries later their descendants sailed into the far corners of Polynesia, reaching Hawai'i, Rapa Nui and, last of all, New Zealand about 1300. Their double-hulled canoes carried families, animals and food plants, with no compass or chart. Navigators practiced **wayfinding**. They memorized where dozens of stars rise and set on the horizon, and which star passes straight overhead at a given island. They felt the long ocean **swells** under the hull. They watched for land-nesting birds flying out to fish at dawn and home at dusk, and for clouds piled over islands still out of sight. In the Marshall Islands, navigators made **stick charts** of palm-leaf ribs and shells to show how swells bend around islands; they studied them ashore and left them at home. In 1976 the voyaging canoe *Hōkūle'a*, guided by Mau Piailug of Satawal in Micronesia, sailed from Hawai'i to Tahiti, about 4,300 km (2,700 miles), without instruments.

The gospel across the Pacific. The islanders had their own gods, priests and sacred places, and in many islands warfare between chiefdoms was common; some practiced human sacrifice. In March 1797 the ship *Duff* landed the first London Missionary Society missionaries on Tahiti. In 1819 King Pōmare II was baptized, and Tahiti became a base for carrying the gospel west. In Tonga, the chief Tāufa'āhau, later King George Tupou I, became a Methodist in 1831, and in Fiji the great chief Cakobau turned to Christianity in 1854. Much of the work was done by Pacific Islanders themselves: Tahitian, Rarotongan, Samoan and Tongan teachers sailed to islands far from home, and many died of fever or violence in Melanesia. Missionaries wrote down island languages and translated the Bible into them. Outside contact also brought great harm: new diseases that killed many, traders who sold guns and alcohol, and, from the 1860s, “blackbirding” recruiters who tricked or forced tens of thousands of islanders into labor on plantations in Queensland and Fiji. Missionaries were among those who protested.

The islands today. As of 2026 there are twelve independent island nations in the Pacific, among them Papua New Guinea, Fiji, Samoa, Tonga, Vanuatu and the Solomon Islands, along with islands governed by or linked to France, the United States, New Zealand, Chile and Britain. Papua New Guinea alone has more than 800 languages, and most Pacific nations are among the most Christian countries on earth. Distance still shapes island life, since goods come by ship or plane and atolls depend on rain caught from roofs. Between 1946 and 1958 the United States tested 67 nuclear weapons at Bikini and Enewetak in the Marshall Islands, moving islanders from their homes. Today the Marshall Islands, the Federated States of Micronesia and Palau are independent nations linked to the United States by Compacts of Free Association.



The Polynesian Triangle. Island positions are plotted by latitude and longitude; each degree of latitude is about 111 km (69 miles).



How to read a stick chart.

PICTURE STUDY



A View Taken in the Bay of Oaite Peha (Vaitepiha), Otaheite ("Tahiti Revisited"), William Hodges, 1776 · Oil on canvas · National Maritime Museum, Greenwich, London

William Hodges was the official artist on Captain James Cook's second voyage around the world (1772–1775). In August 1773 Cook's ships anchored at Vaitepiha Bay on Tahiti, and Hodges made sketches of the valley there. Back in London he painted this view in 1776, filling it with the warm, hazy light of the tropics that had amazed him. For many people in Britain, paintings like this were the first pictures they ever saw of the Pacific islands.

Hodges painted Tahiti as an earthly paradise, and people in Europe loved to imagine it that way. The real islands, as the missionaries and the islanders themselves knew, had wars, hardships and sorrows as well as beauty. (Parents: as Hodges painted them, some of the bathers are unclothed; you may wish to preview the painting.)

Look closely

- Find the mountains behind the valley. Is Tahiti a high island or a low atoll? How can you tell?
- Find the river running down to the sea. Why would people live beside it?
- Find the tall carved wooden figure near the water. What do you think it meant to the people who carved it?
- Look at the light and the haze. How does Hodges make the air feel warm?

Talk about it

1. What does this painting show about the land of a high Pacific island?
2. Why might people in London in 1776 have found this painting so exciting?
3. Hodges showed only the beautiful side of Tahiti. Why is it important to know the whole truth about a place and its people?

Safety first. Bamboo skewers have sharp points. Have an adult snip off the points with garden clippers before you begin, and keep skewers away from eyes.

PROJECT: A MARSHALL ISLANDS STICK CHART

Marshallese navigators made charts of sticks and shells to learn how ocean swells move and bend around islands. You will build your own stick chart of a small group of islands, then use a paper star compass to see how Polynesian navigators steered by the rising and setting stars.

You will need

- About 12 bamboo skewers or thin straight sticks (points snipped off)
- 4 thin, bendable strips: split bamboo, pipe cleaners or strips of stiff paper
- Raffia, yarn or thin string
- 5 or 6 small shells, beads or buttons
- White glue
- A paper plate, a pencil and a protractor for the star compass

Steps

1. Make a square frame with four skewers, about 8 inches (20 cm) on a side. Tie each corner tightly with string wrapped in an X.
2. Tie two skewers across the diagonals of the frame. Tie one more across the middle from side to side, and one from top to bottom. These straight sticks stand for the main

ocean swells.

3. Choose places for three to five islands. Tie or glue a shell or bead at each, using the crossing points of sticks for some of them.
4. Bend a flexible strip into a curve around one side of each island and tie its ends to the frame or nearby sticks. These curved sticks show swells bending as they pass an island.
5. Make a key on a card: shell = island; straight stick = main swell; curved stick = bent swell; crossing point = where swells meet.
6. For the star compass, draw a circle on the paper plate and mark north, east, south and west. Using the protractor, mark points every $11\frac{1}{4}^\circ$ around the circle (32 points). Label the east side “stars rise” and the west side “stars set.”
7. On a clear night, stand facing east with an adult. Mark on your plate where one bright star rises. Watch it for an hour and see how it climbs. A navigator steering toward that rising point would keep a steady heading.

Tips

- Real stick charts were not exact maps of distance. They taught patterns, and each navigator’s chart could be read fully only by him and his students.
- Tie your corners tight before adding anything else, or the whole chart will wobble.

Check your work

- My stick chart has a frame, straight swell sticks, curved sticks and at least three islands.
- My key explains what each part means.
- I can explain how a navigator could use swells and stars to find land without a compass.

MAP NOTEBOOK

1. Draw the Polynesian Triangle and label Hawai’i, New Zealand (Aotearoa), Rapa Nui, Tahiti, Samoa and Tonga. Shade Melanesia and Micronesia in two other colors.
2. Draw two cross-sections side by side: a high volcanic island with a fringing reef, and an atoll with a lagoon where the volcano has sunk away. Label each.
3. Draw the *Messenger of Peace* under sail and write three sentences about John Williams and the islanders who sailed with him.

From history. Mau Piailug (1932–2010) was one of the last masters of traditional navigation, taught as a boy by his grandfather on the tiny island of Satawal in the Caroline Islands of Micronesia. When Hawaiians built *Hōkūle’a* in the 1970s, no Hawaiian still knew the old way, so Mau agreed to guide the canoe to Tahiti in 1976. He later chose to teach his knowledge to Hawaiians, including Nainoa Thompson, who became a master navigator himself. Thanks to Mau’s willingness to share what his people had kept, voyaging canoes have since sailed across much of the Pacific without instruments.

WORKED EXAMPLES

Example 1. The 1976 voyage of *Hōkūleʻa* went from Maui, Hawaiʻi (about 20.8°N , 156.3°W), to Tahiti (about 17.5°S , 149.6°W). One degree of latitude is about 111 km, and near the equator one degree of longitude is also about 111 km. Find the straight-line distance in km and miles.

(Use the map or drawing “The Hawaiʻi to Tahiti voyage runs nearly due south across the equator.” shown earlier in this lesson.)

1. North-south: Maui is north of the equator and Tahiti south, so add: $20.8^{\circ} + 17.5^{\circ} = 38.3^{\circ}$. $38.3 \times 111 \approx 4,251$ km.
2. East-west: $156.3^{\circ} - 149.6^{\circ} = 6.7^{\circ}$. $6.7 \times 111 \approx 744$ km.
3. Straight line: $\sqrt{(4,251^2 + 744^2)} \approx \sqrt{(18,071,000 + 553,500)} \approx 4,316$ km.
4. In miles: $4,316 \times 0.621 \approx 2,680$ miles.

Answer: About 4,300 km (about 2,700 miles), almost all of it north to south. That is why stars that showed latitude were so useful on this voyage.

Example 2. A star passes straight overhead (through the zenith) at every place whose latitude equals the star’s declination. Arcturus, which Hawaiians call *Hōkūleʻa*, has a declination of about 19°N . Sirius has a declination of about 17°S . Where does each star pass overhead, and how could a navigator use this?

1. Arcturus (declination 19°N) passes overhead at latitude 19°N . The island of Hawaiʻi lies at about 19° to 20°N .
2. Sirius (declination 17°S) passes overhead at about 17°S . Tahiti lies at about 17.5°S .
3. A navigator sailing north from Tahiti watches Arcturus each night. When it passes straight overhead, the canoe has reached the latitude of Hawaiʻi.
4. Then the canoe turns and sails east or west along that latitude, watching for birds and clouds, until it finds the island.

Answer: Arcturus passes overhead near Hawaiʻi (about 19°N), and Sirius near Tahiti (about 17°S). A zenith star tells the navigator when he has reached the right latitude.

Example 3. Suppose a navigator on a canoe can see a low atoll only when it is within about 15 km (9 miles), but land-nesting birds that fish by day are seen up to about 30 km (19 miles) from their island. How much larger is the circle of sea in which the navigator can detect the island by watching birds?

1. Area of a circle = $\pi \times r^2$.
2. Seeing the island: $\pi \times 15^2 = \pi \times 225 \approx 707 \text{ km}^2$.
3. Seeing the birds: $\pi \times 30^2 = \pi \times 900 \approx 2,827 \text{ km}^2$.
4. Compare: $2,827 \div 707 = 4$.

Answer: Four times larger. Doubling the distance at which you can detect an island makes the target four times bigger, which is why navigators watched birds, clouds and swells so carefully.

PRACTICE

1. **EASY** Name the three island regions of the Pacific, and give the meaning of each name.
2. **EASY** Give two differences between a high island and an atoll.
3. **EASY** What was the name of the ship John Williams built, where did he build it, and to which islands did he sail it in 1830?
4. **MEDIUM** Rarotonga is at about 21.2°S, 159.8°W, and Apia, Samoa, at about 13.8°S, 171.8°W. One degree of latitude is about 111 km, and at this latitude one degree of longitude is about 106 km. Find the straight-line distance in km and miles.
(Use the map or drawing “Rarotonga lies southeast of Samoa.” shown earlier in this lesson.)
5. **MEDIUM** Sirius has a declination of about 17°S. At what latitude does it pass straight overhead? Which island in the lesson diagram lies near that latitude?
6. **MEDIUM** The 1976 voyage of *Hōkūle‘a* covered about 4,300 km (2,700 miles) in about 34 days. What was its average distance per day in km and miles, and its average speed in km per hour?
7. **MEDIUM** The Pacific Ocean covers about 165 million km². All the land on earth covers about 149 million km². How much larger is the Pacific? Give the answer in square miles too (1 km² $\approx$ 0.386 square mile).
8. **HARD** Look at the stick chart diagram. What do the shells, the straight sticks and the curved sticks stand for? Why did Marshallese navigators leave their charts at home instead of taking them to sea?
(Use the map or drawing “Reading a stick chart.” shown earlier in this lesson.)
9. **HARD** Explain Darwin’s idea of how an atoll forms, and the evidence found on Enewetak in 1952.
10. **CHALLENGE** Write a paragraph weighing the good and the harm that came to the Pacific Islands from outside contact in the 1800s.

COMMON MISTAKES

- Thinking the Pacific Islands were found by accident by drifting canoes. The settlement of Polynesia was planned voyaging by skilled navigators who could sail against the wind and return home.
- Thinking all Pacific islands are alike. High volcanic islands and low coral atolls offer very different soils, water and ways of life.
- Thinking the gospel spread in the Pacific only through European missionaries. Most of the teachers and many of the martyrs were Pacific Islanders.

Make it a game • Find the Island. Hide a small “island” (a shell or coin) somewhere in a room. One player is the navigator, eyes open but hands behind the back. A partner gives only wayfinding clues: “The swell comes from the east” (point east), “A bird is flying toward the window,” “Clouds are piling up over the bookshelf,” “The star you need is straight overhead.” The navigator must find the island using the clues. Count the clues it takes; then switch roles and try to find it in fewer.

Scripture. “If I take the wings of the morning, and dwell in the uttermost parts of the sea; Even there shall thy hand lead me, and thy right hand shall hold me.” (Psalm 139:9–10, KJV)

No place on earth is more like “the uttermost parts of the sea” than the islands of the Pacific. The navigators who found them, the islanders who lived on them, and the missionaries who sailed to them were never beyond the reach of God’s hand.

Practice answers

1. Polynesia (“many islands”), Micronesia (“small islands”) and Melanesia (“black islands”).
2. A high island is volcanic, with mountains, streams and rich soil; an atoll is a low ring of coral islets around a lagoon, only a few meters high, with thin soil and little fresh water.
3. The *Messenger of Peace*, built on Rarotonga. In 1830 he sailed it to Samoa.
4. North-south: $7.4^\circ \times 111 \approx 821$ km. East-west: $12.0^\circ \times 106 \approx 1,272$ km. Straight line: $\sqrt{(821^2 + 1,272^2)} \approx 1,514$ km, about 1,500 km (about 940 miles).
5. At about 17°S . Tahiti (about 17.5°S) lies near that latitude; Fiji (about 18°S) is close too.
6. $4,300 \div 34 \approx 126$ km per day; $2,700 \div 34 \approx 79$ miles per day. $126 \div 24 \approx 5.3$ km per hour.
7. $165 - 149 = 16$ million km^2 larger. $16,000,000 \times 0.386 \approx 6.2$ million square miles.
8. Shells are islands, straight sticks are the main ocean swells, and curved sticks are swells bending around islands. Navigators memorized the charts on land and steered by feeling the swells under the canoe; at sea, especially at night, they had to read the ocean itself, not look at sticks.
9. A coral reef grows around the shore of a volcanic island. Over a very long time the volcano slowly sinks, but the coral keeps growing upward toward the light, so the reef stays at the surface. At last the volcano disappears below the sea, leaving a ring of reef and islets around a lagoon. In 1952 drilling on Enewetak passed through more than 1,200 m of coral and reached volcanic rock, as Darwin’s idea predicted.

10. A good answer names real harms: diseases that killed many islanders, traders selling guns and alcohol, violence such as that of the sandalwood traders, and blackbirding that forced tens of thousands into plantation labor. It also names real goods: the gospel, which many islanders received gladly and then carried to other islands themselves; written languages and translated Bibles; schools; and an end to practices such as human sacrifice in many places. It notes that missionaries often protested the abuses of traders and recruiters, and that the islanders were not only receivers but also active missionaries and leaders.

UNIT 7 REVIEW

Answer each question. Show your work for calculations, give distances in both kilometers and miles, and use complete sentences for explanations. The review is worth 60 points.

1. (6 pts) Name the strait between Sumatra and the Malay Peninsula. Name one other strait a ship could use instead, and explain why most ships choose the first one.
2. (6 pts) What is the Wallace Line, where does it run, and what did Wallace notice on either side of it?
3. (6 pts) Explain how the monsoon winds and the spices of the Moluccas made the ports of the straits rich, and name the faiths that arrived along these sea routes.
4. (6 pts) Why did Stamford Raffles choose Singapore for a British port in 1819, and what did he do to attract merchants?
5. (6 pts) A ship from Colombo to Hong Kong goes about 5,600 km through the Strait of Malacca, or about 6,700 km around through the Sunda Strait. How much farther is the detour in km and miles, and how many extra hours at 37 km/h (20 knots)?
6. (6 pts) Give three examples of “technology overcoming geography” in Singapore.
7. (6 pts) Explain, using climate, why more than four Australians in five live near the coast.
8. (6 pts) Sydney uses UTC+10, Perth UTC+8 and New Zealand UTC+12 (standard time). When it is 9:00 a.m. in Perth, what time is it in Sydney and in Wellington? Then explain why Christchurch is much drier than Hokitika.
9. (6 pts) Describe three ways Pacific navigators found islands without instruments, and explain what a Marshall Islands stick chart showed.
10. (6 pts) Tell the story of John Williams in four or five sentences, and explain the part Pacific Islanders themselves played in spreading the gospel.

UNIT PROJECT: MY ATLAS PAGE: SOUTHEAST ASIA AND OCEANIA, WITH A STICK CHART

Make a two-page spread for your regional atlas. On the first page, draw a large map of the Strait of Malacca and the islands of Southeast Asia: label Sumatra, Java, Borneo, Sulawesi, New Guinea, Luzon and Mindanao; shade the Strait of Malacca, Sunda Strait and Lombok Strait; mark Singapore, Jakarta, Manila and the Banda Islands; and draw the Wallace Line and arrows for the two monsoons. On the second page, draw Australia, New Zealand and the Polynesian Triangle with their main cities, the Great Dividing Range, the Southern Alps and the Tropic of Capricorn.

Attach or photograph your Marshall Islands stick chart with its key. Write a paragraph explaining how geography (straits, monsoons, deserts, rain shadows and ocean distance) shaped where people live and how they trade in this region, and name one story of technology or skill overcoming that geography.

- **Accuracy:** Islands, straits, cities, mountains and the Wallace Line are placed and labeled correctly.

- **Stick chart:** The chart is sturdy, has islands, straight and curved swell sticks, and a clear key.
- **Explanation:** The paragraph explains at least three ways geography shaped the region and one example of technology or skill overcoming it, with correct facts.
- **Care:** The pages are neat, colorful, titled and easy to read, with a compass rose and a scale bar.

Answer key

1. The Strait of Malacca. Other routes: the Sunda Strait (between Sumatra and Java) or the Lombok Strait (east of Bali). Most ships use Malacca because it is the shortest sea road between the Indian Ocean and the South China Sea; the others add hundreds of kilometers and many hours.
2. It is a boundary traced by Alfred Russel Wallace that runs through the Lombok Strait between Bali and Lombok and north through the Makassar Strait between Borneo and Sulawesi. West of it the animals are mostly Asian (such as tigers and orangutans); east of it they are mostly Australian kinds (such as cockatoos and marsupials), even though Bali and Lombok are only about 25 km (15 miles) apart.
3. Ships from India, Arabia and China sailed with one monsoon and had to wait in port for the wind to reverse, so harbor towns on the straits became meeting places for merchants. Cloves and nutmeg grew only in the Moluccas and Banda, so traders came from far away to buy them, and kingdoms such as Srivijaya and Malacca grew rich controlling the route. Hinduism, Buddhism, Islam and Christianity all arrived by sea along these trade routes.
4. Singapore sits at the southern end of the Strait of Malacca, a choke point every ship between the Indian Ocean and China must pass, and it had a deep, sheltered harbor. The Dutch controlled other ports in the region, and Raffles wanted a British station on the route to China. He made Singapore a free port, with no customs duties, so merchants of many nations came.
5. $6,700 - 5,600 = 1,100$ km, about 680 miles. $1,100 \div 37 \approx 30$ extra hours.
6. Any three of: the container port (first terminal 1972, about 39 million TEU in 2023) and the new automated port at Tuas; land reclamation, which has made the island about a quarter larger; the Causeway to the mainland (1924); desalination; NEWater recycled water (since 2003); steamship coaling after the Suez Canal opened in 1869.
7. Australia straddles the Tropic of Capricorn in the belt of the subtropical high, where sinking dry air makes deserts, so roughly 70 percent of the land is arid or semi-arid. Rain falls mainly on the eastern slopes of the Great Dividing Range, in the monsoon north and on the southwest and south coasts in winter. People settled and built cities where the rain, rivers and harbors are, especially in the southeast.
8. Sydney: 11:00 a.m. Wellington: 1:00 p.m. The westerly winds rise over the Southern Alps and drop their rain on the West Coast (Hokitika, about 2,800 mm or 110 inches a year); the air sinks and dries on the east side, leaving Christchurch on the Canterbury Plains in a rain shadow (about 600 mm or 24 inches).
9. Any three of: a star compass of the points where stars rise and set; zenith stars that pass overhead at an island's latitude; reading ocean swells felt through the hull; land-nesting birds flying out at dawn and home at dusk; clouds piled over islands. A stick chart used shells for islands, straight sticks for main swells and curved sticks for swells bending around islands; navigators studied it ashore and left it at home.

10. John Williams of the London Missionary Society came to the Pacific in 1817 and worked from the Society Islands. He sent Polynesian teachers such as Papeiha to new islands, including Rarotonga in 1823. On Rarotonga he built his own ship, the Messenger of Peace, and sailed it to Samoa in 1830. He was killed on November 20, 1839, on Erromango (Vanuatu), an island that later became Christian. Much of the work was done by Tahitian, Rarotongan, Samoan and Tongan teachers who went to distant islands, and many of them died there.

THE AMERICAS

Our tour of the world ends in the Americas, two continents joined by a thin land bridge and stretching from the Arctic islands of Canada to Cape Horn. The land is built on a simple pattern: a great wall of young mountains down the western side (the Rockies, the Sierra Madre and the Andes), older worn highlands in the east (the Canadian Shield, the Guiana and Brazilian Highlands), and between them great plains and river basins (the Prairies, the Pampas and the Amazon). In this unit you will study Canada, Mexico and Central America, the Panama Canal and South America, each in the same way as every other region this year: its land and rivers first, then its ports and resources, then the faith and history of its peoples.

You will stand with the railway men at Craigellachie in 1885 as the last spike of the Canadian Pacific is driven, march with Cortés from the hot Gulf coast up to the lakes of Tenochtitlan, ride the *Ancon* through the locks of Panama on opening day in 1914, and climb Chimborazo with Alexander von Humboldt. Two of the lessons carry the year's technology thread: a railway that crossed a continent of rock and mountains, and a canal that lifted ships over the Continental Divide with nothing but rain and gravity. You will meet missionaries from Jean de Brébeuf and James Evans in Canada to Junípero Serra in Mexico and Jim Elliot in Ecuador.

This is the last unit of the year, so it ends with the finishing of your regional atlas. You will add the Americas pages and the map of the Americas' railways and canals, then gather, check and bind every page you have made since Europe in Unit 1 into one book of your own.

BEFORE YOU BEGIN

- Can read latitude and longitude and use a map's grid and scale (Units 1-7)
- Can calculate time differences between time zones
- Knows how a pound lock raises and lowers a boat (Unit 6)
- Can convert between kilometers and miles and between meters and feet

MASTERY CHECKLIST

- I can locate the major landforms of the Americas: the Canadian Shield, the Rockies, the Sierra Madre, the Mexican Plateau, the Andes, the Amazon Basin and the Pampas.
- I can explain how altitude, ocean currents and rain shadows make the climates of Mexico, Central America and South America.
- I can tell how the Canadian Pacific Railway crossed the Shield, the Prairies and the mountains, and calculate a railway grade.
- I can explain how the Panama Canal's locks and Gatún Lake lift ships across the isthmus, and calculate lock lifts, water volumes and distances saved.
- I can describe how the peoples, faith, farming and trade of each region were shaped by its land, naming real wrongs and real achievements honestly.
- I have finished and bound a regional atlas of the world's great regions.

OPTIONAL BOOKS AND RESOURCES

- **National Gallery of Art, Washington** (<https://www.nga.gov/>): Free. Search the collection for Frederic Edwin Church's *Niagara* (1857) to see the painting in high resolution, along with other American landscape paintings.
- **Panama Canal Authority** (<https://pancanal.com/>): Free. The official site of the canal's operator, with facts about the locks, Gatún Lake and the expanded canal. A parent should preview it; some pages are written for shipping companies.
- **Library of Congress** (<https://www.loc.gov/>): Free. Search for historic photographs and maps of the Panama Canal's construction and of the railways of Canada and South America for your atlas pages.

8.1 CANADA ★ ⚙️

OBJECTIVES

- Locate Canada's great regions (the Atlantic coast, the St. Lawrence Lowlands, the Canadian Shield, the Prairies, the Western Cordillera and the Arctic) and explain why most Canadians live in the south.
- Tell how the St. Lawrence River opened Canada to the French and the fur trade, and how the Canadian Pacific Railway (1881–1885) crossed the Shield, the Prairies and the mountains to tie the country together.
- Calculate railway grades, journey speeds and time differences across Canada's six time zones.

Warm-up. Lay a ruler on a stack of two books so it makes a ramp, and roll a toy car or a marble up it with a gentle push. Now add a third and a fourth book. How much harder is the push? Write down what a railway builder would have to do if a mountain stood in the way: go over it, go around it, or go through it? Keep your answer for the end of the lesson.

Watch. *History of The Spiral Tunnels* (History of British Columbia, 11:31).

<https://www.youtube.com/watch?v=Wci2LRZyqSk>

After the story: watch how the Spiral Tunnels near Field, British Columbia, replaced the steep, dangerous Big Hill on the Kicking Horse Pass by looping the track inside the mountains to make the climb gentler.

Note: Captions were not available to check; preview it first and make sure the narration is a real voice and not an AI voice. It describes runaway trains and accidents on the Big Hill. The tunnels opened in 1909, more than twenty years after the 1885 last spike in the lesson's story.

Backup video. *"Canada: Landform Regions"- 16mm Canadian Geography Documentary (1964)* (Canada 160 Archive, 15:05). <https://www.youtube.com/watch?v=yquS-vwK92c>

With On the map: watch this old classroom film and look for each of Canada's landform regions, especially the rocky Canadian Shield, the St. Lawrence Lowlands and the flat Prairies. Note: Captions were not available to check; preview it first. This is a 1964 school film, so the narration and some facts are dated, and it may give geologic ages in millions of years. The film's region names and numbers may differ from the lesson's, and its population figures are from the 1960s.

KEY TERMS

Canadian Shield

A huge region of very old, hard rock that curves like a horseshoe around Hudson Bay and covers about half of Canada. Glaciers scraped it bare, leaving thin soil, countless lakes and rich minerals.

St. Lawrence Lowlands

The flat, fertile lands along the St. Lawrence River and the shores of Lakes Erie and Ontario, where Quebec City, Montreal and Toronto stand and most Canadians live.

Western Cordillera

The belt of mountain ranges in western Canada, including the Rocky Mountains, the Selkirks and the Coast Mountains.

grade

How steep a road or railway is, written as a percent: the rise divided by the run, times 100. A 2% grade rises 2 m in every 100 m (2 ft in every 100 ft).

transcontinental railway

A railway that crosses a whole continent, from one ocean to another.

standard time

A system in which a whole region keeps one clock time instead of each town keeping its own sun time. Railways made it necessary.

CORE IDEAS

The story. On the morning of November 7, 1885, a small crowd of railway men in heavy coats stood among the cedars at a place called Craigellachie, in Eagle Pass in the mountains of British Columbia. Two lines of track had been built toward each other, one from the east and one from the west, and now only a single rail length was missing. Donald Smith, one of the railway's directors, took a hammer and drove the last spike. It was a plain iron spike, like the millions before it. Standing near him were Sandford Fleming, the engineer who had led the railway's first surveys, and William Cornelius Van Horne, the general manager who had driven the work forward. When the crowd called for a speech, Van Horne said only, "All I can say is that the work has been well done in every way." The Canadian Pacific Railway now ran from Montreal to the Pacific, and Canada was joined from sea to sea.

On the map. Canada is the second-largest country in the world, about 9.98 million km² (3.85 million sq mi), with coasts on three oceans: the Atlantic, the Pacific and the Arctic. Its land falls into great regions. In the east are the rocky Atlantic provinces. Along the **St. Lawrence River** and the lower Great Lakes lie the **St. Lawrence Lowlands**, small but fertile, with Quebec City, Montreal, Ottawa and Toronto. North and west of them, curving around Hudson Bay, spreads the **Canadian Shield**, about half the country: ancient rock scraped bare by glaciers, dotted with countless lakes, poor for farming but rich in nickel, iron, gold and copper. West of the Shield are the flat **Prairies**, and beyond them the **Western Cordillera**: the Rocky Mountains, the Selkirks and the Coast Mountains, which fall to the Pacific at Vancouver. In the far north are the tundra and the Arctic islands. Because the north is so cold, most of Canada's roughly 41 million people (2024) live in a band within a few hundred kilometers of the United States border.

How geography shaped history. The St. Lawrence is the front door of Canada. In 1535 the French sailor Jacques Cartier sailed up it to the Iroquoian village of Hochelaga, where Montreal stands today, and was stopped by the Lachine Rapids. In 1608 Samuel de Champlain founded Quebec on a high cliff where the river narrows. From there French

traders and First Nations canoe men followed the rivers and lakes deep into the continent for the beaver fur that Europe wanted, and in 1670 the English Hudson's Bay Company began trading through the icy bay to the north. Canada was built on waterways. Yet waterways freeze in winter, and they do not cross the Rocky Mountains. When British Columbia joined Canada in 1871, it did so on a promise: a railway to the Pacific within ten years.

Technology overcoming geography. The Canadian Pacific was built mostly between 1881 and 1885, and it had to beat three barriers. North of Lake Superior lay the Shield, solid rock and swampy muskeg that swallowed tons of fill; Van Horne built factories on the spot to make dynamite. Across the Prairies the work went fast, with track crews laying several kilometers a day. Then came the mountains. The line climbed the Rockies at Kicking Horse Pass, where the descent on the western side, the "Big Hill," had a grade of 4.5%, so steep that runaway trains were a constant danger. In 1909 the railway replaced it with the **Spiral Tunnels**, which loop inside the mountains to make the track longer and cut the grade to 2.2%. In the Selkirks the line crossed Rogers Pass, found by the surveyor Major A. B. Rogers. In British Columbia, the contractor Andrew Onderdonk hired thousands of Chinese workers to blast tunnels and ledges along the Fraser Canyon. They were paid less than white workers and did some of the most dangerous work, and hundreds died. In 1885, the same year the line was finished, Canada placed a head tax of \$50 on Chinese immigrants, a real wrong that Canada formally apologized for in 2006.

What the railway changed. The first through passenger train left Montreal on June 28, 1886, and reached Port Moody on the Pacific less than a week later, a trip of about 4,600 km (2,900 mi) that had once taken months. Settlers poured onto the Prairies, which became one of the world's great wheat lands, and Vancouver grew into Canada's Pacific port. Trains also needed timetables that made sense across a whole continent, and Sandford Fleming became a leading champion of standard time zones. As of 2026, Canada keeps six time zones, from Newfoundland (UTC-3:30) to Pacific time (UTC-8).

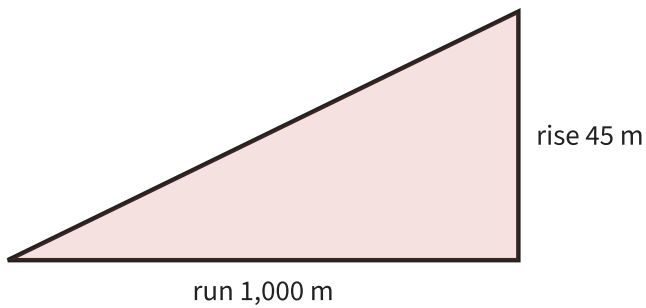
Peoples and faith. Canada is home to First Nations, the Inuit of the Arctic and the Métis, as well as the descendants of French, British and many later settlers; English and French are both official languages. Catholic missionaries came with New France. The Jesuit Jean de Brébeuf lived among the Huron (Wendat) for years and was killed in 1649 during the wars of that time. Later Protestant settlers brought Anglican, Presbyterian and Methodist churches, and the Methodist missionary James Evans created a syllabic alphabet for the Cree language around 1840 so that Cree readers could have the Scriptures. In the 2021 census a little over half of Canadians named themselves Christians. As of 2026, Canada is a parliamentary democracy and a constitutional monarchy with King Charles III as its head of state.



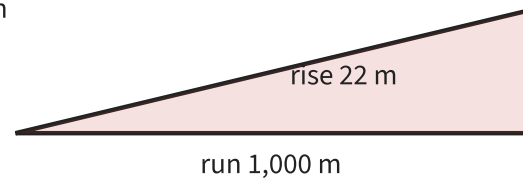
The Canadian Pacific Railway, completed in 1885, crossed the Canadian Shield, the Prairies and the Western Cordillera.

$$\text{Grade} = \text{rise} \div \text{run} \times 100$$

Big Hill (1884–1909)
grade 4.5%



Spiral Tunnels (1909)
grade 2.2%



Heights are stretched to show the difference; real grades look much flatter.

Grade is rise divided by run. The Spiral Tunnels halved the grade by making the track longer.

PICTURE STUDY



Niagara, Frederic Edwin Church, 1857 · Oil on canvas · National Gallery of Art, Washington, D.C. (Corcoran Collection)

Frederic Edwin Church (1826–1900) was an American landscape painter who had studied with Thomas Cole, the founder of the Hudson River School. He visited Niagara Falls several times and made many sketches before painting this canvas, about 2.3 m (7.5 ft) wide. He chose the Horseshoe Falls, the great curving falls on the Canadian side of the border, and left out the usual rocky ledge in front, so the viewer seems to hang right over the rushing water. When it was shown in New York in 1857, crowds paid to see it, and it was later shown in Britain as well.

Niagara is a lesson in geography. The Niagara River carries the water of the upper Great Lakes from Lake Erie to Lake Ontario, and it forms part of the border between Canada and the United States. Ships could never climb the falls, so in 1829 the colony of Upper Canada opened the first Welland Canal to carry boats around them. Church's painting shows the very barrier that canal builders had to beat.

Look closely

- Find the edge where the water drops. How did Church make you feel how wide the falls are?
- Look at the bottom of the painting. Where are you standing? Is there any solid ground in front of you?
- Find the rainbow and the spray. What do they tell you about how much water is falling?
- Look at the horizon line. Why do you think Church made the painting so long and low?

Talk about it

1. Why would a waterfall like this make the Niagara River useless for ships, and what did people build to get around it?
2. Many viewers in 1857 said the painting made them think of the power of God. What in the picture might have made them feel that?
3. This waterfall lies on the border of two countries. How can a river be both a border and a highway?

PROJECT: CLIMBING THE BIG HILL: A MODEL RAILWAY GRADE

You will build two model railway grades, one as steep as the old Big Hill (4.5%) and one as gentle as the Spiral Tunnels (2.2%), and then wrap a paper track around a can to see how a spiral makes a track longer and gentler. Along the way you will learn to measure and calculate grade the way railway surveyors did.

You will need

- A stiff board, shelf or long piece of cardboard about 1 m (about 3 ft) long
- Books or blocks to prop it up, and thin cardboard or coins to fine-tune the height
- Meter stick or yardstick and a ruler with millimeters
- A toy train car, toy car or marble
- A tall round container (an oatmeal canister or coffee can), a strip of paper about 5 cm (2 in) wide and 1 m long, and tape
- Pencil, paper and calculator

Steps

1. Lay the board on a table. Measure 100 cm along it from the low end and make a mark. This is your *run*.
2. Prop up the board so that the mark stands 4.5 cm above the table. (Rise $4.5 \text{ cm} \div \text{run } 100 \text{ cm} \times 100 = 4.5\%$.) This is the Big Hill.
3. Roll the toy car down the slope from the mark three times and measure how far past the bottom it rolls each time. Record the average.
4. Lower the board until the mark stands only 2.2 cm high. This is the grade of the Spiral Tunnels. Roll the car three more times and record.
5. Now wrap the paper strip around the canister in a rising spiral, going around twice and taping it as you go. Measure the height it climbs and the length of the strip. Calculate its grade: $\text{height} \div \text{length} \times 100$.
6. Unwrap the strip and lay it straight from the floor to the same height. Explain in two sentences why a longer track can climb the same height at a gentler grade.
7. Draw your two ramps in your atlas with their rise, run and grade labeled, and add a small sketch of the Spiral Tunnels looping inside the mountain.

Tips

- A real 4.5% grade looks gentle on a table. On a railway it was dangerous because a heavy train going downhill builds up great speed and is hard to stop.

- Make sure you measure the rise straight up from the table, not along the board.

Check your work

- My two ramps had grades of 4.5% and 2.2%, measured correctly.
- I calculated the grade of my spiral track.
- I can explain why the Spiral Tunnels made the line safer.

MAP NOTEBOOK

1. Trace an outline of Canada. Shade and label the Canadian Shield, the St. Lawrence Lowlands, the Prairies, the Western Cordillera and the Arctic. Add Hudson Bay and the Great Lakes.
2. Draw the route of the Canadian Pacific Railway from Montreal to Port Moody. Mark Lake Superior, Winnipeg, Calgary, Kicking Horse Pass, Rogers Pass and Craigellachie, and write 1885 beside the last spike.
3. Draw a strip of Canada's six time zones from St. John's to Vancouver and show the clock time in each when it is noon in Toronto.

From history. In 1883, while railway crews were blasting a cut through the rocks of the Canadian Shield near the place that became Sudbury, Ontario, they uncovered rich copper and nickel ore. Within a few years mines opened, and the Sudbury district became one of the greatest nickel-mining regions in the world. The railway that was built to cross the Shield ended up revealing some of the Shield's greatest treasure.

WORKED EXAMPLES

Example 1. As of 2026, Canada's standard time zones include Newfoundland (UTC−3:30), Atlantic (UTC−4), Eastern (UTC−5), Central (UTC−6), Mountain (UTC−7) and Pacific (UTC−8). When it is 12:00 noon standard time in Halifax (Atlantic), what time is it in Winnipeg (Central), in Vancouver (Pacific) and in St. John's, Newfoundland?

1. Winnipeg: −6 is 2 hours behind −4. $12:00 - 2 \text{ h} = 10:00 \text{ a.m.}$
2. Vancouver: −8 is 4 hours behind −4. $12:00 - 4 \text{ h} = 8:00 \text{ a.m.}$
3. St. John's: −3:30 is half an hour ahead of −4. $12:00 + 0:30 = 12:30 \text{ p.m.}$

Answer: 10:00 a.m. in Winnipeg, 8:00 a.m. in Vancouver and 12:30 p.m. in St. John's.

Example 2. The Big Hill west of Kicking Horse Pass had a grade of 4.5%, and the Spiral Tunnels that replaced it in 1909 have a grade of 2.2%. (a) How much does each climb in 1 km (1,000 m) of track? (b) How long must each track be to climb 300 m (about 984 ft)?

(Use the map or drawing “ $\text{Rise} = \text{grade} \div 100 \times \text{run}$.” shown earlier in this lesson.)

1. $\text{Grade} = \text{rise} \div \text{run} \times 100$, so $\text{rise} = \text{grade} \div 100 \times \text{run}$.
2. (a) Big Hill: $4.5 \div 100 \times 1,000 \text{ m} = 45 \text{ m}$. Spiral Tunnels: $2.2 \div 100 \times 1,000 \text{ m} = 22 \text{ m}$.
3. (b) $\text{Run} = \text{rise} \div (\text{grade} \div 100)$. Big Hill: $300 \div 0.045 \approx 6,670 \text{ m}$, about 6.7 km (4.1 mi). Spiral Tunnels: $300 \div 0.022 \approx 13,640 \text{ m}$, about 13.6 km (8.5 mi).
4. The gentler grade needs about twice as much track, which is why the tunnels loop around inside the mountain.

Answer: (a) 45 m on the Big Hill and 22 m in the Spiral Tunnels. (b) About 6.7 km (4.1 mi) of track at 4.5%, but about 13.6 km (8.5 mi) at 2.2%.

Example 3. The first through passenger train on the Canadian Pacific left Montreal on June 28, 1886, and reached Port Moody on the Pacific after about 140 hours, covering about 4,600 km (2,900 mi). What was its average speed, including all stops? About how many days was the trip?

1. $\text{Average speed} = \text{distance} \div \text{time}$.
2. In kilometers: $4,600 \text{ km} \div 140 \text{ h} \approx 33 \text{ km/h}$.
3. In miles: $2,900 \text{ mi} \div 140 \text{ h} \approx 21 \text{ mph}$.
4. Days: $140 \text{ h} \div 24 \text{ h per day} \approx 5.8 \text{ days}$.

Answer: About 33 km/h (about 21 mph) on average; a little under six days. Before the railway, the same trip took months by canoe, wagon and ship.

PRACTICE

1. **EASY** What is the Canadian Shield? Give two facts about its land and one reason it matters to Canada.
2. **EASY** Where and when was the last spike of the Canadian Pacific Railway driven, and by whom?
3. **EASY** Which French explorer sailed up the St. Lawrence to Hochelaga in 1535, and who founded Quebec in 1608?
4. **MEDIUM** It is 12:00 noon in Toronto (Eastern, UTC−5). What time is it in St. John's, Newfoundland (UTC−3:30), and in Calgary (Mountain, UTC−7)? Use standard time.
5. **MEDIUM** A train climbs 3 km (about 1.9 mi) of track on the old Big Hill grade of 4.5%. How many meters and feet does it rise? (1 m $\approx$ 3.28 ft)

6. **MEDIUM** A modern train runs from Montreal to Vancouver, about 4,600 km (2,900 mi), at an average of 60 km/h (about 37 mph). How many hours does it take, and about how many days?
7. **MEDIUM** Use the map of the Canadian Pacific Railway and the lesson. (a) Which city on the line stands on the shore of Lake Superior? (b) Name the passes where the line crosses the Rockies and then the Selkirks.
(Use the map or drawing "Follow the railway from Montreal west to Port Moody." shown earlier in this lesson.)
8. **HARD** Explain why the stretch north of Lake Superior was one of the hardest and most expensive parts of the Canadian Pacific to build. Use the words *Shield*, *rock* and *muskeg*.
9. **HARD** Canada's people live mostly in a band along the southern border, and the land's rivers and valleys often run north to south toward the United States. Explain why Canada's leaders thought an east-west railway was needed to hold the country together.
10. **CHALLENGE** The Spiral Tunnels cut the grade from 4.5% to 2.2%. If a locomotive could pull a train of 20 cars up the Big Hill, and the pulling force needed for the climb is roughly proportional to the grade, about how many cars of the same weight could it pull up the 2.2% grade? Why is this only a rough estimate?

COMMON MISTAKES

- Thinking most of Canada is good farmland. About half is the rocky Canadian Shield, and much of the north is tundra; Canada's best farmland is in the St. Lawrence Lowlands and on the Prairies.
- Confusing grade with angle. A 4.5% grade means 4.5 m of rise in 100 m of run, which is an angle of only about 2.6°, yet it is very steep for a railway.
- Forgetting the half-hour in Newfoundland. Newfoundland time is UTC−3:30, so it is 30 minutes ahead of Atlantic time, not a full hour.

Make it a game · Last Spike Relay. Write twelve stops of the Canadian Pacific on cards (Montreal, Ottawa, Sudbury, Port Arthur, Winnipeg, Regina, Calgary, Banff, Kicking Horse Pass, Rogers Pass, Craigellachie, Port Moody) and shuffle them. Two teams race to lay the cards in order from east to west. Then a parent reads a clue for each card, such as "Here the line meets Lake Superior" or "Here the Spiral Tunnels loop inside the mountain," and the first team to point to the right card scores a point. The team that lays down Craigellachie last gets to shout "Well done in every way!"

Scripture. "Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain:" (Isaiah 40:4, KJV)

Isaiah spoke of preparing a highway for the Lord. Railway builders did something like it on a small scale: they filled valleys, cut through hills and made rough places passable. The prophet's words remind us that the One who made the mountains is greater than all of them.

Practice answers

1. It is a vast region of very old, hard rock curving around Hudson Bay, about half of Canada. Its soil is thin and it has countless lakes left by glaciers, so it is poor for farming. It matters because it is rich in minerals such as nickel, iron, gold and copper.
2. At Craigellachie, in Eagle Pass, British Columbia, on November 7, 1885, by Donald Smith, a director of the railway.
3. Jacques Cartier sailed to Hochelaga (today's Montreal) in 1535. Samuel de Champlain founded Quebec in 1608.
4. St. John's is $1\frac{1}{2}$ hours ahead: 1:30 p.m. Calgary is 2 hours behind: 10:00 a.m.
5. $\text{Rise} = 0.045 \times 3,000 \text{ m} = 135 \text{ m}$. In feet: $135 \times 3.28 \approx 443 \text{ ft}$.
6. $4,600 \div 60 \approx 77$ hours (or $2,900 \div 37 \approx 78$ hours), about 3.2 days.
7. (a) Port Arthur (today part of Thunder Bay, Ontario). (b) Kicking Horse Pass in the Rockies, then Rogers Pass in the Selkirks.
8. The line there crossed the Canadian Shield, where hard ancient rock had to be blasted with great amounts of dynamite, and where low places were filled with muskeg, a soft, swampy ground that swallowed fill and track. Few people lived there, so supplies had to be brought in from far away.
9. Without an east-west link, each region would trade and travel most easily with the American region just south of it, and distant British Columbia had joined Canada only on the promise of a railway. The Canadian Pacific joined the Atlantic provinces, Quebec and Ontario, the Prairies and the Pacific coast inside Canada, so goods, settlers, mail and soldiers could move across the country without going through the United States.
10. $4.5 \div 2.2 \approx 2$, so roughly twice as many, about 40 cars. It is only rough because a train must also overcome rolling friction and air resistance, which do not depend on the grade, and curves on the spiral add some drag.

8.2 MEXICO AND CENTRAL AMERICA

OBJECTIVES

- Locate the Sierra Madre Occidental and Oriental, the Mexican Plateau, the volcanic belt, the Yucatán Peninsula, the Isthmus of Tehuantepec and the seven countries of Central America.
- Explain how altitude makes the tierra caliente, tierra templada and tierra fría, and why most Mexicans live on the high central plateau rather than on the hot coasts.
- Tell how the land shaped the Aztec and Maya worlds, the Spanish conquest, the silver and galleon trade and the spread of Christianity in the region.

Warm-up. Fill two glasses with water, one from the hot tap and one with ice. Hold your hand over each. Now think of a mountain road that starts on a hot beach and climbs to a city more than 2 km (over a mile) high. Make a guess: how many degrees cooler will the city be than the beach? Write your guess down and check it with the rule in this lesson.

Watch. *13th August 1521: End of the Aztec Empire with the Fall of Tenochtitlan to Hernán Cortés* (HistoryPod, 2:35). <https://www.youtube.com/watch?v=LJnb0km6U3Y>

After the story: watch this short summary of how Cortés and his Tlaxcalan allies besieged Tenochtitlan, cut the causeways, and took the city on August 13, 1521.

Note: Captions were not available to check; preview it first. It mentions famine, disease and the destruction of the city during the siege, and it uses British spellings.

Backup video. *Mexico City - Drive Thru History®: Ends of the Earth* (Drive Thru History with Dave Stotts, 4:30). <https://www.youtube.com/watch?v=fdsA9szSp2c>

With On the map: watch Dave Stotts in Mexico City and look for how the modern city stands where Tenochtitlan once rose on its lake in the high Valley of Mexico. Note:

Captions were not available to check; preview it first. This is a short clip from a trusted Christian history series.

KEY TERMS

Mexican Plateau

The high, wide tableland in the middle of Mexico between the Sierra Madre Occidental and the Sierra Madre Oriental. Its southern end, around Mexico City, is more than 2,000 m (6,500 ft) high.

isthmus

A narrow strip of land with water on both sides that joins two larger pieces of land. Central America is an isthmus joining North and South America.

altitude zones

Bands of climate on a mountainside, because the air grows cooler as you climb. In Latin America they are called tierra caliente (hot land), tierra templada (temperate land), tierra

fría (cold land) and tierra helada (frozen land).

volcanic belt

A line of volcanoes. Mexico's Trans-Mexican Volcanic Belt crosses the country from west to east south of Mexico City, and another chain runs along the Pacific side of Central America.

cenote

A natural well or sinkhole in the limestone of the Yucatán Peninsula, where the roof of an underground river or cave has fallen in. The Maya depended on them for water.

chinampa

A raised garden bed built up from mud and plants in a shallow lake. The Aztecs grew corn, beans and squash on chinampas around Tenochtitlan.

CORE IDEAS

The story. On November 8, 1519, a small Spanish army led by Hernán Cortés, with thousands of Tlaxcalan allies, marched along a stone causeway across a lake toward the city of Tenochtitlan. They had landed on the hot Gulf coast near today's Veracruz that spring and had climbed for months, past steaming lowlands, through cool oak and pine forests, and over a high pass between the snowy volcanoes Popocatepetl and Iztaccíhuatl. Below them lay the Valley of Mexico, more than 2,200 m (7,200 ft) above the sea, with its shining lakes, and in the middle of the largest lake stood the Aztec capital, a city of temples, canals and floating gardens. One of Cortés's soldiers, Bernal Díaz del Castillo, wrote years later that it looked like the enchanted cities in the romances he had read, and that some of the men wondered whether they were dreaming. The emperor Moctezuma came out to meet them.

On the map. Mexico is shaped like a funnel that narrows toward the south. Two long ranges, the **Sierra Madre Occidental** in the west and the **Sierra Madre Oriental** in the east, hold up the high **Mexican Plateau** between them. Across the south of the plateau runs a belt of volcanoes, including Pico de Orizaba (Citlaltépetl), Mexico's highest mountain at 5,636 m (18,491 ft). The northern plateau is dry; the southern part, with Mexico City, Guadalajara and Puebla, gets summer rains and holds most of the people. Mexico narrows to about 200 km (125 mi) at the **Isthmus of Tehuantepec**, then the low limestone **Yucatán Peninsula** juts north into the Gulf; it has almost no rivers on its surface, only underground streams and cenotes. Beyond lies Central America: Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. Its spine is a chain of volcanoes near the Pacific coast, with Lake Nicaragua in a lowland gap. The land narrows to about 50 km (30 mi) in Panama. Moist trade winds from the Caribbean drench the eastern slopes, while the Pacific side has a long dry season.

How the land works. This whole region lies in or near the tropics, so the sun is strong all year, and temperature depends mostly on **altitude**. Air cools by roughly 6.5 °C for every 1,000 m you climb (about 3.6 °F per 1,000 ft). On the hot coasts, the *tierra caliente*, below about 900 m (3,000 ft), farmers grow bananas, sugarcane and cacao. Between about 900 and 1,800 m (3,000 and 6,000 ft) lies the mild *tierra templada*, ideal for coffee, as around Xalapa. Above that, to about 3,600 m (12,000 ft), comes the cool *tierra fría* of corn, beans and wheat,

where Mexico City stands. Higher still is the *tierra helada* of bare rock and snow. Long before Europeans arrived, people chose the cool highlands, which were healthier than the fever-ridden coasts. The same mountains bring danger: these lands sit where ocean plates slide beneath the continent, so earthquakes and eruptions are common. In 1985 a great earthquake struck Mexico City, whose soft old lakebed shakes like jelly.

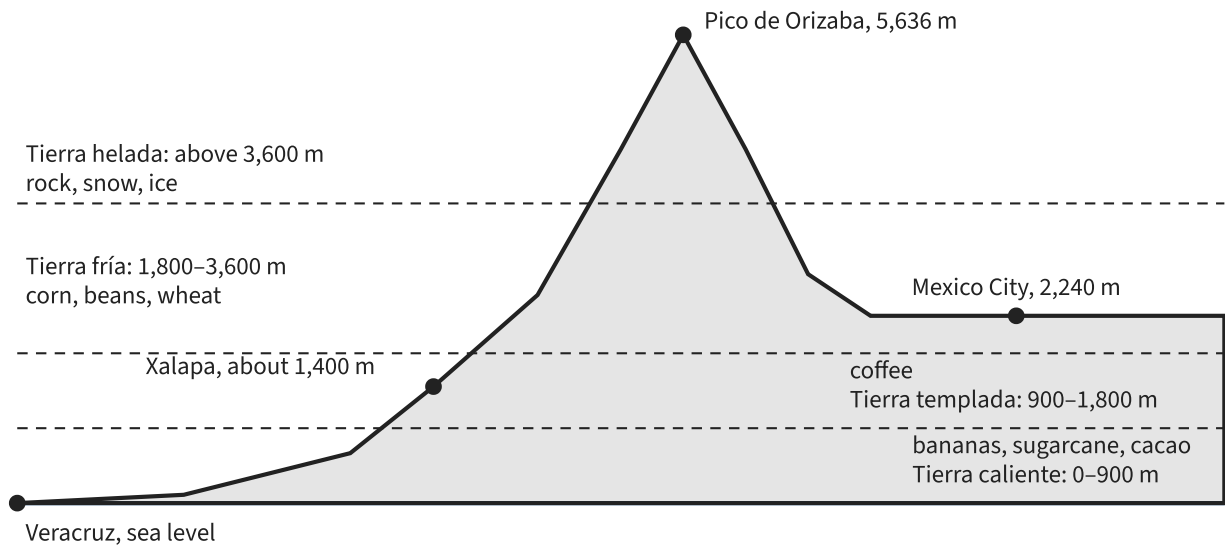
How geography shaped history. The Aztecs built Tenochtitlan on an island because the lake protected it and fed it: they raised **chinampas** in the shallows and carried goods by canoe. The Aztec religion demanded human sacrifice on a large scale, and many subject peoples hated Aztec rule, which is why the Tlaxcalans joined Cortés. After hard fighting and a terrible smallpox epidemic, the city fell on August 13, 1521. The Spanish built Mexico City on its ruins and later drained much of the lake. Spain made New Spain rich through silver from mines such as Zacatecas, found in 1546. Silver went east from Veracruz to Spain, and from 1565 the Manila galleons sailed from Acapulco across the Pacific to the Philippines, trading silver for Chinese silk and porcelain. Farther south, the Maya had built great cities such as Tikal in the lowland forests of Guatemala centuries before, and millions of Maya people still live in the Yucatán, Chiapas and the Guatemalan highlands, many of them speaking Maya languages. Mexico won its independence from Spain in 1821, and the Central American countries soon went their own ways.

Faith and peoples. In 1524 twelve Franciscan friars walked barefoot from Veracruz to Mexico City to begin preaching, and other orders followed, learning Nahuatl and Maya languages and building churches throughout the land. The Dominican Bartolomé de las Casas, later bishop of Chiapas, spent decades protesting the cruelty of Spanish settlers toward Native peoples. In the 1750s Junípero Serra served the missions of the Sierra Gorda before going on to California. Catholic tradition also holds that the Virgin of Guadalupe appeared to a Native man named Juan Diego in 1531, and her basilica in Mexico City is one of the most visited shrines in the world. Most Mexicans today are Catholic (about 78 percent in the 2020 census), and evangelical and Pentecostal churches have grown quickly across the region since the late 1900s, especially in Guatemala and Honduras. Most people of Mexico and much of Central America are *mestizo*, of mixed Native and European descent, while Guatemala has a large Maya population, and Mexico counted about 126 million people in its 2020 census.

The narrow isthmus. Because Central America is so narrow, people dreamed for centuries of a passage between the oceans. In 1907 Mexico opened a railway across the Isthmus of Tehuantepec that carried cargo from coast to coast, and planners studied a canal through Lake Nicaragua. In the end the shortest crossing, in Panama, won, as you will see in the next lesson.



Mexico and Central America: highlands in the middle, hot coasts on both sides, and a land bridge narrowing toward Panama.



Heights are drawn to one scale; distances from left to right are not to scale.

Altitude zones on the climb from Veracruz to the Valley of Mexico. Horizontal distances are not to scale.

PICTURE STUDY



The Valley of Mexico from the Hill of Santa Isabel, José María Velasco, 1875 · Oil on canvas · Museo Nacional de Arte (MUNAL), Mexico City

José María Velasco (1840–1912) was Mexico's greatest landscape painter. He also studied botany, geology and natural science, and he painted the Valley of Mexico again and again with the care of a scientist. In this painting he stood on a hill on the north side of the valley and looked out across the flat floor of the old lakebed, with what remained of Lake Texcoco shining in the distance and Mexico City far away.

The painting is a geography lesson in itself. It shows a high basin ringed by mountains, a valley that once held the lakes and causeways of Tenochtitlan, and the clear, thin air of the *tierra fría* more than 2,000 m (6,500 ft) above the sea.

Look closely

- Find the lake. How big is it compared with the whole valley? What do you think happened to the rest of the water since 1519?
- Look for the city. Why might a city grow up in the middle of a flat basin surrounded by mountains?
- Look at the plants and rocks in the foreground. Do they look like the plants of a hot, wet coast or of a cool, dry highland?
- Look at the sky and the far mountains. How did Velasco make you feel the size of the valley?

Talk about it

1. Compare this view with Bernal Díaz's description of the same valley in 1519. What has changed?

2. Velasco was both a painter and a student of nature. How does his picture show both of those interests?
3. Why would a valley with no natural outlet for its water be likely to flood, and why did later rulers drain the lakes?

PROJECT: A SALT-DOUGH RELIEF MAP OF MEXICO AND CENTRAL AMERICA

You will build a raised map of Mexico and Central America that shows the two Sierra Madres, the high plateau between them, the volcanic belt, the low Yucatán and the narrow isthmus. Then you will paint the altitude zones on it so that you can see at a glance where the hot lands and the cold lands lie. This map will become a page of your regional atlas.

You will need

- Salt dough: 2 cups flour, 1 cup salt, about 3/4 cup water (mix and knead until smooth)
- A piece of heavy cardboard or a wooden board about 30 × 40 cm (12 × 16 in)
- An outline map of Mexico and Central America, traced or printed
- Toothpicks, paper flags and fine markers
- Paints: dark green, light green, yellow-brown, brown and white; blue for water

Steps

1. Trace the outline of Mexico and Central America onto the board, leaving room for the Gulf, the Caribbean and the Pacific.
2. Spread a thin layer of dough over the land. Keep the Yucatán Peninsula and the coastal plains low and flat.
3. Build two long ridges for the Sierra Madre Occidental and the Sierra Madre Oriental, and raise the land between them into a high plateau that rises toward the south.
4. Add a row of small cones across the south of the plateau for the volcanic belt and make Pico de Orizaba the tallest. Add a chain of smaller volcanoes along the Pacific side of Central America.
5. Press the land down low at the Isthmus of Tehuantepec and make Central America thin and narrow, narrowest of all in Panama. Press a hollow for Lake Nicaragua.
6. Let the map dry for two or three days (or bake at a low temperature with a parent's help). Paint the low coasts dark green (tierra caliente), the middle slopes light green (tierra templada), the plateau yellow-brown (tierra fría) and the volcano tops white (tierra helada). Paint the water blue.
7. Use toothpick flags to mark Mexico City, Veracruz, Acapulco, Guadalajara, Mérida, Guatemala City and Panama City, and draw the Tropic of Cancer with a fine marker.

Tips

- Heights on a relief map are always exaggerated. If the mountains were to true scale, they would be almost flat on your board.
- Build the plateau before the volcanoes, just as a geologist would describe the land: first the tableland, then the peaks on top.

Check your work

- My map shows both Sierra Madres, the plateau, the volcanic belt, the Yucatán and the isthmus in the right places.
- My altitude zones are painted in the right order from the coast to the peaks.
- At least seven cities and the Tropic of Cancer are labeled correctly.

MAP NOTEBOOK

1. Draw the route of Cortés from Veracruz to Tenochtitlan as a side view (an elevation profile), climbing from the coast through Xalapa and over the pass between the volcanoes, then down into the Valley of Mexico. Label the altitude zones.
2. Draw a sketch of Tenochtitlan on its island with three causeways to the shore and chinampas in the shallow lake.
3. List the seven countries of Central America from north to south, and next to each write its capital.

From history. From 1565 to 1815 the Manila galleons sailed between Acapulco, on Mexico's Pacific coast, and Manila in the Philippines, usually once or twice a year. They carried Mexican and Peruvian silver west and brought Chinese silk, porcelain and spices east. The return voyage was possible because the Augustinian friar and navigator Andrés de Urdaneta found in 1565 that a ship sailing north into the westerly winds near Japan could ride them across the Pacific to California and then sail south to Acapulco. For two and a half centuries, Mexico was a bridge between Asia and Europe.

WORKED EXAMPLES

Example 1. Air cools by about $6.5\text{ }^{\circ}\text{C}$ for every 1,000 m of altitude. If the average temperature on the coast at Veracruz is about $25\text{ }^{\circ}\text{C}$ ($77\text{ }^{\circ}\text{F}$), estimate the temperature at the pass between Popocatepetl and Iztaccíhuatl, about 3,600 m (11,800 ft) high, that Cortés crossed in 1519.

(Use the map or drawing "Each 1,000 m of climb cools the air by about $6.5\text{ }^{\circ}\text{C}$." shown earlier in this lesson.)

1. Find how many thousands of meters the pass is above the sea: $3,600\text{ m} \div 1,000\text{ m} = 3.6$.
2. Find the cooling: $3.6 \times 6.5\text{ }^{\circ}\text{C} = 23.4\text{ }^{\circ}\text{C}$.
3. Subtract from the coast: $25\text{ }^{\circ}\text{C} - 23.4\text{ }^{\circ}\text{C} \approx 1.6\text{ }^{\circ}\text{C}$.
4. Convert to Fahrenheit: $1.6 \times 9 \div 5 + 32 \approx 35\text{ }^{\circ}\text{F}$.

Answer: About $2\text{ }^{\circ}\text{C}$ (about $35\text{ }^{\circ}\text{F}$), close to freezing. That is a rough estimate, but it shows why Cortés's men, dressed for the tropics, suffered from cold on the pass.

Example 2. Veracruz is at about 19.2°N , 96.1°W , and Mexico City is at about 19.4°N , 99.1°W . Estimate the straight-line distance between them. At this latitude, one degree of longitude is about 105 km (65 mi), and one degree of latitude is about 111 km (69 mi).

1. Difference in longitude: $99.1^{\circ} - 96.1^{\circ} = 3.0^{\circ}$. East-west distance: $3.0 \times 105 \text{ km} = 315 \text{ km}$.
2. Difference in latitude: $19.4^{\circ} - 19.2^{\circ} = 0.2^{\circ}$. North-south distance: $0.2 \times 111 \text{ km} \approx 22 \text{ km}$.
3. The north-south part is very small, so the straight-line distance is only a little more than 315 km. (Exactly: the square root of $315^2 + 22^2 \approx 316 \text{ km}$.)
4. In miles: $316 \text{ km} \div 1.609 \approx 196 \text{ mi}$.

Answer: About 316 km (about 196 mi) in a straight line. Cortés's real route, winding through Tlaxcala and Cholula, was much longer.

Example 3. The Tropic of Cancer is at about 23.4°N . Mexico City is at about 19.4°N . Is Mexico City inside the tropics? How far south of the Tropic of Cancer is it, in km and miles?

1. The tropics are the lands between the Tropic of Cancer (23.4°N) and the Tropic of Capricorn (23.4°S). 19.4°N is between them, so Mexico City is inside the tropics.
2. Difference in latitude: $23.4^{\circ} - 19.4^{\circ} = 4.0^{\circ}$.
3. Each degree of latitude is about 111 km (69 mi): $4.0 \times 111 \text{ km} = 444 \text{ km}$; $4.0 \times 69 \text{ mi} = 276 \text{ mi}$.

Answer: Yes. Mexico City lies about 444 km (276 mi) south of the Tropic of Cancer, inside the tropics. Its cool climate comes from its altitude, not its latitude.

PRACTICE

1. **EASY** Name the two mountain ranges that hold up the Mexican Plateau and tell which is on the west and which is on the east.
2. **EASY** List the seven countries of Central America from north to south.
3. **EASY** Match each crop to its altitude zone: coffee, bananas, wheat. Zones: tierra caliente, tierra templada, tierra fría.
4. **MEDIUM** Pico de Orizaba is 5,636 m high. Convert its height to feet ($1 \text{ m} \approx 3.281 \text{ ft}$). Is it higher or lower than 18,000 ft?
5. **MEDIUM** Mexico City stands about 2,240 m (7,350 ft) above sea level. Using the rule of about 6.5°C cooler per 1,000 m, how much cooler would you expect it to be than a town at sea level at the same latitude?
6. **MEDIUM** Use the map. Which city is farther east: Panama City (about 79.5°W) or Miami (about 80.2°W)? What does this tell you about the shape of the Americas?

(Use the map or drawing “Read the longitudes on the grid.” shown earlier in this lesson.)

7. **MEDIUM** The Isthmus of Tehuantepec is about 200 km wide and Panama at its narrowest is about 50 km wide. Convert both widths to miles ($1 \text{ mi} \approx 1.609 \text{ km}$). How many times wider is Tehuantepec?
8. **HARD** Why does the Yucatán Peninsula have almost no rivers, and how did the Maya get water there?
9. **HARD** Give two reasons from geography why most Mexicans have lived on the southern part of the high plateau rather than on the coasts.
10. **CHALLENGE** In a paragraph, explain how both the land and the peoples of Mexico helped Cortés’s small army bring down Tenochtitlan, and name at least one real wrong of the conquest.

COMMON MISTAKES

- Thinking that everywhere in the tropics is hot. In Mexico and Central America, altitude matters more than latitude: Mexico City, inside the tropics, has mild days and cool nights.
- Treating Central America as part of South America. Central America is the southern end of North America; the continent ends at the Panama-Colombia border.
- Picturing the Aztec capital on dry land. Tenochtitlan stood on an island in Lake Texcoco, joined to the shore by causeways, and today’s Mexico City is built largely on the drained lakebed.

Make it a game • Climb the Zones. Lay four pieces of paper in a row on the floor, labeled Caliente, Templada, Fría and Helada. A parent calls out a crop, a city or a fact (bananas, coffee around Xalapa, Mexico City, the snowy top of Orizaba, cacao, wheat, sugarcane, Veracruz). The player must jump to the right zone within five seconds. A correct jump scores a point; a player who can also give the zone’s height range scores a bonus point. First to ten points wins.

Scripture. “In his hand are the deep places of the earth: the strength of the hills is his also.” (Psalm 95:4, KJV)

From the deep cenotes of the Yucatán to the snowy peak of Orizaba, the lands of Mexico and Central America belong to the God who made them. The psalmist calls us to worship Him for both the depths and the heights.

Practice answers

1. The Sierra Madre Occidental on the west and the Sierra Madre Oriental on the east.
2. Belize and Guatemala (in the north), then Honduras, El Salvador, Nicaragua, Costa Rica and Panama.
3. Bananas: tierra caliente. Coffee: tierra templada. Wheat: tierra fría.
4. $5,636 \times 3.281 \approx 18,492 \text{ ft}$ (the official figure is 18,491 ft). It is higher than 18,000 ft.

5. $2.24 \times 6.5 \approx 14.6$ °C cooler (about 26 °F cooler). In fact the difference is somewhat smaller because the wide plateau warms in the sun, but the rule shows why the city is so mild.
6. Panama City is farther east, because 79.5°W is a smaller west longitude than 80.2°W. It shows that the isthmus curves eastward, so the Americas do not lie in a straight north-south line; South America lies mostly east of North America.
7. $200 \div 1.609 \approx 124$ mi; $50 \div 1.609 \approx 31$ mi. Tehuantepec is about 4 times as wide ($200 \div 50 = 4$).
8. The Yucatán is made of porous limestone, so rainwater sinks underground and flows in caves and underground rivers instead of on the surface. The Maya drew water from cenotes, natural sinkholes where the cave roofs had collapsed, and they also stored rainwater in reservoirs and cisterns.
9. The altitude makes the plateau cool and pleasant even in the tropics, and in the past it was healthier, with fewer fevers carried by mosquitoes than on the hot, wet coasts. The southern plateau also gets dependable summer rain and has rich volcanic soils and flat basins for farming and cities.
10. The land made Tenochtitlan strong, on an island reached only by causeways, but the Spanish built boats to fight on the lake and cut the causeways to starve the city. More important, many peoples, such as the Tlaxcalans, hated Aztec rule and its heavy tribute and human sacrifice, so thousands of Native warriors fought with Cortés. Smallpox, brought from Europe, killed huge numbers in the city in 1520. Real wrongs followed the conquest: the killing of many Native people, the forced labor of survivors in mines and estates, and the deaths of millions from disease and harsh treatment, which men like Bartolomé de las Casas protested.

8.3 THE PANAMA CANAL ★ ⚙️

OBJECTIVES

- Trace the Panama Canal from the Atlantic to the Pacific and name its parts: the Gatún Locks, Gatún Lake, the Culebra (Gaillard) Cut, the Pedro Miguel Locks and the Miraflores Locks.
- Explain how a lock canal lifts ships over the Continental Divide using only the water of the Chagres River and gravity, and calculate lock lifts, water volumes and the distance a ship saves.
- Tell the story of the failed French canal, the American canal of 1904–1914, the doctors who conquered yellow fever and malaria, and the workers who built it.

Warm-up. Fill a bowl with water and set it on a stack of books. Put an empty cup on the table below it. Fill a drinking straw or a piece of clean tubing with water, hold your fingers over both ends, put one end into the bowl and the other into the cup, and let go. Watch the water flow uphill over the rim of the bowl and down into the cup with no pump at all. How could a canal use a lake set high in the hills to fill its locks?

Watch. *15th August 1914: The Panama Canal officially opened with the transit of SS Ancon* (HistoryPod, 2:46). <https://www.youtube.com/watch?v=l0obGVIYc0w>

After the story: watch this short history of the canal, from de Lesseps's failed French attempt to the American project and the SS Ancon's crossing on August 15, 1914.

Note: Captions were not available to check; preview it first. It mentions that the United States backed Panama's break from Colombia, and it may mention deaths among the workers.

Backup video. *The Surprising Efficiency of Canal Locks* (Practical Engineering, 10:37). <https://www.youtube.com/watch?v=SBvclVcesEE>

Before the project: watch how a lock raises and lowers a ship using only gravity and valves, then look for the water-saving basins on the new Panama Canal locks. Note: Captions were not available to check, but this comes from a trusted engineering channel; preview it first. It covers canal locks in general, and Panama is only one part of it.

KEY TERMS

lock

A chamber with gates at each end in which the water level is raised or lowered to lift or lower a ship from one level of a waterway to another.

flight of locks

Two or more lock chambers built one after another like a staircase. The Gatún Locks are a flight of three steps.

Continental Divide

The line of high ground that separates rivers flowing to the Atlantic from rivers flowing to the Pacific. In Panama it is low, but still had to be cut through.

Gatún Lake

The large artificial lake formed when the Gatún Dam blocked the Chagres River. Its surface is about 26 m (85 ft) above sea level, and ships cross it in the middle of the canal.

culvert

A large tunnel in the lock walls that lets water flow in or out of the chambers by gravity, without pumps.

transit

One complete trip of a ship through the canal from one ocean to the other.

CORE IDEAS

The story. On August 15, 1914, a cargo and passenger steamer named the *Ancon* left Cristóbal on the Atlantic side of Panama and entered the great concrete chambers of the Gatún Locks. Water poured in through tunnels in the walls, and the ship rose like an elevator, three steps up, until it floated on Gatún Lake, 26 m (85 ft) above the sea. It steamed across the lake, through the deep Culebra Cut in the hills, and down through the Pedro Miguel and Miraflores Locks to the Pacific. The trip took about nine and a half hours. The opening was quiet, because the First World War had begun in Europe only days before, but the event changed the map of the world. For centuries ships had sailed around the stormy tip of South America to get from one ocean to the other. Now they could cross the Americas in a single day.

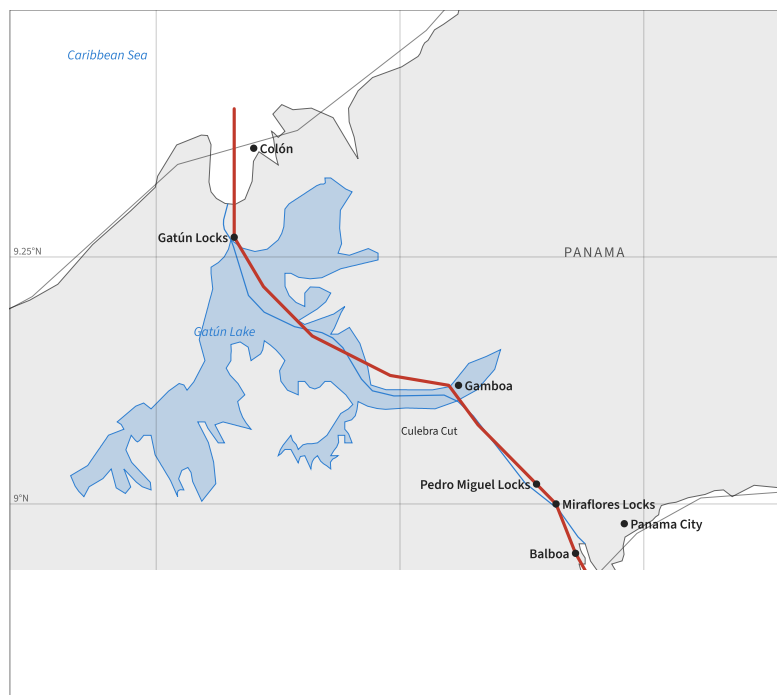
On the map. The canal is about 82 km (51 mi) long, from Limón Bay near Colón on the Caribbean to the Bay of Panama at Balboa on the Pacific. Surprisingly, it does not run east to west. The isthmus bends like an S, so the canal runs from northwest to southeast, and its Pacific end is *east* of its Atlantic end. The land between is low but rugged hills and jungle, crossed by the **Chagres River**, which floods violently in the rainy season. The climate is tropical, with heavy rains from about May to December and a drier season in the first months of the year. Those rains are the canal's lifeblood.

How it worked. The first attempt was French. Ferdinand de Lesseps, the hero of the Suez Canal, began digging in 1881 and planned a canal at sea level, as at Suez. But Panama was not a flat desert. Landslides poured back into the cuts, the Chagres flooded the works, and yellow fever and malaria killed thousands of workers; one common estimate is about 22,000 deaths. The French company collapsed in 1889. In 1903 Panama declared its independence from Colombia with the support of the United States, and soon signed a treaty letting the Americans build and control a canal zone. The American engineers chose a different plan. Chief engineer John Stevens, and after 1907 Colonel George Washington Goethals, built a **lock canal**. They dammed the Chagres at Gatún with what was then the largest earth dam in the world, making Gatún Lake. Instead of digging down to sea level, they lifted ships up to the lake. Each lock chamber is about 305 m (1,000 ft) long and 33.5 m (110 ft) wide. To fill a chamber, valves open and lake water rushes down through huge **culverts** in the walls; to empty it, water flows out toward the sea. No pumps are needed. Gravity and the rain that

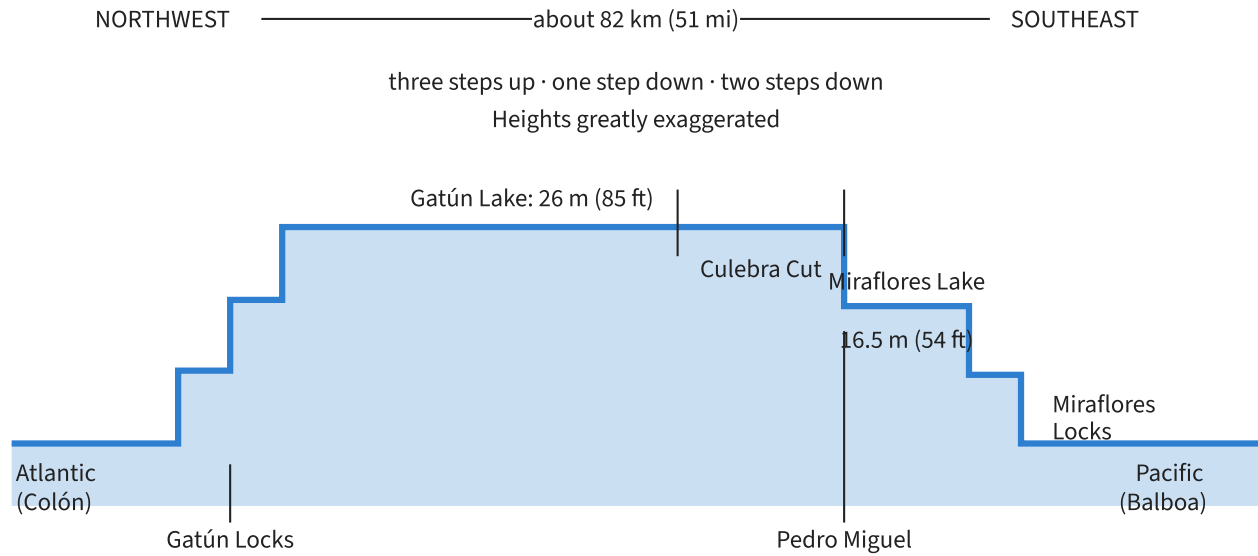
fills the lake do all the lifting, but each transit lets about 197 million liters (52 million gallons) of fresh water flow to the sea.

Doctors, diggers and the human cost. The canal could not be built until disease was beaten. The Cuban doctor Carlos Finlay had argued that mosquitoes spread yellow fever, and Walter Reed's army team proved it in Cuba in 1900. In Panama, Dr. William Gorgas drained swamps, screened windows, spread oil on standing water and fumigated houses; by 1906 yellow fever had disappeared from the canal zone. Malaria was reduced but not ended. At the Culebra Cut, steam shovels and trains carried away mountains of rock as landslides kept sliding back in. The largest group of workers came from Barbados and other West Indian islands, alongside Panamanians, Spaniards, Americans and many others. Workers were divided into a "gold roll," mostly white Americans, and a "silver roll," mostly Black West Indians, who were paid less and housed worse. About 5,600 workers died during the American years (1904–1914), most of them West Indians. The canal is a triumph of engineering, and it was paid for in hard labor and many lives.

Technology overcoming geography. The canal shortened the sea voyage from New York to San Francisco from about 21,000 km (13,000 mi) around Cape Horn to about 8,400 km (5,200 mi). The United States ran the canal until December 31, 1999, when, under the Torrijos–Carter Treaties of 1977, it passed to Panama. In 2016 Panama opened a third set of larger locks for "Neopanamax" ships, with chambers about 427 m (1,400 ft) long and 55 m (180 ft) wide, and side basins that save and reuse about 60 percent of the water used in each lockage. Geography still has a say. In 2023 a very dry year lowered Gatún Lake, and the canal authority had to limit the number of ships for months. As of 2026, the canal is owned and run by the Republic of Panama through the Panama Canal Authority and remains one of the world's most important shipping routes.



The Panama Canal runs northwest to southeast. Its Pacific end lies east of its Atlantic end.



An elevation profile of the canal. Heights are greatly exaggerated.

PICTURE STUDY



The SS Ancon Entering Pedro Miguel Locks on Opening Day, Photographer of the Panama Railroad Company, August 15, 1914 · Black-and-white photograph · U.S. National Archives, Record Group 185 (photo 185-G-0889)

The canal's builders kept official photographers on the job from the beginning, and their thousands of pictures show the Culebra Cut, the steam shovels, the giant lock walls and the workers who made them. On August 15, 1914, they followed the *Ancon*, a steamer owned by the Panama Railroad, as it made the first official transit from ocean to ocean. In this picture the ship has just come out of the Culebra Cut and is entering the Pedro Miguel Locks.

A photograph like this is a primary source. It was taken on the day itself by people who were there, so it can show us details that later paintings or diagrams might leave out.

Look closely

- Find the ship and the people on board. Why do you think so many passengers crowded onto the decks?
- Look at the canal around the ship. Is it in a lock chamber, a cut through the hills or open water? What clues tell you?
- Look for the walls, gates or banks. Compare their size with the ship.
- Look at the people on shore. What does the scene tell you about how important this day was to Panama?

Talk about it

1. What can a photograph show us that a written report cannot? What can it not show?
2. The canal opened during the first weeks of a great war in Europe. Why might the world have paid less attention to this day than the builders hoped?
3. Whose work made this moment possible? Name at least three groups of people.

PROJECT: A GRAVITY CANAL: FILLING LOCKS FROM A LAKE WITH NO PUMPS

In Unit 6 you built a pound lock. Now you will build what made the Panama Canal special: a high lake that feeds a staircase of locks by gravity alone. You will use a siphon to show how water from a lake set high in the hills can fill each lock chamber without pumps, and you will measure how much water a single trip costs.

You will need

- A large plastic tub or bucket (Gatún Lake), set on a sturdy box or stack of books
- Three clear plastic containers of the same size, such as cut-down 2-liter bottles or deli tubs (the lock chambers), set on three different heights of books like stairs
- About 1.5 m (5 ft) of clear aquarium tubing, cut into three pieces
- A measuring cup, a ruler, a marker and masking tape
- Water with a few drops of food coloring, and a towel or a tray for spills

Steps

1. Set up the tub highest, then the three containers below it like stairs going down toward the 'sea' (a tray or sink). Label them Lake, Upper chamber, Middle chamber, Lower chamber.
2. Fill the tub with colored water and mark its level with tape. Measure how high the water surface is above the table.
3. Fill one piece of tubing with water, pinch both ends, and place one end in the lake and the other in the upper chamber. Let go and watch the chamber fill. Stop the flow (pinch the tube) when the chamber's level is close to the lake's.

4. Use a second tube to let water flow from the upper chamber down into the middle chamber, and a third from the middle into the lower one. This is how the real culverts move water down the flight.
5. Float a small boat (a bottle cap) in the lower chamber and tell its story as it is lifted, chamber by chamber, toward the lake.
6. Measure how far the lake's level dropped after one 'ship' passed. Measure the water lost to the sea with the measuring cup. Record your numbers.
7. Write two sentences: Why can the Panama Canal fill its locks without pumps? Why does a dry year cause trouble for the canal?

Tips

- A siphon only works while the outflow end is lower than the water surface in the source. That is exactly why Gatún Lake must stay high.
- If your siphon stops, refill the tube completely; any air bubble can break the flow.

Check your work

- My lake filled the chambers by gravity alone.
- I measured and recorded how much water one trip used.
- I can explain why the canal depends on rain filling Gatún Lake.

MAP NOTEBOOK

1. Draw a map of the canal from Colón to Balboa. Mark the Gatún Locks, Gatún Lake, the Chagres River, the Culebra Cut, the Pedro Miguel Locks, Miraflores Lake and the Miraflores Locks, and add a compass rose to show the northwest-to-southeast direction.
2. Draw the canal's elevation profile from ocean to ocean and label the height of each level in meters and feet.
3. Draw a sea route from New York to San Francisco around Cape Horn and another through Panama, and write the distance of each beside it.

From history. Sixty years before the canal, the isthmus already had a transcontinental line: the Panama Railroad, about 77 km (48 mi) long from Colón to Panama City, completed in January 1855. It was built for travelers heading to the California gold fields, who could now cross from ocean to ocean in a few hours instead of days by mule and canoe. Building it through swamp and jungle cost the lives of many workers from the same diseases that later defeated the French. When the Americans began the canal, the railroad became the backbone of the work, hauling away the rock from the Culebra Cut, and it had to be moved to new ground when Gatún Lake flooded its old route.

WORKED EXAMPLES

Example 1. The Gatún Locks lift ships from sea level to Gatún Lake, about 26 m (85 ft) above the sea, in three equal steps. How high is each step? Then the Pedro Miguel Locks lower ships from Gatún Lake to Miraflores Lake, about 16.5 m (54 ft), in one step. How far is that drop?

(Use the map or drawing “Count the steps on each side of Gatún Lake.” shown earlier in this lesson.)

1. Gatún step: $26 \text{ m} \div 3 \approx 8.7 \text{ m}$; $85 \text{ ft} \div 3 \approx 28 \text{ ft}$.
2. Pedro Miguel drop: $26 \text{ m} - 16.5 \text{ m} = 9.5 \text{ m}$; $85 \text{ ft} - 54 \text{ ft} = 31 \text{ ft}$.
3. The Miraflores Locks then lower ships the last 16.5 m (54 ft) to the Pacific in two steps, about 8.25 m (27 ft) each at average tide.

Answer: Each Gatún step is about 8.7 m (28 ft). The Pedro Miguel drop is about 9.5 m (31 ft).

Example 2. A lock chamber of the original canal is about 305 m long and 33.5 m wide. How much water does it take to raise the water in one chamber by one step of 8.7 m? Give your answer in cubic meters, liters and U.S. gallons. ($1 \text{ m}^3 = 1,000 \text{ L}$; $1 \text{ m}^3 \approx 264 \text{ gal}$)

1. Volume = length $\times$ width $\times$ height = $305 \text{ m} \times 33.5 \text{ m} \times 8.7 \text{ m}$.
2. $305 \times 33.5 = 10,217.5 \text{ m}^2$ of water surface.
3. $10,217.5 \times 8.7 \approx 88,900 \text{ m}^3$.
4. Liters: $88,900 \times 1,000 \approx 88.9$ million L. Gallons: $88,900 \times 264 \approx 23.5$ million gal.

Answer: About $88,900 \text{ m}^3$, or about 89 million liters (about 23.5 million gallons), for one step in one chamber. That is why a full transit, which sends water down both sides of the canal, uses about 197 million liters (52 million gallons) of lake water.

Example 3. Going through Panama shortened the sea trip from New York to San Francisco from about 21,000 km (13,000 mi) to about 8,400 km (5,200 mi). How much distance is saved? If a ship steams at an average of 30 km/h (about 19 mph), how many days does it save?

1. Distance saved: $21,000 - 8,400 = 12,600 \text{ km}$; $13,000 - 5,200 = 7,800 \text{ mi}$.
2. Time saved: $12,600 \text{ km} \div 30 \text{ km/h} = 420 \text{ hours}$.
3. Days: $420 \div 24 = 17.5 \text{ days}$.

Answer: About 12,600 km (7,800 mi) and about $17\frac{1}{2}$ days of steaming, not counting the coal, wages and storms avoided around Cape Horn.

PRACTICE

1. **EASY** Name the three sets of locks on the original Panama Canal, in order from the Atlantic to the Pacific, and tell how many steps each has.
2. **EASY** What river was dammed to make Gatún Lake, and why was the lake so important to the canal?
3. **EASY** Who was William Gorgas, and why was his work necessary before the canal could be finished?
4. **MEDIUM** Use the map. Colón is at about 9.36°N , 79.90°W , and Balboa is at about 8.95°N , 79.57°W . Which end of the canal is farther east? In which compass direction does a ship travel from the Atlantic to the Pacific?
(Use the map or drawing "Compare the longitudes of the two ends." shown earlier in this lesson.)
5. **MEDIUM** The canal is about 82 km long. A ship takes about 9 hours to pass through. What is its average speed in km/h and in mph? ($1 \text{ mi} \approx 1.609 \text{ km}$)
6. **MEDIUM** The expanded locks opened in 2016 have chambers about 427 m long and 55 m wide. The original chambers are about 305 m by 33.5 m. About how many times larger is the floor area of a new chamber?
7. **MEDIUM** If the water-saving basins of the new locks reuse about 60 percent of the water, and a lockage would otherwise use 100 million liters, how many liters flow out to the sea? Give the answer in gallons too ($1 \text{ gallon} \approx 3.785 \text{ L}$).
8. **HARD** Explain why the French plan for a sea-level canal failed in Panama even though a sea-level canal had worked at Suez.
9. **HARD** Look at the elevation profile. A ship goes from the Pacific to the Atlantic. List each level it passes through, with heights, and say whether each lock lifts or lowers it.
(Use the map or drawing "Read the profile from right to left." shown earlier in this lesson.)
10. **CHALLENGE** In 2023 a dry year lowered Gatún Lake, and the canal had to limit how many ships could pass. Using what you know about how the locks work, explain why rainfall matters so much to the canal, and suggest two ways engineers have tried to make the canal use less water.

COMMON MISTAKES

- Thinking the canal runs east to west. It runs from northwest to southeast, and the Pacific end is east of the Atlantic end.
- Thinking the locks use pumps. The water flows by gravity from Gatún Lake through culverts in the lock walls.
- Thinking ships go through at sea level as at Suez. Ships are lifted about 26 m (85 ft) to Gatún Lake and lowered again on the other side.

Make it a game • Lock Master. Draw the canal's profile on a long strip of paper with ten boxes: Atlantic, Gatún step 1, step 2, step 3, Gatún Lake, Pedro Miguel, Miraflores Lake, Miraflores step 1, step 2, Pacific. Each player has a bottle-cap ship. Take turns drawing cards that say things like "Open the valves: rise one step," "Landslide in the Culebra Cut: lose a turn," "Dry season: the lake is low, wait one turn" and "Tandem

lockage: move two spaces.” To move into a lock you must say whether the ship is rising or falling and how many meters. The first ship to reach the other ocean wins.

Scripture. “They that go down to the sea in ships, that do business in great waters; These see the works of the LORD, and his wonders in the deep.” (Psalm 107:23-24, KJV)

The sailors who cross from ocean to ocean in a single day pass through one of the great works of human hands, but they also pass through hills, rain and rivers that only God could make. Every lock at Panama is filled by rain He sends.

Practice answers

1. Gatún Locks (three steps up), Pedro Miguel Locks (one step down) and Miraflores Locks (two steps down).
2. The Chagres River. The lake carries ships across much of the isthmus, and its water flows by gravity to fill every lock, so no pumps are needed.
3. He was the American army doctor in charge of sanitation in Panama. Using the discovery that mosquitoes spread yellow fever and malaria, he drained and oiled standing water, screened buildings and fumigated houses, ending yellow fever in the canal zone by 1906 and greatly reducing malaria. Without this, disease would have killed too many workers, as it had during the French attempt.
4. Balboa, the Pacific end, is farther east (79.57°W is less far west than 79.90°W). A ship going from the Atlantic to the Pacific travels toward the southeast.
5. $82 \div 9 \approx 9.1$ km/h. $82 \text{ km} \approx 51$ mi, and $51 \div 9 \approx 5.7$ mph. Ships move slowly because of the time spent in the locks.
6. New: $427 \times 55 \approx 23,500 \text{ m}^2$. Old: $305 \times 33.5 \approx 10,200 \text{ m}^2$. $23,500 \div 10,200 \approx 2.3$ times larger.
7. 40 percent is lost: $0.40 \times 100 \text{ million} = 40 \text{ million liters}$. $40,000,000 \div 3.785 \approx 10.6$ million gallons.
8. Suez crosses flat, dry desert, so a channel could be dug at sea level with no locks. Panama has rugged hills along the Continental Divide, unstable soil that kept sliding back into the cuts, and the flood-prone Chagres River crossing the route. The French also had no defense against yellow fever and malaria, which killed thousands of workers. A sea-level canal there would have required far more digging than the money, machines and medicine of the 1880s could manage.
9. Pacific Ocean (sea level), raised two steps by the Miraflores Locks to Miraflores Lake (about 16.5 m, 54 ft), raised one step by the Pedro Miguel Locks to Gatún Lake and the Culebra Cut (about 26 m, 85 ft), then lowered three steps by the Gatún Locks to the Atlantic (sea level).
10. Every lockage sends lake water downhill to the sea, and only rain refills Gatún Lake. In a dry year the lake drops; then each transit drains it further, and a low lake also means less depth for ships' keels in the channel, so fewer and lighter ships can pass. Ways to save water include the water-saving basins of the 2016 locks, which reuse about 60 percent of the water; sending two smaller ships through a chamber together (tandem lockages); and plans to add new reservoirs to store more rainy-season water.

8.4 SOUTH AMERICA

OBJECTIVES

- Locate the Andes, the Altiplano and Lake Titicaca, the Atacama Desert, the Amazon Basin, the Guiana and Brazilian Highlands, the Pampas, the Río de la Plata and Patagonia.
- Explain how altitude, the Humboldt Current and rain shadows shape South America's climates, using Humboldt's mountain zones as a model.
- Tell how the land shaped the Inca world, the Spanish and Portuguese empires, the spread of Christianity, and the farming, mining and railways of the continent.

Warm-up. Hold a wet sponge (a cloud) over the left side of a tray and tilt a book on the tray like a mountain. Push the sponge up the book's slope, squeezing it as it rises. Where did the water fall: on the near side of the 'mountain' or the far side? Now look at a map of South America and guess which side of the Andes is the dry side in Chile and Peru, and which in Argentina.

Watch. *Exploring the Hidden Rail Networks of South America / Part 2* (Railways Explained, 14:55). <https://www.youtube.com/watch?v=E7yd9ZUH3iU>

With the big idea: watch the sections on Peru, Chile, Bolivia and Ecuador and notice how the Andes force railways into steep climbs, switchbacks and separate, disconnected lines.

Note: Captions were not available to check; preview it first. It opens with a short plug for the channel's e-book, it may briefly mention government decisions about the railways, and only parts of the 15 minutes are about the Andes.

KEY TERMS

Andes

The longest mountain range on any continent, about 7,000 km (4,300 mi) long, running down the western side of South America from Venezuela to Tierra del Fuego.

Altiplano

A high, cold plateau in the Andes of Peru and Bolivia, mostly about 3,600 to 4,000 m (12,000 to 13,000 ft) above the sea, holding Lake Titicaca.

Amazon Basin

All the land drained by the Amazon River and its tributaries, about 7 million km² (2.7 million sq mi), most of it covered by tropical rain forest.

Pampas

The wide, flat, fertile grasslands of Argentina and Uruguay, famous for cattle, wheat and the gauchos who herded on horseback.

rain shadow

A dry area on the side of a mountain range away from the wet winds. The air drops its rain as it rises over the mountains and comes down dry on the other side.

Humboldt Current

A cold ocean current that flows north along the coasts of Chile and Peru. It cools the air above it so that little rain falls, helping make the Atacama one of the driest deserts on earth, and it feeds rich fisheries.

CORE IDEAS

The story. On June 23, 1802, the Prussian scientist Alexander von Humboldt, the French botanist Aimé Bonpland and a young Ecuadorian, Carlos Montúfar, struggled up the icy slopes of Chimborazo, a huge snow-covered volcano in the Andes of Ecuador. In those days Chimborazo was thought to be the highest mountain in the world. They had no ropes or climbing gear; their porters turned back, their gums bled and they grew dizzy in the thin air. At about 5,875 m (19,280 ft), by Humboldt's own measurement, a deep gap in the ridge stopped them, a few hundred meters short of the summit. No climb in Europe's records had ever gone so high, though we now know that Inca priests had long before climbed even higher Andean peaks for their ceremonies. Humboldt was less proud of the height than of what he had seen on the way up: as they climbed, the plants changed from tropical forest, to oak and grass, to mosses and lichens, to bare snow, in bands as clear as the climate zones from the equator to the poles. In 1807 he published a famous picture of a mountain covered with the names of plants at the heights where they grow.

On the map. South America lies mostly east of North America. Lima and Quito are actually a little west of New York, but most of the continent lies far to the east of it. Down its western side runs the wall of the **Andes**, about 7,000 km (4,300 mi) long. Their highest peak, Aconcagua in Argentina, is 6,961 m (22,838 ft), the highest point outside Asia. In Peru and Bolivia the Andes spread into the high **Altiplano**, where Lake Titicaca lies at about 3,810 m (12,500 ft). East of the mountains lie the low, wet **Amazon Basin**, the old, worn **Guiana Highlands** in the north and the **Brazilian Highlands** in the east. The Amazon, about 6,400 km (4,000 mi) long, rises in the Andes of Peru, only about 160 km (100 mi) from the Pacific, and flows all the way east to the Atlantic. It carries more water than any other river, about one-fifth of all the river water that reaches the oceans. To the south, the Paraná and Uruguay Rivers meet in the wide estuary of the **Río de la Plata**, around which spread the flat **Pampas**, and beyond them the dry, windy plateaus of Patagonia.

How the land works. The equator crosses the Amazon, so the basin is hot and rainy all year, and the rain forest there is the largest on earth. In the Andes, as Humboldt saw, climate depends on height: Quito, almost on the equator but 2,850 m (9,350 ft) up, has cool, spring-like weather all year. On the Pacific coast of Peru and northern Chile, the cold **Humboldt Current** chills the air so that clouds rarely make rain, and the Andes block moist air from the east; the result is the **Atacama Desert**, where some weather stations have recorded almost no rain for years. Farther south the winds blow from the west. They drench southern Chile with rain and leave Patagonia, on the Argentine side, in a **rain shadow**. The Pampas between have deep soils and moderate rains, some of the best farmland in the world.

How geography shaped history. The Inca built an empire along the spine of the Andes, ruling from Cusco. Their road system ran for tens of thousands of kilometers with rope

bridges over gorges; they farmed on stone terraces and kept llamas for carrying loads. In 1532 Francisco Pizarro, with fewer than two hundred men, seized the Inca ruler Atahualpa at Cajamarca, at a time when the empire was weakened by civil war and by smallpox, which had spread ahead of the Spanish. Spain then drew enormous wealth from the silver mountain of Potosí, high in the Andes of today's Bolivia, worked largely by forced Native labor under brutal conditions. The Treaty of Tordesillas (1494) had divided new lands between Spain and Portugal, so Portuguese Brazil grew along the eastern coast, where sugar plantations were worked by enslaved Africans brought across the Atlantic in huge numbers. In the 1810s and 1820s Simón Bolívar and José de San Martín led armies over the Andes to win independence for Spanish South America, and Brazil became independent in 1822.

Faith. Catholic missionaries came with the conquerors and also, at times, stood against them. Jesuits such as José de Anchieta, who helped found São Paulo in 1554, learned Native languages and wrote the first grammar of Tupi. From 1609 Jesuits gathered Guaraní people into mission towns in Paraguay and nearby lands that protected them from slave raiders, until the order was expelled in 1767. Protestant missions came later. The English naval officer Allen Gardiner died of starvation in Tierra del Fuego in 1851 while trying to reach its peoples, and in January 1956 Jim Elliot and four other American missionaries were killed by Waorani men in the rain forest of Ecuador; later, Elisabeth Elliot and Rachel Saint lived among the Waorani, and many came to faith. Today most South Americans are Catholic, Brazil has more Catholics than any other country, and evangelical churches have grown rapidly since the late 1900s.

Technology overcoming geography. The Andes were the great barrier. The Central Railway of Peru, begun in 1870 under the American builder Henry Meiggs, climbs from Callao and Lima with switchbacks and many tunnels to nearly 4,800 m (about 15,700 ft), one of the highest railways ever built. In 1910 the Transandine Railway joined Argentina and Chile beneath the crest of the Andes, completing a rail link from Buenos Aires to Valparaíso. On the Pampas, railways built mostly with British money fanned out from Buenos Aires, carrying wheat and chilled beef to the port for ships bound for Europe.

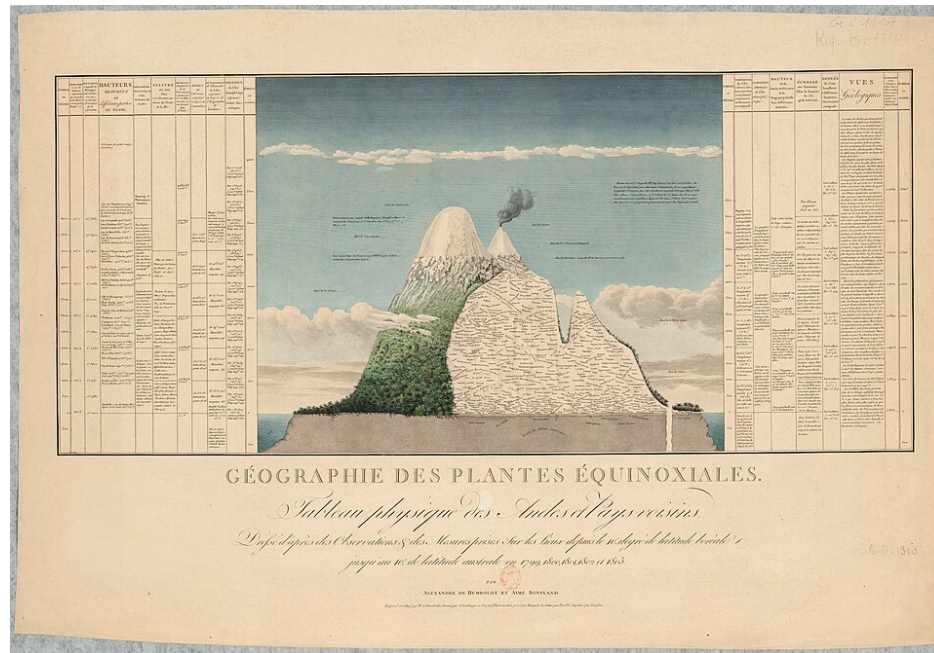


South America: the Andes in the west, the Amazon in the north, the Pampas in the south.



Technology overcoming geography in the Americas: great railways and canals.

PICTURE STUDY



*Geography of the Equinoctial Plants: Physical Picture of the Andes and Neighboring Countries (the Naturgemälde, or "Picture of Nature"), Alexander von Humboldt and Aimé Bonpland; drawn by Pierre Turpin and others from Humboldt's sketches, plate dated 1805; published 1807 · Hand-colored engraving · Published with Humboldt and Bonpland's *Essai sur la géographie des plantes* (Paris, 1807); this copy is in the Bibliothèque nationale de France, Paris*

After returning to Europe, Humboldt turned his notes from the Andes into one great picture. It shows Chimborazo cut in half like a cake, with Cotopaxi smoking in the distance. On the mountain he wrote the names of the plants at the heights where he had found them, and in the columns on each side he listed what changes with height: temperature, air pressure, the boiling point of water, the color of the sky, the kinds of animals and the crops people grow.

Humboldt wanted people to see nature as one connected whole, where rock, air, water, plants and people all depend on one another. His picture became one of the first great infographics, and its idea of altitude zones is the same one you used for the tierra caliente and tierra fría of Mexico.

Look closely

- Find the snow line. About how far up the mountain does it begin?
- Look at the plants drawn at the foot of the mountain and those near the top. How do they differ?
- Look at the columns of numbers on the sides. What kind of information do you think Humboldt measured?
- Find the second volcano in the background. Why might Humboldt have added it?

Talk about it

1. Why did Humboldt think the climb up one tropical mountain was like a journey from the equator to the pole?
2. What is the advantage of putting so much information in one picture? What is the disadvantage?
3. How could a farmer in the Andes use the ideas in this picture to decide what to plant?

PROJECT: MY NATURGEMÄLDE: A CROSS-SECTION OF SOUTH AMERICA

Like Humboldt, you will make one large picture that shows how land, height, rain and life fit together. Your cross-section will cut across South America from the Pacific Ocean, over the Andes, and down into the Amazon lowlands, and it will show altitude zones, crops, animals and cities at their true heights.

You will need

- A large sheet of poster board or several sheets of paper taped together, about 60 × 45 cm (24 × 18 in)
- Ruler, pencil, colored pencils or paints
- Graph paper for planning
- An atlas, or the map in this lesson
- Optional: magazine pictures or your own drawings of llamas, condors, coffee plants, palms and potatoes

Steps

1. Choose a line across the continent at about 13°S: from the Pacific coast near Lima, over the Andes near Cusco, down into the Amazon lowlands of Peru and Brazil.
2. Draw a vertical scale on the left side of your poster: 1 cm for every 500 m, from 0 to 6,500 m. Write the same heights in feet beside it (1,000 m ≈ 3,280 ft).
3. Sketch the profile of the land: a narrow, dry coastal strip; a steep climb into the Andes with peaks over 5,000 m; the high valleys around Cusco (about 3,400 m); then a long slope down the eastern side to the Amazon lowlands, under 500 m.
4. Color the zones. Use Humboldt's idea: tropical forest on the low eastern side, cloud forest on the eastern slopes, cool valleys with potatoes and corn, high grassland (the puna) with llamas, and snow on the peaks. Leave the Pacific coast sandy brown for the desert.
5. Draw arrows to show the moist air from the Atlantic and the Amazon rising up the eastern slopes and dropping rain, and a note on the coast about the cold Humboldt Current.
6. Label at least six things at their correct heights: Lima, Cusco, Lake Titicaca (shown off to the side), a snow line, a llama, a coffee plant, potatoes and a rain-forest tree.
7. Write a title, your name and the date, and a short paragraph explaining what your Naturgemälde shows. Add it to your atlas.

Tips

- Your horizontal distances can be squeezed; what matters most is that the heights are correct.
- The snow line in the tropical Andes is high, roughly 5,000 m (16,000 ft); farther south it is much lower.

Check your work

- My cross-section has a correct height scale in meters and feet.
- I showed the desert coast, the Andes, the eastern slopes and the Amazon lowlands in the right order.
- At least six labels are placed at the right heights.

MAP NOTEBOOK

1. Trace an outline of South America. Draw and label the Andes, the Amazon and three of its tributaries, Lake Titicaca, the Atacama Desert, the Pampas, the Río de la Plata, Patagonia and the equator.
2. Copy the map of the Americas with railways and canals into your atlas. Draw each railway or canal in a different color and write the year it was finished.
3. Draw a simple diagram of the rain shadow in southern South America: wet westerly winds from the Pacific, rain on the Chilean side, dry Patagonia on the Argentine side.

From history. In 1541 and 1542 the Spanish captain Francisco de Orellana, part of an expedition led by Gonzalo Pizarro, went down a river in eastern Ecuador to look for food and could not get back against the current. Instead he and his men floated and sailed the whole length of the great river to the Atlantic, the first Europeans known to travel it. The expedition's chaplain, the Dominican friar Gaspar de Carvajal, wrote an account of the voyage. He described fierce battles with warrior women, and from the old Greek legend of women warriors, the Amazons, the river got its name.

WORKED EXAMPLES

Example 1. The Andes run from about 10°N in Venezuela to about 55°S at Tierra del Fuego. Roughly how long are they in a straight north-south line? (One degree of latitude $\approx 111 \text{ km} \approx 69 \text{ mi.}$)

1. Count the degrees from 10°N to the equator (10°) and from the equator to 55°S (55°): $10 + 55 = 65^{\circ}$.
2. Kilometers: $65 \times 111 \text{ km} \approx 7,200 \text{ km}$.
3. Miles: $65 \times 69 \text{ mi} \approx 4,500 \text{ mi}$.
4. The Andes curve a little and do not run exactly north-south, so the figure usually given, about 7,000 km (4,300 mi), is close to this estimate.

Answer: About 7,200 km (4,500 mi) in a straight north-south line, consistent with the usual figure of about 7,000 km (4,300 mi).

Example 2. Humboldt reached about 5,875 m on Chimborazo, whose summit is about 6,263 m (20,548 ft). How far short of the top did he stop, in meters and feet? ($1 \text{ m} \approx 3.28 \text{ ft}$)

1. Subtract: $6,263 \text{ m} - 5,875 \text{ m} = 388 \text{ m}$.
2. Convert: $388 \times 3.28 \approx 1,273 \text{ ft}$.

Answer: About 388 m (about 1,270 ft) short of the summit. Even so, it was the highest climb then on record.

Example 3. New York is at about 74.0°W , Lima at about 77.0°W and Rio de Janeiro at about 43.2°W . Which of the two South American cities lies west of New York? How many hours of the sun's travel separate New York and Rio? (The sun crosses 15° of longitude each hour.)

(Use the map or drawing "Use the grid to compare the longitudes of North and South American cities." shown earlier in this lesson.)

1. A larger west longitude means farther west. Lima (77.0°W) is larger than New York (74.0°W), so Lima is west of New York.
2. Rio (43.2°W) is east of New York: $74.0^{\circ} - 43.2^{\circ} = 30.8^{\circ}$.
3. Hours: $30.8^{\circ} \div 15^{\circ} \text{ per hour} \approx 2.05 \text{ hours}$.

Answer: Lima lies about 3° west of New York. Rio de Janeiro lies about 31° east, about 2 hours ahead in sun time. South America is not just south of North America but mostly southeast of it.

PRACTICE

1. **EASY** Name the highest mountain in South America, give its height in meters and feet, and the country it stands in.
2. **EASY** Where does the Amazon River begin, and into which ocean does it flow?
3. **EASY** What are the Pampas, and what have they been famous for?
4. **MEDIUM** Lake Titicaca lies at about 3,810 m. Convert this to feet ($1 \text{ m} \approx 3.281 \text{ ft}$). Is it higher than the summit of any mountain in the Appalachians (the highest, Mount Mitchell, is 6,684 ft)?
5. **MEDIUM** The Amazon is about 6,400 km long. Convert to miles ($1 \text{ mi} \approx 1.609 \text{ km}$). If a raft drifted the whole river at an average of 4 km/h (about 2.5 mph), day and night, how many days would the trip take?
6. **MEDIUM** Quito is at 2,850 m, almost on the equator. Using about 6.5°C cooler per 1,000 m, how much cooler than a sea-level town at the equator would you expect it to be? Why does this make Quito's climate pleasant?
7. **MEDIUM** Use the map of South America. (a) Which city shown lies closest to the equator? (b) Which two cities shown lie on opposite sides of the Andes at about the same latitude in the south of the map?
(Use the map or drawing "Use the equator and the grid lines." shown earlier in this lesson.)
8. **HARD** Explain why the Atacama Desert on the coast of northern Chile is so dry, even though it lies next to an ocean.
9. **HARD** Use the map of the Americas with railways and canals. Name the railway or canal that solved each problem: (a) crossing the Rockies to reach British Columbia; (b) avoiding the long voyage around Cape Horn; (c) crossing the Andes between Argentina and Chile; (d) crossing the narrow neck of southern Mexico before 1914.
(Use the map or drawing "Match each route to the barrier it overcame." shown earlier in this lesson.)
10. **CHALLENGE** Write a paragraph comparing the Andes and the Amazon as obstacles to travel. Which was harder for people to cross, and how did people in different centuries overcome each?

COMMON MISTAKES

- Thinking South America lies directly south of North America. Most of it lies to the southeast; Lima is west of New York, but Rio de Janeiro is about 31° of longitude east of it.
- Thinking the Amazon flows into the Pacific because it starts near it. It rises in the Andes, only about 160 km (100 mi) from the Pacific, but flows east all the way to the Atlantic.
- Assuming that every place near the equator is hot and wet. Quito and the Andes are cool because of their height, and the Atacama and the coast of Peru are deserts because of the cold current.

Make it a game • Humboldt's Mountain. Draw a tall mountain on a large sheet of paper with height lines every 1,000 m from 0 to 6,000 m. Make cards with things found in the Andes and the lands around them: palm tree, coffee plant, cloud forest, potatoes,

corn, llama, condor, Quito, Cusco, La Paz, Lake Titicaca, snow line, rain-forest jaguar. Players take turns drawing a card and placing it on the mountain at the right height. A parent checks with the lesson: a card within about 500 m of the right height scores a point. The highest scorer is named the Humboldt of the day.

Scripture. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;” (Acts 17:26, KJV)

Paul spoke these words in Athens, far from the Americas, but they reach to the Quechua of the Andes, the Waorani of the rain forest, the gauchos of the Pampas and the people of every city in this unit. One God made them all and set the lands where they dwell, and the gospel has gone out to every one of these regions.

Practice answers

1. Aconcagua, 6,961 m (22,838 ft), in Argentina.
2. It rises in the Andes of Peru, not far from the Pacific, and flows east across the continent into the Atlantic Ocean.
3. The flat, fertile grasslands of Argentina and Uruguay around the Río de la Plata, famous for cattle ranching (and the gauchos), wheat and other grain.
4. $3,810 \times 3.281 \approx 12,500$ ft. Yes, the lake's surface is almost twice as high as Mount Mitchell.
5. $6,400 \div 1.609 \approx 3,980$ mi, about 4,000 mi. Time: $6,400 \div 4 = 1,600$ hours, and $1,600 \div 24 \approx 67$ days.
6. $2.85 \times 6.5 \approx 18.5$ °C cooler (about 33 °F cooler). Instead of steamy lowland heat, Quito has mild, spring-like weather all year.
7. (a) Quito, at about 0.2°S. (b) Santiago, Chile (west of the Andes) and Buenos Aires, Argentina (east of the Andes), both at about 33° to 35°S.
8. The cold Humboldt Current cools the air above it, so the air near the coast is cool and stable and rarely rises to form rain clouds. The region also lies in the belt of sinking dry air near the Tropic of Capricorn, and the high Andes block moist air coming from the Amazon and the Atlantic in the east. With moisture cut off on both sides, almost no rain falls.
9. (a) The Canadian Pacific Railway (1885). (b) The Panama Canal (1914). (c) The Transandine Railway, completing the Buenos Aires to Valparaíso rail link (1910). (d) The Tehuantepec Railway (1907).
10. A strong answer explains that the Andes are high, steep and cold, with thin air, while the Amazon is low, hot and covered by dense forest, swamps and rivers that flood. The Inca crossed the Andes with roads, stairs and rope bridges and llama trains; railways like the Central Railway of Peru and the Transandine used switchbacks and tunnels; today roads and airplanes cross them. The Amazon was entered mostly by river, from Orellana's voyage in 1542 to steamboats to Manaus in the rubber era, because its rivers are natural highways even where roads are hard to build. Students may argue either way, but should support their choice with facts about the land.

UNIT 8 REVIEW

Answer each question. Show your work for calculations and use complete sentences for explanations. Give distances and heights in both metric and U.S. units where asked. The review is worth 60 points.

1. (5 pts) Name Canada's great physical regions from east to west across the south of the country, and explain why most Canadians live within a few hundred kilometers of the United States border.
2. (6 pts) A railway climbs 120 m (about 394 ft) on a 4.5% grade. How long is the track? How long would it need to be at 2.2%? Give both answers in km and miles.
3. (5 pts) It is 3:00 p.m. standard time in Montreal (UTC−5). What time is it in Vancouver (UTC−8), in Regina (UTC−6) and in St. John's, Newfoundland (UTC−3:30)?
4. (6 pts) Tell the story of the last spike of the Canadian Pacific Railway (where, when, who) and explain why British Columbia insisted on the railway. Name one group of workers who paid a heavy price to build it.
5. (6 pts) Name the four altitude zones of Mexico and Central America with their approximate heights, and give one crop or feature of each. In which zone does Mexico City lie?
6. (6 pts) Explain how the geography of the Valley of Mexico both protected Tenochtitlan and helped the Aztecs feed it. Then name one reason, from people rather than land, that Cortés's small army was able to take the city in 1521.
7. (6 pts) Draw or describe the elevation profile of the Panama Canal from the Atlantic to the Pacific, naming each set of locks, the number of steps, and the heights of Gatún Lake and Miraflores Lake in meters and feet.
8. (6 pts) A lock chamber is 300 m long and 33 m wide. How many cubic meters of water does it take to raise the water 9 m? How many liters and U.S. gallons is that? ($1 \text{ m}^3 = 1,000 \text{ L} \approx 264 \text{ gal}$) Where does the water come from, and how does it get into the chamber?
9. (4 pts) Give two reasons the French attempt to build a canal (1881–1889) failed, and name the doctor whose work against mosquitoes made the American canal possible.
10. (5 pts) Explain why the Atacama Desert is so dry, and why Patagonia, on the other side of the Andes much farther south, is also dry.
11. (5 pts) Humboldt found that climbing Chimborazo was like traveling from the equator toward the pole. Explain what he meant, and use the rule of about 6.5°C per 1,000 m to estimate how much colder it was at his highest point, about 5,875 m, than at sea level.

UNIT PROJECT: MY REGIONAL ATLAS OF THE WORLD, FINISHED AND BOUND

Finish your regional atlas with pages for the Americas: Canada with the Canadian Pacific Railway, Mexico and Central America with their altitude zones, the Panama Canal with its elevation profile, and South America with your Naturgemälde. Then draw a full-page map of the Americas with their great railways and canals (the Canadian Pacific, the first U.S.

transcontinental railroad, the Erie Canal, the Tehuantepec Railway, the Panama Canal, the Central Railway of Peru and the Buenos Aires to Valparaíso line), each in its own color with its year in the key.

Gather every page you have made this year, from Europe in Unit 1 to the Americas in Unit 8. Add a title page, a table of contents, a world map that shows all eight regions, and a one-page introduction explaining what you learned about how geography shaped the peoples of the world and how technology helped people overcome it. Copy Acts 17:26 on the first page. Bind the atlas by punching holes and tying it with ribbon or string, or by stitching the folded pages, and give it a cover you design yourself.

- **Accuracy:** Landforms, rivers, cities, railways and canals are placed correctly on every map, with correct dates and heights in both metric and U.S. units.
- **Completeness:** The atlas includes a page for each of the eight regions, the Americas railways-and-canals map, a world map of the regions, a title page, a table of contents and the introduction.
- **Understanding:** The introduction and captions explain clearly how land, climate and water shaped history, faith, farming and trade in each region, and give at least three examples of technology overcoming geography.
- **Craftsmanship:** The pages are neat, colorful and easy to read, with keys and compass roses, and the atlas is firmly bound with a cover the student designed.

Answer key

1. The Atlantic provinces (Appalachian highlands), the St. Lawrence Lowlands, the Canadian Shield, the Prairies (Interior Plains) and the Western Cordillera (with the Arctic in the far north). Most people live in the south because the climate is milder there, the best farmland lies in the St. Lawrence Lowlands and the Prairies, and the north is covered by rocky Shield, forest and tundra with long, very cold winters.
2. At 4.5%: $120 \div 0.045 \approx 2,670 \text{ m} = 2.67 \text{ km}$ (about 1.66 mi). At 2.2%: $120 \div 0.022 \approx 5,450 \text{ m} = 5.45 \text{ km}$ (about 3.39 mi).
3. Vancouver: 12:00 noon. Regina: 2:00 p.m. St. John's: 4:30 p.m.
4. Donald Smith drove the last spike at Craigellachie in Eagle Pass, British Columbia, on November 7, 1885, with Van Horne and Sandford Fleming present. British Columbia had joined Canada in 1871 on the promise of a railway to the Pacific, because without it the province was cut off from the rest of Canada by the Rockies and a vast stretch of Shield and prairie. Thousands of Chinese workers built the line through British Columbia's canyons; they were paid less, did very dangerous work, and hundreds died.
5. Tierra caliente, below about 900 m (3,000 ft): bananas, sugarcane, cacao. Tierra templada, about 900 to 1,800 m (3,000 to 6,000 ft): coffee. Tierra fría, about 1,800 to 3,600 m (6,000 to 12,000 ft): corn, beans, wheat. Tierra helada, above about 3,600 m (12,000 ft): rock and snow. Mexico City (about 2,240 m) lies in the tierra fría.
6. The city stood on an island in Lake Texcoco, reached only by causeways that could be cut, so it was hard to attack; the lake gave fish, canoe transport and chinampas, raised gardens of rich mud where corn, beans and squash grew. Cortés succeeded largely because tens of thousands of Native allies such as the Tlaxcalans, who hated Aztec rule and its tribute and sacrifices, fought with him; smallpox also killed many in the city.

7. Atlantic (sea level); Gatún Locks, three steps up; Gatún Lake and the Culebra Cut, about 26 m (85 ft); Pedro Miguel Locks, one step down; Miraflores Lake, about 16.5 m (54 ft); Miraflores Locks, two steps down; Pacific (sea level).
8. $300 \times 33 \times 9 = 89,100 \text{ m}^3 = 89.1 \text{ million liters}$, about 23.5 million gallons. It comes from Gatún Lake, filled by the rain-fed Chagres River, and flows into the chamber by gravity through large culverts in the lock walls; no pumps are used.
9. The French planned a sea-level canal through rugged, landslide-prone hills and across the flooding Chagres River, which proved far too difficult; and yellow fever and malaria killed thousands of their workers (the company also ran out of money). Dr. William Gorgas led the sanitation work that ended yellow fever in the canal zone.
10. The Atacama lies beside the cold Humboldt Current, which cools the air so that it rarely rises to make rain; it lies in a belt of sinking dry air, and the Andes block moisture from the east. Patagonia lies in the rain shadow of the southern Andes: westerly winds from the Pacific drop their rain on the Chilean side as they rise over the mountains and come down dry on the Argentine side.
11. As he climbed, the plants and climate changed in bands, from tropical forest at the foot to temperate forest and grass, then mosses and lichens, then snow, just as they change with latitude from the equator to the poles. Cooling: $5.875 \times 6.5 \approx 38 \text{ }^\circ\text{C}$ (about $69 \text{ }^\circ\text{F}$) colder than at sea level.

BONUS: MAP LAB

You have toured the world region by region: Europe's plains and Alps, Russia's rivers and railways, the Fertile Crescent, Africa's plateaus, the monsoon lands of South Asia, China's rivers and canal, the islands and straits of Southeast Asia and Oceania, and the Americas from the Canadian Shield to the Andes. Map Lab is a bonus unit of games and challenges that pulls it all together. It is lighter than the regular units, and it is meant to be played.

You will make your own thematic map from a table of numbers, as Charles Dupin did for France in 1826. You will run a Countries Quiz League with teams and a scoreboard, solve and write five-clue Mystery Region cards like the scholars who tracked down the ancient land of Punt, and race in a Flags and Capitals Relay that ends in Brazil's planned capital, Brasília. In every game you will use real skills: classes and keys, population density, latitude and distance, and careful reasoning from evidence, all with the reminder of Acts 17:26 that God "hath made of one blood all nations of men."

BEFORE YOU BEGIN

- Has studied most of the eight regions in Units 1 to 8 (or can use the regional atlas pages as a reference)
- Can read latitude and longitude and use a map key
- Can divide large numbers with a calculator and convert between km and miles
- Can use the Pythagorean theorem with a calculator (for the distance challenges)

MASTERY CHECKLIST

- I can turn a table of numbers into a choropleth map with a clear key, title, date and source.
- I can calculate population density in people per km² and per square mile and explain how it differs from total population.
- I can place countries in the eight regions of this course and name many of their capitals.
- I can estimate distances between cities from their latitude and longitude.
- I can identify a region from clues about its land, history, faith and trade, and write fair clues of my own.
- I can explain what the symbols on several national flags mean and why some capitals were moved or planned.

OPTIONAL BOOKS AND RESOURCES

- **United Nations: Member States** (<https://www.un.org/en/about-us/member-states>): Free. The official list of the 193 member states with the dates each joined. Useful for the Countries Quiz League (Lesson 9.2) and the Flags and Capitals Relay (Lesson 9.4).

- **Natural Earth** (<https://www.naturalearthdata.com/>): Free public-domain map data. Parents comfortable with computers can download outline maps of countries for the Thematic Map Challenge (Lesson 9.1); others can simply trace the maps in this unit.

9.1 THEMATIC MAP CHALLENGE

OBJECTIVES

- Explain what a thematic map is and tell how Charles Dupin turned a table of numbers into a shaded map of France in 1826.
- Sort a table of country populations into classes and shade a choropleth map of South America with a clear key.
- Calculate population density in people per square kilometer and per square mile, and explain why a total-population map and a density map tell different stories.

Warm-up. Look at the table of contents or the pages of any atlas or encyclopedia in your house (or a weather map in a newspaper). Find one map that shows something other than borders, roads and rivers: rainfall, crops, languages, temperature or people. What is the map's "theme"? How does the map show more or less of it: with colors, dots, shading or symbols? Tell a parent in one sentence what the map is trying to teach.

Watch. *Types of Maps and Map Scale - Learn How to Read and Use Maps* (Miacademy & MiaPrep Learning Channel, 7:08). https://www.youtube.com/watch?v=u_xHCRrlvQU

Before the project: watch for the difference between general maps and maps that show one topic (thematic maps), and how a map scale turns distance on the map into real distance.

Note: Captions were not available to check; preview it first. It comes from a children's education channel and is about seven minutes long. This video may cover thematic maps only briefly and might not use the words choropleth or dot density.

Backup video. *Introduction to MAPS! [AP Human Geography Review—Unit 1 Topic 1]* (Heimler's History, 9:50). <https://www.youtube.com/watch?v=iG3XQQ7lgBI>

As review: watch the section on reference maps versus thematic maps and listen for the names of each kind (choropleth, dot density and others) before you make your own map. Note: Captions were not available to check; preview it first. It is a fast-paced review for a high school AP exam, includes a short plug for the teacher's own study guides, and says that 'all maps are lies' when it explains map projections. The video uses AP Human Geography terms (for example graduated symbol, isoline and cartogram) that may go beyond what the lesson covers.

KEY TERMS

thematic map

A map made to show one subject, or theme, such as population, religion, rainfall, crops or trade, across an area.

choropleth map

A thematic map that shades whole areas, such as countries or states, lighter or darker according to a number for each area.

class

A range of numbers (for example, 5 to 20 million people) that all get the same color or shade on a thematic map.

population density

The average number of people living on each square kilometer or square mile of land: population divided by area.

dot map

A thematic map that places one dot for a set number of people or things, so crowded places look crowded and empty places look empty.

CORE IDEAS

The story. In 1826, in Paris, Baron Charles Dupin, an engineer and mathematician, had a table of numbers he wanted the French people to notice. For each of France's 86 *départements* (the districts into which France had been divided since 1790), the table compared the number of boys in school with the number of people living there. A long column of numbers is hard to see. So Dupin drew a map of France and shaded each *département*: light where many children went to school, darker where few did. The result was startling. A rough line could be drawn from Saint-Malo on the English Channel to Geneva near the Alps. North and east of it, much of France was light; south and west of it, much was dark. People who would never have read his table understood his map in a moment. Dupin's map is often called the first **choropleth map**, from Greek words meaning "area" and "many."

How it works. Every thematic map begins with a table. To make a choropleth, the mapmaker first chooses **classes**: three to five ranges of numbers, such as "under 5 million," "5 to 20 million," "20 to 50 million" and "over 50 million." Each class gets one shade, from light (least) to dark (most), and the key shows what each shade means. The mapmaker then colors every area by its class. Choosing classes takes judgment: too few and the map hides real differences; too many and the eye cannot tell the shades apart. A good choropleth uses one color growing darker, not a rainbow, because the eye reads "darker" as "more." A **dot map** works differently: one dot might stand for 100,000 people, placed where those people actually live.

The big idea. A map of *total* population and a map of **population density** can tell very different stories. Brazil has far more people than any other country in South America, about 213 million in 2020, so it is darkest on a total map. But Brazil is huge, about 8.5 million square kilometers (3.3 million square miles), so its density is only about 25 people per square kilometer (about 65 per square mile). Little Ecuador, with about 18 million people on about 284,000 square kilometers (110,000 square miles), is more than twice as crowded. Even density is an average: most South Americans live near the coasts and in the high valleys of the Andes, while large parts of the Amazon basin hold very few people. All through this course you have read thematic maps of rainfall, religion, oil and trade. Now you will

make one yourself, and you will learn to ask of every thematic map: *What is it measuring, and what might it be hiding?*



South America's countries. Use this outline for your choropleth challenge.

Population, 2020



under 5 million



5 to 20 million



20 to 50 million



over 50 million

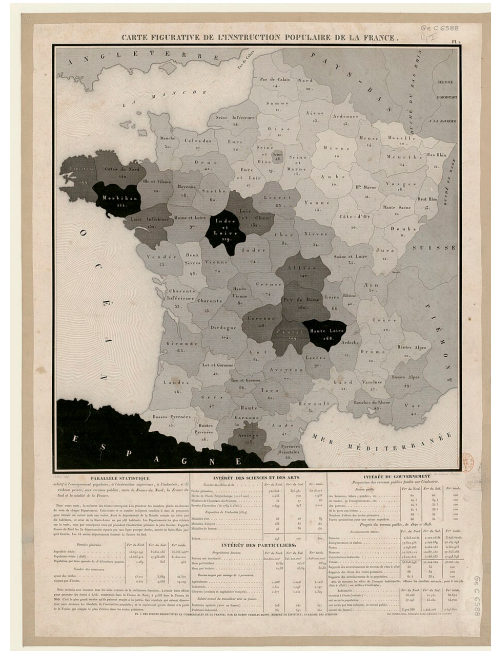
lighter = fewer



darker = more

A four-class key for total population. Darker means more people.

PICTURE STUDY



Carte figurative de l'instruction populaire de la France (Figurative Map of Popular Education in France), Charles Dupin (drawn by J. Collon), 1826 · Printed map with shading by département · Copies survive in French libraries, including the Bibliothèque nationale de France, Paris

Charles Dupin (1784–1873) was a French naval engineer, mathematician and politician who cared about schools and industry. He believed that France would grow stronger if more of its children learned to read, and he wanted a picture that would persuade people at a glance. His shaded map of France is one of the first maps ever to color areas by a number, the same method used today on election maps, weather maps and the population maps you will make in this lesson.

Look closely

- Find the lightest districts and the darkest districts. Are they scattered, or do they gather in regions?
- Imagine a line from Saint-Malo, on the coast of Brittany in the northwest, to Geneva, in the east near the Alps. How do the shades differ on each side of it?
- Look for the key or explanation. How does a reader know what “dark” means on this map?
- Notice what the map does not show: rivers, roads and cities are missing or faint. Why might Dupin leave them out?

Talk about it

1. Why would a shaded map persuade more people than a table with the same numbers?
2. Dupin chose dark shades for districts with little schooling. How does that choice affect a reader’s feelings about those places? Is that fair to the people living there?
3. What other subjects from this course could you show with a map like Dupin’s?

PROJECT: THE CHOROPLETH CHALLENGE: SOUTH AMERICA BY THE NUMBERS

You will turn a table into two thematic maps of South America: one of total population and one of population density. Then you will compare them and write what each map reveals and hides.

You will need

- Two printed or traced outline maps of South America with country borders (trace the figure in this lesson)
- One colored pencil or marker in a single color (blue or green works well), used light to dark
- Pencil, ruler and calculator
- The population table below

Steps

1. Copy this table into your map notebook (populations about 2020, rounded): Brazil 213 million; Colombia 51 million; Argentina 45 million; Peru 33 million; Venezuela 28 million; Chile 19 million; Ecuador 18 million; Bolivia 12 million; Paraguay 7 million; Uruguay 3.5 million; Guyana 0.8 million; Suriname 0.6 million. (French Guiana is part of France; leave it white and label it.)
2. Use the four classes in the key: under 5 million; 5 to 20 million; 20 to 50 million; over 50 million. Write the class next to each country in your table.
3. Draw a key on your first map with four boxes. Shade the first box very lightly, the second a little darker, the third darker still and the fourth as dark as you can press.
4. Shade each country to match its class. Give the map a title, the date of the data (2020) and the source ("United Nations estimates, rounded").
5. On your second map, make a density map. Use these areas: Brazil 8.5 million km²; Colombia 1.14 million km²; Argentina 2.78 million km²; Peru 1.29 million km²; Venezuela 0.92 million km²; Chile 0.76 million km²; Ecuador 0.28 million km²; Bolivia 1.10 million km²; Paraguay 0.41 million km²; Uruguay 0.18 million km²; Guyana 0.21 million km²; Suriname 0.16 million km². Divide population by area to get people per km² for each country.
6. Choose your own four classes for density (for example: under 10; 10 to 20; 20 to 40; over 40 people per km²), draw a key and shade the second map.
7. Lay the two maps side by side. Write three sentences: one about what the total map shows, one about what the density map shows, and one about what neither map can show (where people live inside each country).

Tips

- Use only one color, light to dark. A rainbow of colors makes a reader guess which color means "more."
- Shade lightly at first; you can always press harder, but you cannot erase dark pencil well.

- To change people per km² into people per square mile, multiply by 2.59, since one square mile equals about 2.59 km².

Check your work

- Both maps have a title, a key, a date and a source.
- Every country is in the correct class.
- I can explain why Brazil is darkest on one map but not on the other.

MAP NOTEBOOK

1. Draw a small outline of France and sketch a line from Saint-Malo to Geneva. Shade the side that Dupin's map showed as having more children in school lightly, and the other side darker. Label it "Dupin, 1826."
2. Make a mini dot map: draw a rectangle for an imaginary island and place 20 dots for its people, crowding them along the coast and a river. Write a key: "1 dot = 10,000 people." What is the island's population?
3. Choose one thematic map from earlier in this course (rainfall, religion, oil, monsoon winds). Draw a thumbnail of it and write its theme and how it shows "more" and "less."

From history. Thematic maps grew quickly in the 1800s as governments began counting their people in regular censuses. Britain held its first national census in 1801, the same decade as several European countries, and the United States had counted its people every ten years since 1790. By the 1870s, the U.S. Census Office was printing statistical atlases full of shaded maps of population, farming and industry, and mapmakers had learned to use dots, shading and lines of equal value to make long tables visible.

WORKED EXAMPLES

Example 1. Argentina had about 45 million people in 2020 and covers about 2.78 million square kilometers (1.07 million square miles). Find its population density in people per km² and per square mile, and decide which class it falls in on a density key of under 10, 10 to 20, 20 to 40 and over 40 people per km².

(Use the map or drawing “Argentina is large and long, so its average density is low.” shown earlier in this lesson.)

1. Density means population divided by area. In kilometers: $45,000,000 \div 2,780,000 \approx 16.2$ people per km².
2. In miles: $45,000,000 \div 1,070,000 \approx 42$ people per square mile. (Check: $16.2 \times 2.59 \approx 42$.)
3. Find the class: 16.2 is between 10 and 20, so Argentina goes in the second class.
4. Think about it: Argentina’s average is low, but about a third of its people live in and around Buenos Aires, while Patagonia in the south is nearly empty. The average hides that.

Answer: About 16 people per km² (about 42 per square mile), in the 10 to 20 per km² class.

PRACTICE

1. **EASY** Using the four total-population classes in the key (under 5 million, 5 to 20 million, 20 to 50 million, over 50 million), which class does each of these go in: Peru (33 million), Paraguay (7 million), Uruguay (3.5 million)?
(Use the map or drawing “Match each number to its class.” shown earlier in this lesson.)
2. **MEDIUM** Ecuador had about 18 million people on about 284,000 km² (110,000 square miles). Find its population density in both units.
3. **MEDIUM** Brazil has about 213 million people on about 8.5 million km². Ecuador’s density is about 63 people per km². About how many times more crowded is Ecuador than Brazil?
4. **HARD** Look at the map of South America. The Amazon basin covers much of northern Brazil, Peru’s east and Bolivia’s north. If you made a dot map with one dot for every 500,000 people, where would the dots crowd, and where would there be very few? Give a geographic reason for each.
(Use the map or drawing “Think about coasts, mountains, forests and deserts.” shown earlier in this lesson.)
5. **CHALLENGE** A classmate says, “Brazil is the darkest country on the total-population map, so Brazil must be the most crowded country in South America.” Write two or three sentences explaining the mistake.

COMMON MISTAKES

- Using many unrelated colors for classes. Readers expect one color growing darker to mean “more.”
- Forgetting to divide by area. Big countries look important on a total map even when they are thinly settled.
- Leaving off the date and source. Populations change, so a thematic map must say when and where its numbers came from.

Make it a game · Guess the Theme. One player secretly picks a theme (for example: rainfall, oil, number of Christians, rice farming, people per square mile) and shades a quick choropleth of South America, Europe or Africa on a blank outline using light-to-dark pencil. The others have three guesses to name the theme. A correct first guess earns 3 points, a second guess 2 and a third guess 1. The mapmaker earns 1 point for a fair key and correct facts. Take turns until everyone has drawn twice.

Scripture. “And it came to pass in those days, that there went out a decree from Cæsar Augustus, that all the world should be taxed.” (Luke 2:1, KJV)

Rulers have counted their people for thousands of years, and God used one such count, the Roman enrollment, to bring Joseph and Mary to Bethlehem. Behind every dot and shade on a population map are real people, each made in God’s image and known to Him by name.

Practice answers

1. Peru: 20 to 50 million. Paraguay: 5 to 20 million. Uruguay: under 5 million.
2. $18,000,000 \div 284,000 \approx 63$ people per km^2 . $18,000,000 \div 110,000 \approx 164$ people per square mile.
3. Brazil: $213,000,000 \div 8,500,000 \approx 25$ people per km^2 . $63 \div 25 \approx 2.5$, so Ecuador is about two and a half times as crowded.
4. Dots would crowd along the Atlantic coast of Brazil (São Paulo, Rio de Janeiro), around Buenos Aires and the Río de la Plata, and in the Andes valleys and Pacific coast (Bogotá, Quito, Lima, Santiago). Reasons: good harbors and trade, fertile plains, mild climates in the highlands near the equator. Very few dots would fall in the Amazon rain forest (dense forest, heavy rain, poor soils, travel mostly by river), in the Atacama Desert and in cold, dry Patagonia.
5. A total-population map shows how many people live in each country, not how close together they live. Brazil has the most people, but it is so large that its density (about 25 per km^2 , or 65 per square mile) is lower than that of smaller countries such as Ecuador (about 63 per km^2). To compare crowding you must divide population by area and make a density map.

9.2 COUNTRIES QUIZ LEAGUE

OBJECTIVES

- Tell how the United Nations began in 1945 and explain why counting the world's countries takes careful definitions (as of 2026, 193 member states).
- Place countries in the eight regions of this course and locate capitals by latitude and longitude.
- Use the rule that one degree of latitude is about 111 km (69 miles) to estimate north-south distances between capitals.

Warm-up. Set a timer for two minutes. With a partner or a parent, take turns naming countries, one at a time, without repeating any. Every country named must be placed in one of this course's regions: Europe; Russia and Central Asia; the Middle East and North Africa; Sub-Saharan Africa; South Asia; East Asia; Southeast Asia and Oceania; or the Americas. When the timer rings, count how many you named and which region had the most.

Video. Coming soon. The founding of the United Nations in San Francisco, 1945, and a tour of the world's regions and countries: search The History Guy, Library of Congress, Homeschool Pop (Alternate); candidate needing vetting: Geography Now (country profiles, preview first).

KEY TERMS

country (sovereign state)

A territory with its own government that is independent of any other government and is recognized by other countries.

United Nations

An organization of the world's countries founded in 1945; as of 2026 it has 193 member states.

capital

The city where a country's national government meets.

region

A large area grouped together because its lands share features such as landforms, climate, history, faith or ways of life.

dependency

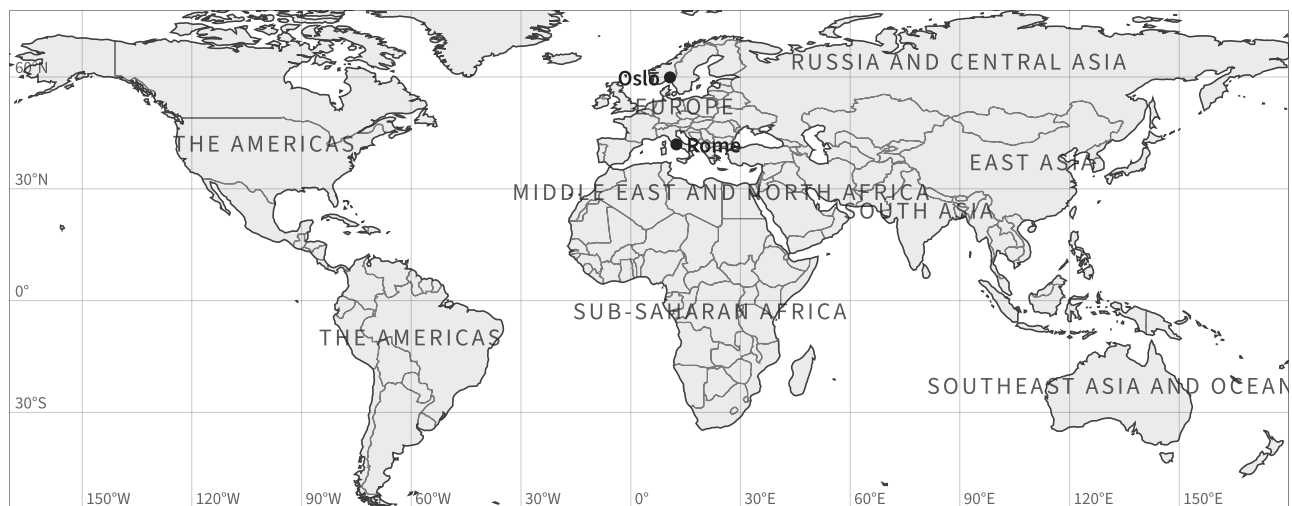
A territory governed by another country, such as French Guiana (part of France) or Greenland (part of the Kingdom of Denmark).

CORE IDEAS

The story. On June 26, 1945, in the Veterans War Memorial Building in San Francisco, delegates from 50 countries signed the Charter of the United Nations. World War II had not yet ended in the Pacific, and the countries that signed hoped to prevent another world war. Poland, which had not been able to send a delegation, signed soon after and became the 51st original member. The United Nations officially came into existence on October 24, 1945. Since then many new countries have joined, especially as colonies in Africa and Asia became independent in the 1950s, 1960s and 1970s and as the Soviet Union and Yugoslavia broke apart in the early 1990s. The newest member is South Sudan, which became independent on July 9, 2011, and joined the United Nations five days later. As of 2026 there are 193 member states.

How to count countries. “How many countries are there?” sounds like an easy question, but the answer depends on definitions. The 193 United Nations members are the usual starting count. Two more, the Holy See (Vatican City) and the State of Palestine, are non-member observer states. A few places govern themselves and are recognized by some countries but are not United Nations members, such as Taiwan and Kosovo (as of 2026). Other lands, like Greenland, Puerto Rico and French Guiana, are parts of or tied to other countries. A good geographer states which definition is being used. Some regional counts are steady and worth knowing: Africa has 54 United Nations member countries, South America has 12 independent countries, and Central America has 7.

On the map. Knowing countries is more than memorizing names. When you hear a country’s name you should be able to see its *place*: its region, its neighbors, its coast or lack of one, its rivers and its latitude. Latitude is a quick tool. Every degree of latitude is about 111 km (69 miles) north to south, anywhere on earth. Oslo, the capital of Norway, lies at about 59.9°N, and Rome lies at about 41.9°N, almost due south. The difference is 18 degrees, so the two capitals are about 2,000 km (about 1,240 miles) apart. In the Countries Quiz League you will play in teams, earning points for naming countries, placing them in their regions, finding their capitals on the map and using latitude to measure the world.



The eight regions of this course. Every question in the League belongs to one of them.

PICTURE STUDY



The Geographer, Johannes Vermeer, 1669 · Oil on canvas · Städel Museum, Frankfurt am Main, Germany

Johannes Vermeer of Delft painted this scholar in 1669, at a time when Dutch mapmakers in Amsterdam led the world in printing maps, globes and atlases. Dutch ships sailed to the East Indies, Africa and the Americas, and every voyage brought back new information for the mapmakers. Vermeer shows the geographer in a moment of thought, dividers in hand, as if he has just measured a distance and is working out what it means.

Look closely

- Find the dividers in the geographer's hand. What would he use them to measure?
- Find the globe on top of the cabinet and the chart on the wall. Why would a geographer need both a globe and flat maps?
- Where does the light come from? What is the geographer looking at?
- Look at the rolled maps and papers on the table and floor. What do they tell you about his work?

Talk about it

1. Vermeer painted the geographer looking up from his map instead of down at it. What might the painter be saying about thinking and learning?
2. What new places would a Dutch geographer in 1669 have been eager to learn about?
3. How is your work in this course like the geographer's work?

PROJECT: BUILD AND PLAY THE COUNTRIES QUIZ LEAGUE

You will make a deck of country cards for the eight regions of this course and run a family or co-op league with teams, rounds and a scoreboard. By the end you will know the countries of

each region and their capitals far better than when you started.

You will need

- 48 to 80 index cards
- A world atlas or a printed world political map
- Colored markers (one color for each of the eight regions)
- A poster board or sheet of paper for a scoreboard
- A timer

Steps

1. Assign each region a color. Make 6 to 10 cards for each region. On the front of each card write a country name in the region's color.
2. On the back write the country's capital, its approximate latitude and longitude, one neighbor and one fact you learned in this course (for example, "Netherlands: Amsterdam is the capital; Rotterdam is Europe's busiest port").
3. Divide players into two or more teams and draw a scoreboard with columns for four rounds.
4. Round 1, Region Rush: the quizmaster reads a country; the first team to name its region scores 1 point.
5. Round 2, Capital Call: the quizmaster reads a country; the team names the capital for 2 points.
6. Round 3, Map Pin: the team must point to the country on a blank or political map within 10 seconds for 2 points.
7. Round 4, Latitude Line: the quizmaster gives two capitals that lie roughly north and south of each other and their latitudes; the team estimates the distance using 111 km (69 miles) per degree. Within 10 percent earns 3 points.
8. Add up the scores. Keep the deck and scoreboard for a league night each week for the rest of the year.

Tips

- Mix easy and hard countries so everyone can score. Younger siblings can play Round 1 only.
- When a team misses, show the country on the map before moving on. Losing a point and learning the place is still a win.
- Check capitals in a current atlas; a few countries have moved their capitals in living memory.

Check your work

- My deck has cards for all eight regions.
- Every card has a correct capital and approximate coordinates.
- I can estimate north-south distance between two capitals using latitude.

MAP NOTEBOOK

1. Draw a simple world outline and color the eight regions of this course in eight colors. Add a key.
2. List the 12 independent countries of South America and write their capitals beside them. Circle the two that have no seacoast (Bolivia and Paraguay).
3. Make a timeline of United Nations membership: 51 members in 1945 and 193 as of 2026. Mark South Sudan (2011) as the newest member.

From history. Geography quizzing has a long history. In 1570 Abraham Ortelius of Antwerp published the *Theatrum Orbis Terrarum*, often called the first modern atlas: a bound book of maps of the same size and style, covering the whole known world. For the first time a student could page through the world region by region, much as you have done in this course. The atlas sold so well that it went through many editions in several languages over the next forty years.

WORKED EXAMPLES

Example 1. Oslo, Norway, lies at about 59.9°N , 10.75°E . Rome, Italy, lies at about 41.9°N , 12.5°E . Since their longitudes are close, estimate the distance between them in km and miles using latitude alone.

(Use the map or drawing “Oslo and Rome both lie in the Europe region, nearly on the same line of longitude” shown earlier in this lesson.)

1. Check that the cities lie almost on the same meridian: 10.75°E and 12.5°E differ by less than 2 degrees, so the route is nearly due north-south.
2. Find the difference in latitude: $59.9^{\circ} - 41.9^{\circ} = 18.0^{\circ}$.
3. Each degree of latitude is about 111 km: $18.0 \times 111 \approx 2,000$ km.
4. Each degree is also about 69 miles: $18.0 \times 69 \approx 1,240$ miles.

Answer: About 2,000 km (about 1,240 miles). The true straight-line distance is only a little more, because the cities are slightly offset east-west.

PRACTICE

1. **EASY** Name the region of this course for each country: Kazakhstan, Kenya, Vietnam, Iraq, Argentina.
(Use the map or drawing “Use the map to check each region.” shown earlier in this lesson.)
2. **EASY** How many original members did the United Nations have, how many members does it have as of 2026, and which country joined most recently?
3. **MEDIUM** Cairo, Egypt, lies at about 30.0°N , 31.2°E . Johannesburg, South Africa, lies at about 26.2°S , 28.0°E . Estimate the north-south distance between them in km and miles.

4. **HARD** A capital lies at about 1.3°N, 103.8°E, at the southern tip of the Malay Peninsula beside a famous strait. Name the country and capital, and its course region.
5. **CHALLENGE** Your friend says, “There are exactly 193 countries in the world, and that’s that.” Write two or three sentences explaining why geographers give a more careful answer.

COMMON MISTAKES

- Confusing a country’s largest city with its capital (Sydney is not Australia’s capital; Canberra is).
- Forgetting to add latitudes when two places are on opposite sides of the equator.
- Calling dependencies such as Greenland or French Guiana independent countries.

Make it a game • Neighbor Chain. One player names a country. The next player must name a country that shares a land border with it, then the next names a neighbor of that country, and so on. No repeats. If you cannot think of a neighbor in 10 seconds, or you name one that does not touch, you are out for the round. Islands like Japan or Madagascar end the chain, so choose wisely! Keep an atlas open to settle arguments. The last player in wins the round.

Scripture. “And hath made of one blood all nations of men for to dwell on all the face of the earth, and hath determined the times before appointed, and the bounds of their habitation;” (Acts 17:26, KJV)

Paul spoke these words in Athens. The names and borders of countries change over time, but every nation on your quiz cards is made of the same human family, and God rules over the times and boundaries of them all.

Practice answers

1. Kazakhstan: Russia and Central Asia. Kenya: Sub-Saharan Africa. Vietnam: Southeast Asia and Oceania. Iraq: the Middle East and North Africa. Argentina: the Americas.
2. 51 original members (50 signed the Charter in San Francisco on June 26, 1945, and Poland signed soon after); 193 members as of 2026; South Sudan joined most recently, in July 2011.
3. The cities are on opposite sides of the equator, so add: $30.0 + 26.2 = 56.2^\circ$. $56.2 \times 111 \approx 6,240$ km; $56.2 \times 69 \approx 3,880$ miles. (About 6,200 km or 3,900 miles.)
4. Singapore (the city-state is its own capital), in Southeast Asia and Oceania, beside the Strait of Malacca and the Singapore Strait.
5. 193 is the number of United Nations member states as of 2026, which is the most common count. But the Holy See and Palestine are observer states, some self-governing places such as Taiwan and Kosovo are recognized by some countries and not others, and many territories are dependencies of other countries. So a careful geographer says which definition is being used.

9.3 MYSTERY REGION

OBJECTIVES

- Tell how Queen Hatshepsut's expedition to the land of Punt left clues that geographers still use to locate it.
- Identify a mystery region from five clues about landforms, climate, history, faith and trade, eliminating wrong answers with reasons.
- Write a fair five-clue card for a region of this course, ordered from hardest to easiest.

Warm-up. A parent places one object from somewhere in the house in a bag (a spice jar, a seashell, a coin, a postcard). You may ask only "yes or no" questions about what the object is made of, where it comes from and what it is used for. How many questions did you need? Which question narrowed things down the most?

Video. Coming soon. Queen Hatshepsut's expedition to Punt and the reliefs at Deir el-Bahari, and the Hereford Mappa Mundi: search Smithsonian, The History Guy, Drive Thru History; flagged, use selectively: Fall of Civilizations.

KEY TERMS

clue

A fact that points toward an answer without giving it away all at once.

elimination

Ruling out possible answers one by one because a clue does not fit them.

evidence

Facts, objects or records that support a conclusion.

relief

A carving in which figures stand out from a flat stone surface; Egyptian temples are covered with them.

Punt

A land that ancient Egyptians reached by sea and traded with for incense, ebony, gold and animals; most scholars place it near the southern Red Sea.

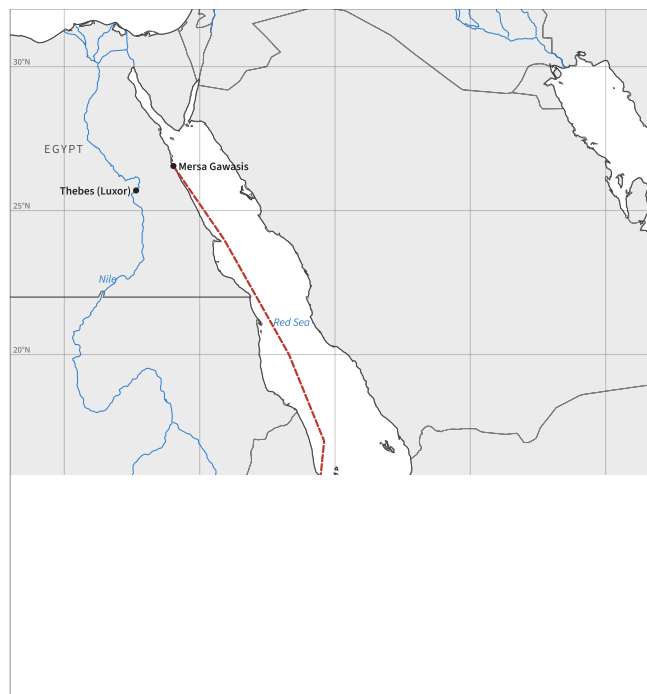
CORE IDEAS

The story. In the 1400s BC, Queen Hatshepsut of Egypt sent five ships down the Red Sea to a land the Egyptians called Punt. The fleet returned loaded with treasures: myrrh and incense trees with their roots wrapped for planting, ebony, ivory, gold, animal skins and live baboons. Hatshepsut had the voyage carved in painted reliefs on the walls of her temple at Deir el-Bahari, across the Nile from Thebes (today's Luxor). But the carvings never say exactly where Punt was. For more than a century scholars have treated the reliefs like a mystery card full of clues. The ships sail on a sea full of fish that live in the Red Sea and the

Indian Ocean. The people of Punt live in round houses raised on posts, reached by ladders. Their trees give incense, a plant of dry tropical lands. Their animals include baboons. Each clue rules out some guesses. Egypt's own deserts lack incense trees; the Mediterranean lacks those fish; a voyage "by sea" rules out the far interior of Africa.

How they figured it out. Archaeologists found more clues at Mersa Gawasis, an ancient harbor on Egypt's Red Sea coast, where they uncovered ship timbers, coils of rope and stone markers that mention Punt. Then, in 2020, scientists studied the chemistry of the teeth and hair of baboon mummies brought to Egypt. The baboons had been born far from Egypt, and the chemistry best matched baboons living today in the lands near the southern Red Sea, around Eritrea and Ethiopia. Most scholars now place Punt along the coasts and hills of the southern Red Sea and the Horn of Africa, perhaps including the facing coast of Arabia. No single clue proved it. Many clues together, each eliminating wrong answers, pointed to one region.

The big idea. A geographer solves a mystery region the same way. Start with the clues that cut the world in half: hemisphere, latitude, coast or interior, climate. Then use clues about rivers, mountains and ports, and finally the clues of history, faith and trade, which are often the most specific. In this lesson you will play "Mystery Region" with five clues per card, ordered from hardest to easiest. Solve it on clue 1 and you win 5 points; on clue 5, only 1. To write good cards you must know each region of this course well: its land first, then how that land shaped its history, its peoples, its faith and its trade.



Egypt's sea road to Punt. Most scholars place Punt near the southern Red Sea and the Horn of Africa.

PICTURE STUDY



The Hereford Mappa Mundi, Made in England; an inscription names Richard of Haldingham and Lafford, about 1300 · Ink and paint on a single sheet of vellum (calfskin) · Hereford Cathedral, Hereford, England

The Hereford Mappa Mundi, about 1.6 meters tall and 1.3 meters wide (about 5 feet 2 inches by 4 feet 4 inches), is the largest medieval world map that survives. It was not made for travelers finding their way. It is a picture of the whole world as a learned Christian of about 1300 understood it: history, geography and the Bible on a single sheet. East, where the Garden of Eden was believed to lie, is at the top, and Jerusalem is at the center. The map is packed with about 500 drawings, many of them clues: a camel, an elephant, a crocodile in the Nile, Noah's ark on the mountains of Armenia, and the Red Sea painted red.

Look closely

- Find Jerusalem at the center. Why would a medieval Christian mapmaker place it there?
- East is at the top. Turn your atlas so east is up and compare the shapes. Can you find the Mediterranean Sea running up from the bottom?
- Find the little drawings of animals and cities. Which ones could be clues to a region, like the clues on a mystery card?
- Look at the edge of the circle. What lands lie at the far edges of this map?

Talk about it

1. The Hereford map is not accurate in shape. What does it get right, and what was it trying to teach?
2. If you made a mystery card from the drawings on this map, which region would be easiest to guess? Why?

3. How has geographers' knowledge of the world changed between 1300 and the maps in your atlas?

PROJECT: MYSTERY REGION CLUE CARDS

You will write a set of mystery cards, one or two for every region of this course, each with five clues from hardest to easiest. Then you will play the cards with your family and check whether your clues were fair.

You will need

- 16 index cards
- Your regional atlas pages and lesson notes from Units 1 to 8
- A world map or globe
- Pencil and a red pen

Steps

1. Choose a region (or a single country or river basin within a region). Write its name lightly on the back of a card.
2. On the front, write Clue 1, the hardest: a fact about latitude, climate or landforms that fits more than one region (for example, "Most of my people live on river plains watered by summer monsoon rains").
3. Write Clue 2 about rivers, mountains or seas, and Clue 3 about farming, resources or trade.
4. Write Clue 4 about faith or history, such as a missionary, a famous kingdom or a great building.
5. Write Clue 5, the easiest: a famous city, port, canal or railway from this course.
6. Check every clue for accuracy in your notes or an atlas. Mark any clue you are unsure of in red and fix it or replace it.
7. Make at least one card for each of the eight regions. Play them with your family: 5 points for a correct guess after clue 1, 4 after clue 2, and so on down to 1.

Tips

- A good Clue 1 should fit two or three regions, not the whole world and not only one place.
- Use real facts from the course, not opinions ("the best food" is not a clue).
- Write about faith and peoples respectfully and accurately, as you would want your own home described.

Check your work

- Each card has five accurate clues, ordered from hardest to easiest.
- I made at least one card for each of the eight regions.
- Players could solve my cards by reasoning, not by luck.

MAP NOTEBOOK

1. Draw the Red Sea from Egypt to the Bab-el-Mandeb and trace Hatshepsut's ships to Punt. Draw a stilt house and an incense tree as clues.
2. Sketch a tiny circle map in the style of the Hereford Mappa Mundi with east at the top. Place Jerusalem in the middle and add three picture clues.
3. Make an "elimination ladder": write one mystery clue at the top and list the regions it rules out beneath it.

From history. Scholars have proposed many places for Punt over the years, from southern Arabia to the coast of Somalia and even farther away. The finds at Mersa Gawasis, excavated in the 2000s by a team of Italian and American archaeologists, suggested that Egyptian shipwrights built ships near the Nile, carried the parts across the desert, assembled the ships on the Red Sea coast and took them apart again after the voyage. That one harbor turned a guess into strong evidence that the road to Punt ran down the Red Sea.

WORKED EXAMPLES

Example 1. Solve this mystery card and explain how each clue narrows the answer. Clue 1: Much of my land lies between 20°N and 40°N, and most of it gets less than 250 mm (10 inches) of rain a year. Clue 2: Two great rivers flow southeast through my plains toward a gulf. Clue 3: Farmers here were among the first in the world to raise wheat and barley in fields. Clue 4: Abraham set out from a city in my lands, and Jonah was sent to a great city on one of my rivers. Clue 5: Baghdad stands on one of my rivers.

1. Clue 1: dry lands between 20°N and 40°N include North Africa, the Middle East, parts of Central Asia, northern Mexico and the southwestern United States. The others (Europe, the tropics, the far north) are eliminated.
2. Clue 2: two great rivers flowing southeast to a gulf fits the Tigris and Euphrates flowing to the Persian Gulf. The Nile flows north, so Egypt is eliminated.
3. Clue 3: early wheat and barley farming fits the Fertile Crescent (Lesson 3.1).
4. Clue 4: Abraham left Ur of the Chaldees (Genesis 11:31), and Jonah was sent to Nineveh on the Tigris. This confirms Mesopotamia.
5. Clue 5: Baghdad stands on the Tigris, in today's Iraq.

Answer: Mesopotamia, the land between the Tigris and Euphrates in the Fertile Crescent, mostly in today's Iraq, in the region of the Middle East and North Africa. A player who solved it at Clue 2 would earn 4 points.

PRACTICE

1. **EASY** Mystery region: (1) My land is mostly a high plateau, so my rivers tumble over falls near the coast. (2) A belt of dry grassland called the Sahel crosses my north. (3)

Kingdoms here traded gold for salt across the Sahara. (4) Mary Slessor and David Livingstone served as missionaries here. (5) Victoria Falls is on my Zambezi River. Name the region.

2. **MEDIUM** Mystery region: (1) My summer winds blow from the sea and bring most of the year's rain in a few months. (2) The highest mountains on earth wall me off in the north. (3) Two great river plains, the Indus and the Ganges, feed hundreds of millions. (4) William Carey translated the Bible into many of my languages. (5) My first passenger train ran out of Bombay (Mumbai) in 1853. Name the region and say on which clue you would have been sure.
3. **MEDIUM** Look at the map of the Red Sea. A ship leaving Mersa Gawasis sails south about 1,300 km (about 810 miles) to the coast of Eritrea. If it averages about 80 km (50 miles) a day, how many days will the voyage take?
(Use the map or drawing "Follow the route south from Egypt toward Punt." shown earlier in this lesson.)
4. **HARD** Here is a weak Clue 1: "I have mountains and rivers." Explain why it is weak and rewrite it as a good Clue 1 for Russia and Central Asia.
5. **CHALLENGE** Write your own five-clue mystery card for East Asia, from hardest to easiest. Include at least one clue each about land, history or faith, and trade or technology.

COMMON MISTAKES

- Guessing after one clue without checking whether the clue fits more than one region.
- Writing a Clue 1 so vague that it fits the whole world, or a Clue 1 so specific that it gives the answer away.
- Treating an old map like the Hereford Mappa Mundi as a mistake to laugh at instead of a source that shows how people once understood the world.

Make it a game • Twenty Questions: World Edition. One player thinks of a country, river, mountain range, port or city from this course. The others may ask up to twenty yes-or-no questions. Good questions cut the world in half: "Is it in the Northern Hemisphere?" "Is it on a coast?" "Did a missionary from this course work there?" Solve it in ten questions or fewer for 2 points, in eleven to twenty for 1 point. If nobody solves it, the thinker scores 2 points.

Scripture. "For the king had at sea a navy of Tharshish with the navy of Hiram: once in three years came the navy of Tharshish, bringing gold, and silver, ivory, and apes, and peacocks." (1 Kings 10:22, KJV)

Like Hatshepsut's ships, Solomon's fleets brought home treasures from distant lands. The Bible lists the cargo but does not draw the map, so Bible scholars, like Egyptologists, weigh the clues of goods, animals and voyage times to suggest where those ships sailed.

Practice answers

1. Sub-Saharan Africa (Unit 4).

2. South Asia (Unit 5). Most students will be sure by Clue 2 or 3 (the Himalaya and the Indus and Ganges); answers may vary, but the reasoning should name a clue that fits only one region.
3. $1,300 \div 80 \approx 16$ days ($810 \div 50 \approx 16$ days). About two and a half weeks.
4. It fits nearly every region on earth, so it eliminates nothing. A better clue: "My land stretches across eleven time zones, and my longest rivers flow north into a frozen ocean." (Other accurate clues that fit only two or three regions are acceptable.)
5. Answers vary. Example: (1) My great rivers flow mostly from west to east into the Pacific. (2) One of my rivers carries so much yellow loess that it gives its name to a sea. (3) My farmers have grown rice in flooded fields for thousands of years. (4) Matteo Ricci and Hudson Taylor learned my language to share the gospel. (5) The Grand Canal links my two greatest rivers. Check that every clue is accurate and that the clues grow easier.

9.4 FLAGS AND CAPITALS RELAY

OBJECTIVES

- Explain how geography shapes where capitals stand, using the founding of Brasília in 1960 and other planned capitals.
- Read the symbols of national flags, including crosses, stars, maps and plants, and tell what they say about a country's land, history and faith.
- Estimate the distance between two capitals from their latitude and longitude, in km and miles.

Warm-up. Find any flag in your house or neighborhood (a U.S. flag, a state flag, a team banner or a picture in a book). Count its colors, stripes, stars or symbols. For each one, write a guess about what it stands for. Then check: the 13 stripes of the U.S. flag stand for the original 13 colonies and the 50 stars for the 50 states. What does your flag “say” without words?

Video. Coming soon. The building of Brasília (1956–1960) and the meaning of national flags: search The History Guy, Smithsonian, Library of Congress, Homeschool Pop (Alternate); flagged, use selectively: UsefulCharts (flags); candidate needing vetting: Geography Now (flag segments).

KEY TERMS

planned capital

A capital city built on purpose, often on a new site, to serve as the seat of a national government (for example, Washington, Canberra, Brasília and Abuja).

forward capital

A capital placed toward a country's interior or frontier to draw people, roads and trade into lands that were thinly settled.

vexillology

The study of flags, from the Latin *vexillum*, a Roman banner.

Nordic cross

A cross set off-center toward the flagpole, used on the flags of Denmark, Norway, Sweden, Finland and Iceland.

plateau

A broad, high area of fairly level land. Brasília stands on Brazil's Central Plateau.

CORE IDEAS

The story. On April 21, 1960, Brazil moved its capital from Rio de Janeiro, a beautiful port on the Atlantic, to a brand-new city on the empty Central Plateau, more than 900 km (about 580 miles) inland. Brazil's first republican constitution, in 1891, had already called for a

capital in the interior, but for decades nothing happened. Then President Juscelino Kubitschek made it his great project. The planner Lúcio Costa laid out the city in the shape of an airplane or a bird with outstretched wings, and the architect Oscar Niemeyer designed its white, curving government buildings. Tens of thousands of workers built the city in less than four years. Why move? Most Brazilians lived near the coast, as they had since colonial days, while the vast interior was thinly settled. A capital on the plateau, more than 1,000 meters (3,300 feet) above sea level, would pull roads, farms and towns into the heart of the country. Geographers call such a city a **forward capital**.

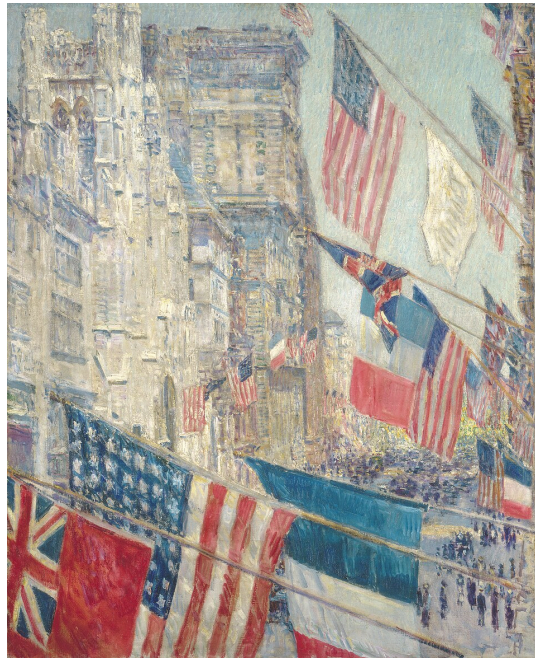
Capitals and geography. Brasília is not alone. Brazil's first capital was Salvador, on the coast of Bahia, until 1763, when the capital moved to Rio de Janeiro, closer to the gold mines of Minas Gerais. The United States built Washington on the Potomac River as a compromise between North and South, and Congress first met there in 1800. Australia chose a site between its two rival cities, Sydney and Melbourne, and named it Canberra in 1913. Nigeria moved its capital from Lagos, on the coast, to Abuja, near the middle of the country, in 1991. Each choice was shaped by geography: harbors, rivers, the center of the land and the balance between regions.

What flags say. A flag is a map of a nation's story in a few colors. Many flags carry the cross, a reminder of how deeply Christianity shaped those lands: the Nordic cross of Denmark, Norway, Sweden, Finland and Iceland; the white cross of Switzerland; and the British Union Flag, which since 1801 has joined the crosses of Saint George (England), Saint Andrew (Scotland) and Saint Patrick (Ireland). Some flags show the land itself: the cedar of Lebanon, the maple leaf of Canada (adopted in 1965) and the outline of the island on the flag of Cyprus. Brazil's blue globe shows the stars over Rio de Janeiro on the morning of November 15, 1889, when the republic was proclaimed, with the motto *Ordem e Progresso* ("Order and Progress"). In today's relay you will race to match flags, capitals and countries, and explain the geography behind each one.



Brazil's capitals: Salvador (until 1763), Rio de Janeiro (1763-1960) and Brasília (since 1960).

PICTURE STUDY



Allies Day, May 1917, Childe Hassam, 1917 · Oil on canvas · National Gallery of Art, Washington, D.C.

Childe Hassam was an American painter who loved the light and life of city streets. In the spring of 1917, just after the United States entered World War I, British and French delegations visited New York, and Fifth Avenue was hung with the flags of the three allied nations. Hassam painted the avenue as a river of banners: the Stars and Stripes, the British Union Flag and the French Tricolor fluttering together above the crowd. He went on to paint about thirty “flag pictures” of New York’s streets during the war.

Look closely

- Find each of the three nations' flags. How can you tell them apart from far away?
- Look at the crosses on the British flag. Which saints do they stand for?
- How does Hassam use the flags to lead your eye down the avenue?
- Look at the people in the street. Are they the main subject, or are the flags?

Talk about it

1. Why would a city hang the flags of other countries beside its own?
2. What feelings does this painting give you about the friendship of these three nations in 1917?
3. If you painted your own street hung with flags, which flags would you choose and why?

PROJECT: FLAGS AND CAPITALS RELAY CARDS

You will draw a set of flag cards for countries from every region of this course, with each country's capital and one geographic fact, and then run a team relay race across a room or yard.

You will need

- 32 or more index cards
- Colored pencils or markers
- An atlas or a reliable flag chart for checking colors and designs
- Two baskets or boxes, and masking tape for a start line

Steps

1. Choose four countries from each of the eight regions of this course (32 in all).
2. On one card, draw and color the country's flag carefully. On a second card, write the country's name, and on a third, its capital.
3. On the back of the capital card, write one geographic fact about the capital (for example, "Cairo: on the Nile, just above where the delta begins").
4. Set up the relay: place the flag cards face up at the far end of the room and the name and capital cards in a basket at the start line.
5. Each runner draws a name card and a capital card, runs to the far end, finds the matching flag and lays all three cards together. Then the runner runs back and tags the next teammate.
6. When all cards are matched, the team checks them aloud. Each correct set earns 1 point; reading the geographic fact correctly earns 1 bonus point.
7. Store the cards with your Quiz League deck for review all year.

Tips

- Some flags look very alike (Indonesia and Monaco, Chad and Romania). Write a small clue on your card to tell them apart.

- Draw the flag in the right proportions and with the symbols facing the right way; look carefully at your source.
- Check that every capital is current. Brazil, Nigeria and Kazakhstan are examples of countries that moved their capitals in the last hundred years.

Check your work

- My cards include four countries from each of the eight regions.
- Every flag, name and capital is correct.
- I can explain the symbols of at least five flags.

MAP NOTEBOOK

1. Draw the British Union Flag and, beside it, the three separate crosses of Saint George, Saint Andrew and Saint Patrick. Show how they combine.
2. Draw a map of Brazil and mark Salvador, Rio de Janeiro and Brasília with the years each was the capital.
3. Design a flag for your own family or homeschool. Use at least one symbol of your land (a river, mountain, tree or star) and write what each part means.

From history. By long tradition, Denmark's flag, the Dannebrog, is said to have fallen from the sky during a battle in Estonia in 1219, and it is often called the oldest national flag still in use. Whatever its exact origin, the red flag with a white cross was in use in Denmark by the 1300s, and its off-center cross became the model for the flags of Norway, Sweden, Finland and Iceland, binding the Nordic lands together in one family of banners.

WORKED EXAMPLES

Example 1. Rio de Janeiro lies at about 22.9°S , 43.2°W . Brasília lies at about 15.8°S , 47.9°W . Estimate the straight-line distance between Brazil's old and new capitals in km and miles.

(Use the map or drawing "Brasília lies northwest of Rio, on the Central Plateau." shown earlier in this lesson.)

1. North-south: $22.9^{\circ} - 15.8^{\circ} = 7.1^{\circ}$ of latitude. At 111 km per degree: $7.1 \times 111 \approx 790$ km.
2. East-west: $47.9^{\circ} - 43.2^{\circ} = 4.7^{\circ}$ of longitude. A degree of longitude shrinks away from the equator; at about 19°S it is about $111 \times 0.94 \approx 105$ km. So $4.7 \times 105 \approx 490$ km.
3. The two legs form a right angle, so use the Pythagorean theorem: $\sqrt{(790^2 + 490^2)} = \sqrt{(624,100 + 240,100)} = \sqrt{864,200} \approx 930$ km.
4. Convert to miles: $930 \div 1.61 \approx 580$ miles.

Answer: About 930 km (about 580 miles), with Brasília to the northwest of Rio de Janeiro.

PRACTICE

1. **EASY** What is the capital of Australia, and why was it built where it is?
2. **EASY** Name the five countries whose flags use the Nordic cross, and the region of this course they belong to.
3. **MEDIUM** The British Union Flag combines three crosses. Name each cross and the land it stands for, and give the year the present flag began.
4. **HARD** Salvador lies at about 13.0°S, 38.5°W, and Brasília at about 15.8°S, 47.9°W. A degree of longitude at about 14°S is about 108 km. Estimate the straight-line distance between Brazil's first and present capitals in km and miles.
(Use the map or drawing "Brasília lies far west of Salvador and a little south." shown earlier in this lesson.)
5. **CHALLENGE** Both Brazil (1960) and Nigeria (1991) moved their capitals from the coast toward the interior. Write two or three sentences giving geographic reasons a country might do this, and one reason it might be difficult.

COMMON MISTAKES

- Assuming a country's largest or most famous city is its capital (Rio de Janeiro, Sydney, Lagos and Istanbul are not capitals).
- Mixing up flags that use the same colors in a different order or arrangement (Ireland and Côte d'Ivoire, Italy and Mexico).
- Using 111 km for a degree of longitude far from the equator. Degrees of longitude shrink toward the poles.

Make it a game • Capital Lightning. The quizmaster holds up a flag card or names a country. The first player to call out the capital and point to it on a wall map scores 1 point; also naming the river, coast or plateau it stands on scores a bonus point. A wrong capital loses a point. After every ten cards, the player in last place chooses the next region. First to 15 points wins.

Scripture. "We will rejoice in thy salvation, and in the name of our God we will set up our banners: the LORD fulfil all thy petitions." (Psalm 20:5, KJV)

Banners and flags gather people together and tell what they stand for. The psalmist sets up his banners in the name of God, a reminder that a nation's true hope rests not in its flag or capital but in the Lord who rules over all nations.

Practice answers

1. Canberra. Sydney and Melbourne were rivals, so Australia chose a site between them for a new planned capital, named in 1913.
2. Denmark, Norway, Sweden, Finland and Iceland; all are in Europe.
3. The cross of Saint George (red on white) for England, the cross of Saint Andrew (white diagonal on blue) for Scotland and the cross of Saint Patrick (red diagonal on white) for Ireland. The present flag dates from 1801.

4. North-south: $2.8^\circ \times 111 \approx 310$ km. East-west: $9.4^\circ \times 108 \approx 1,015$ km. $\sqrt{(310^2 + 1,015^2)} = \sqrt{(96,100 + 1,030,225)} \approx \sqrt{1,126,325} \approx 1,060$ km, about 660 miles.
5. A central capital can draw roads, settlers and trade into a thinly settled interior, sit closer to all regions of the country, and stand apart from the crowding of an old port city or the rivalry between regions. It is difficult because everything must be built from nothing, roads and supplies must travel far inland, and government workers must leave cities with deep roots and established ports.

UNIT 9 REVIEW

Answer each question. Show your work for calculations and use complete sentences for explanations. Give distances in both kilometers and miles. The review is worth 60 points.

1. (10 pts) What is a choropleth map? Charles Dupin made one of the first in 1826. What did his map show, and why did it persuade people better than a table of the same numbers?
2. (10 pts) Colombia had about 51 million people in 2020 on about 1.14 million km² (440,000 square miles). Find its population density in both units. Would it be more or less crowded than Brazil (about 25 people per km²)?
3. (10 pts) Stockholm, Sweden, lies at about 59.3°N, 18.1°E, and Tunis, Tunisia, at about 36.8°N, 10.2°E. (a) Name the course region of each. (b) Estimate the north-south distance between them using latitude alone, in km and miles.
4. (10 pts) As of 2026 the United Nations has 193 member states. Explain why “How many countries are there in the world?” does not have one simple answer. Give two examples.
5. (10 pts) Solve this mystery card and tell which clue made you sure: (1) I am a chain of thousands of islands near the equator. (2) My waters connect the Indian and Pacific Oceans. (3) My islands grow rice on terraced hillsides and export spices. (4) Most of my people are Muslim, though Christians and Hindus also live here. (5) I am the world’s largest island country, and my capital is Jakarta.
6. (10 pts) In 1960 Brazil moved its capital from Rio de Janeiro to Brasília, on the Central Plateau about 930 km (580 miles) northwest of Rio. Give two geographic reasons for the move, and name the three crosses on the British Union Flag and the lands they stand for.

UNIT PROJECT: MY MAP LAB GAME NIGHT

Host a family or co-op Map Lab game night. Prepare and display your two South America choropleth maps (total population and density), your Countries Quiz League deck and scoreboard, at least eight Mystery Region cards (one for each region of this course) and your Flags and Capitals relay cards. Run at least two of the games for your guests. Afterward, write a one-page reflection: which region you now know best, which you need to study more, and one thing these games taught you about how geography shapes the lives of peoples around the world.

- **Accuracy:** Maps, classes, densities, capitals, flags and clues are correct and checked against reliable sources.
- **Map craft:** Both thematic maps have a title, key, date and source, with one color shaded clearly from light to dark.
- **Reasoning:** Mystery cards move from hard to easy and can be solved by reasoning; distance estimates show their work in km and miles.

- **Hosting and reflection:** The games run smoothly and fairly, and the reflection is thoughtful, specific and neatly written.

Answer key

1. A choropleth map shades whole areas lighter or darker according to a number for each area. Dupin shaded the départements of France by how many children were in school compared with the population. People could see at a glance a pattern (more schooling north and east of a line from Saint-Malo to Geneva, less to the south and west) that was hidden in a long table.
2. $51,000,000 \div 1,140,000 \approx 45$ people per km^2 ; $51,000,000 \div 440,000 \approx 116$ people per square mile. Colombia is more crowded than Brazil, nearly twice as dense.
3. (a) Stockholm: Europe. Tunis: the Middle East and North Africa. (b) $59.3 - 36.8 = 22.5^\circ$. $22.5 \times 111 \approx 2,500$ km; $22.5 \times 69 \approx 1,550$ miles.
4. The answer depends on the definition used. The Holy See and Palestine are observer states, not members; some self-governing places such as Taiwan and Kosovo are recognized by some countries but are not UN members; and dependencies such as Greenland or French Guiana belong to other countries. A careful geographer says which count is being used.
5. Indonesia, in Southeast Asia and Oceania. Answers on which clue made the student sure will vary, but should give a reason (for example, Clue 4 rules out the mostly Catholic Philippines; Clue 5 names the capital).
6. Reasons: most Brazilians lived near the coast while the vast interior was thinly settled, and a capital on the Central Plateau would draw roads, farms and towns inland and stand nearer the center of the country. The crosses: Saint George for England, Saint Andrew for Scotland and Saint Patrick for Ireland.