TCM Teacher Created Materials

Smithsonian

STEAM Readers

Science ■ Technology ■ Engineering ■ Arts ■ Mathematics

Lessons and Activities

Earth & Space Science

Table of Contents

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Smithsonian

STEAM Readers

Science ▪ Technology ▪ Engineering ▪ Arts ▪ Mathematics

Management Guide

EARTH & SPACE SCIENCE

TCM Teacher Created Materials

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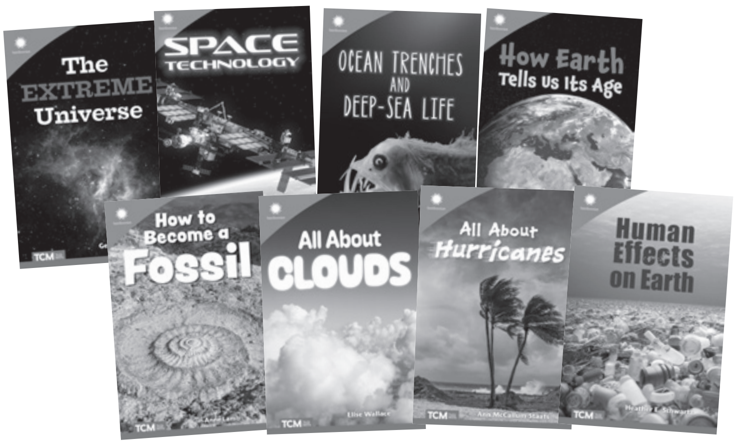
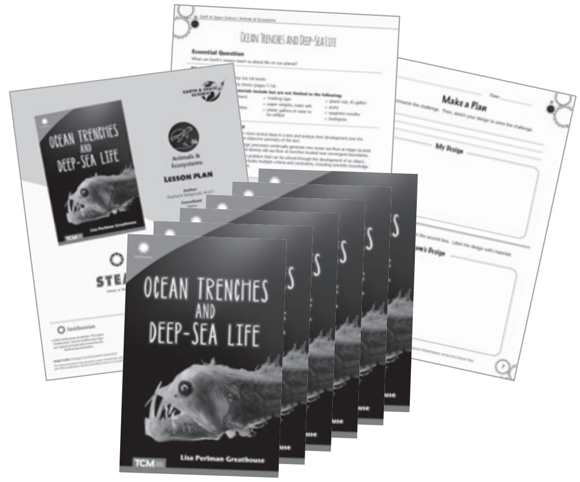
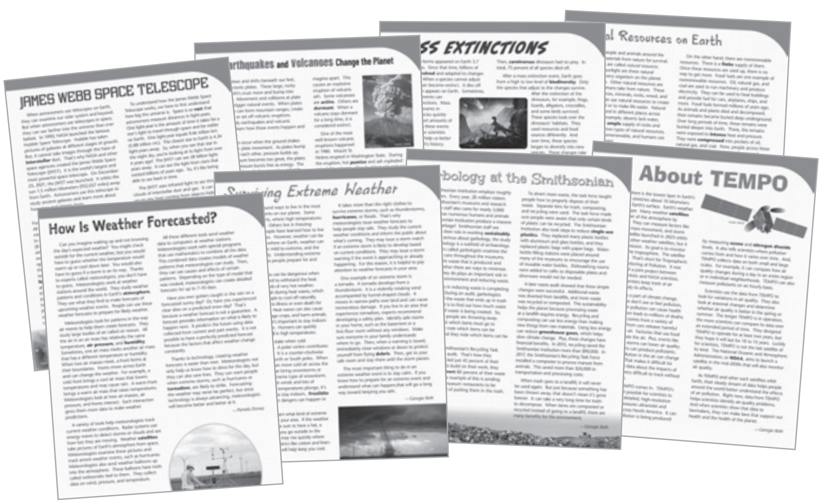
Kit Components

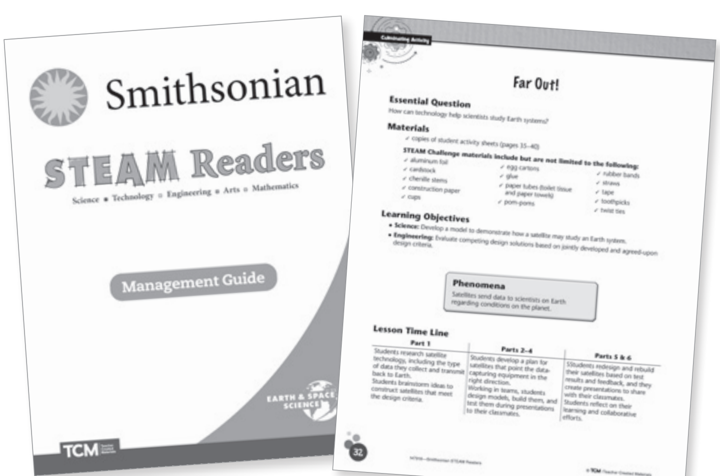
16 lesson plans with 6 copies of each text







Management Guide with Culminating STEAM Challenge



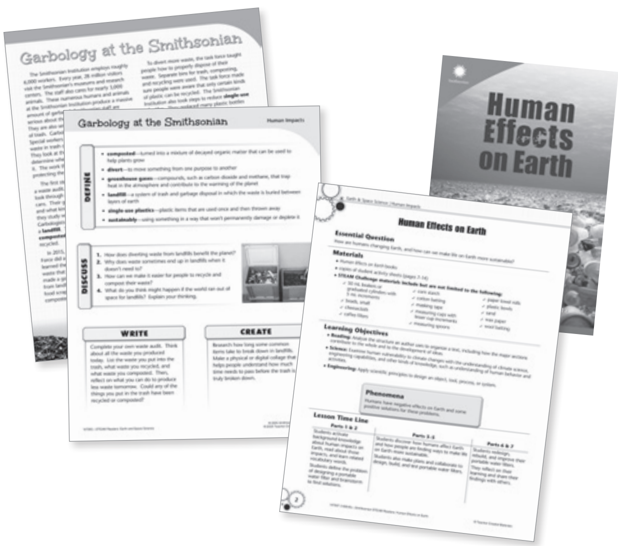
Digital Learning Resources

Lesson Plan Components

Each lesson sequence is organized in a consistent format for ease of use.

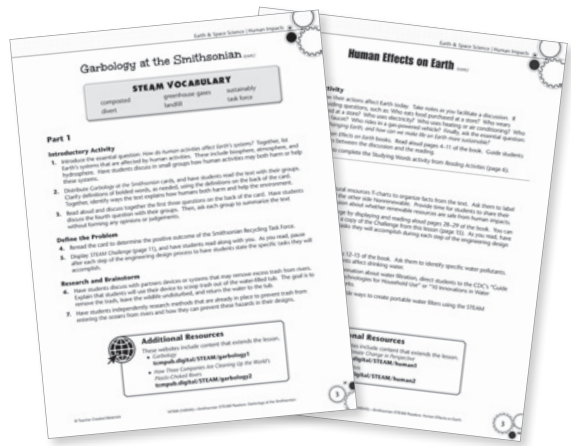
Overview

- The overview page includes the essential question, learning objectives, a materials list, and a suggested time line for lessons.



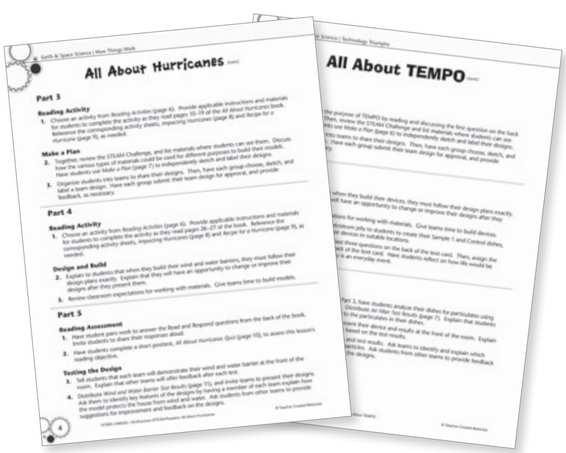
Introducing and Defining the Problem

- Students are presented with the essential question and science concepts in the text.
- Students are introduced to the STEAM Challenge, then actively read and research to help complete the challenge.



Designing, Building, and Testing the Solution

- Students create plans to solve the STEAM Challenge.
- Students apply their plans to design, build, and test their solutions.



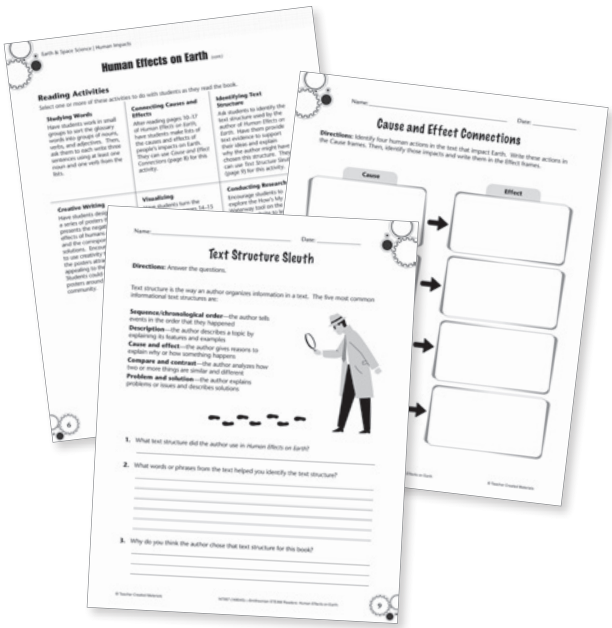
Rebuild, Retest, Reflect, and Share

- Students take what they've learned and apply it to rebuild and retest their solutions.
- Students reflect, share work, and take assessments.

Lesson Plan Components *(cont.)*

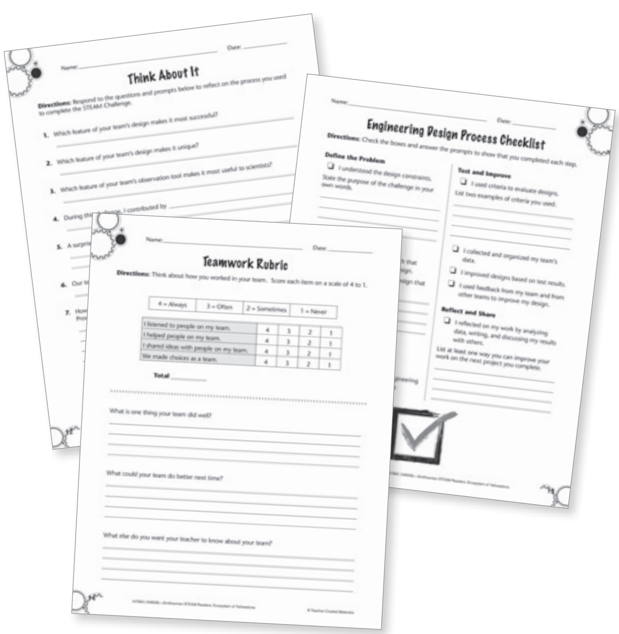
Student Activity Sheets

Literacy skills are supported with meaningful activities that promote higher-order thinking skills.

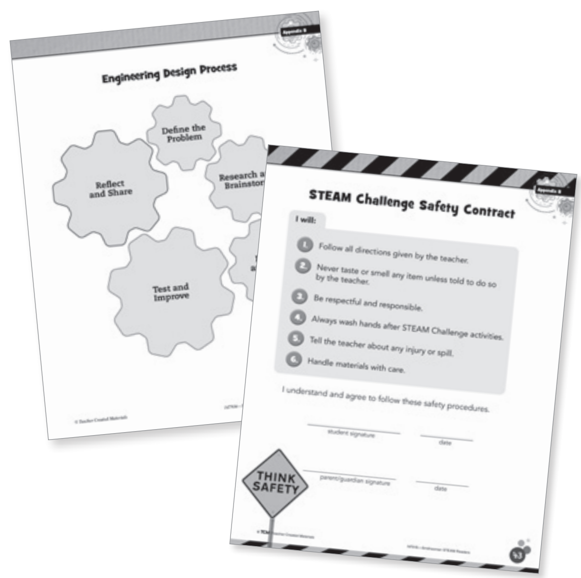


STEAM Challenge activity sheets support students throughout the engineering design process.

Reflection activities provide opportunities for students to consider collaborative processes.



Appendix C includes quick reference sheets for students and teachers.



Smithsonian

OCEAN TRENCHES AND DEEP-SEA LIFE

Lisa Perlman Greathouse

TCM Teacher Created Materials

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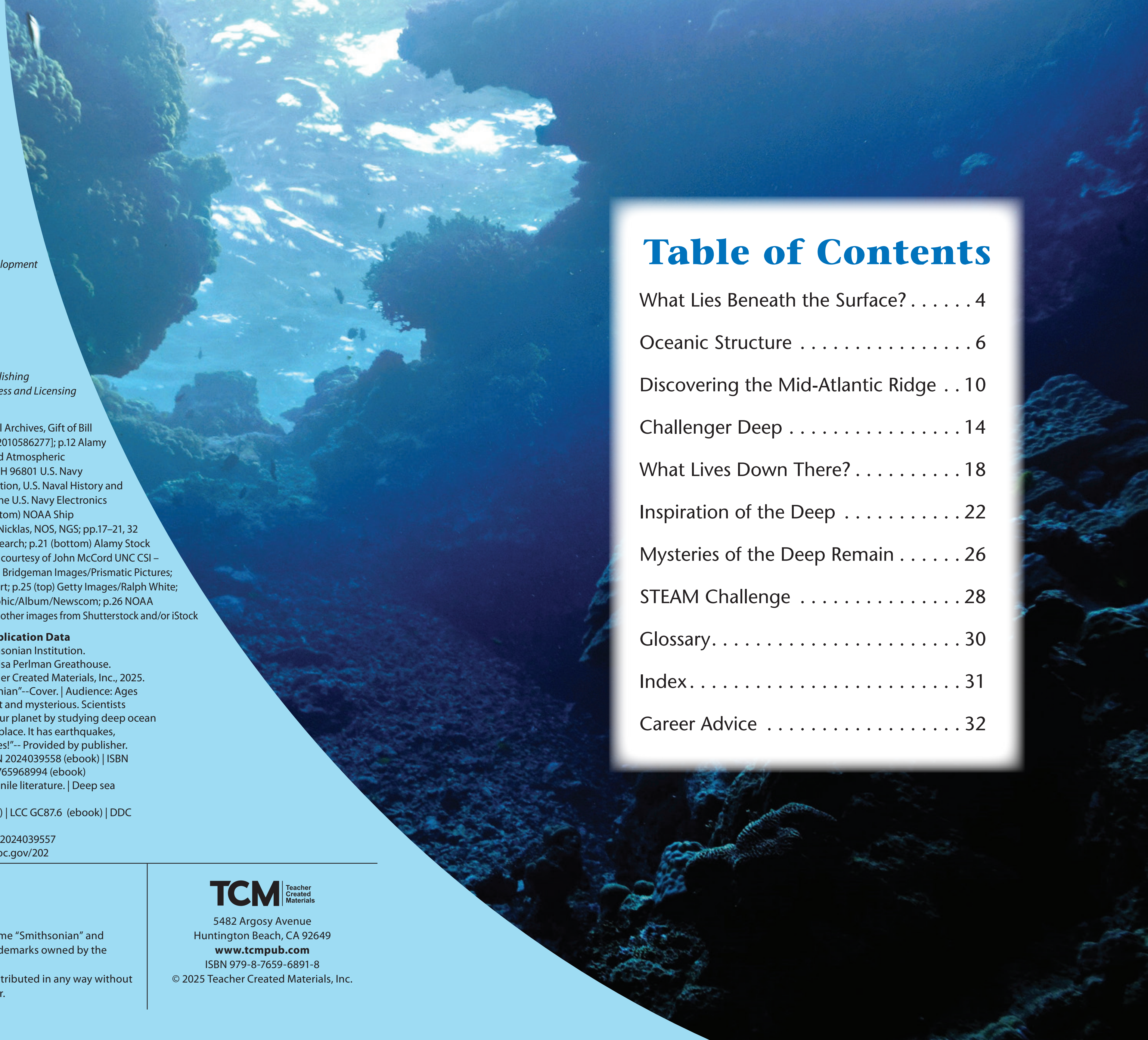

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What Lies Beneath the Surface?

For centuries, people have wondered what lurks below the surface of Earth's oceans. Beneath the glistening water, oceans are complex, mysterious, **dynamic**, and deep. And because Earth's surface is about 70 percent water, that means most of the surface of our planet is under the oceans. Movies and books have explored the subject, sometimes playing off our fears of the unknown. What strange creatures might lurk deep in the darkness below?

Scientists have been studying the very bottom of Earth's oceans for decades. They have discovered the ocean floor holds answers to questions about our planet's formation. Scientists once thought the ocean floor was a flat, still, and boring place. Now, we know the seafloor is always changing. Frequent earthquakes and volcanic eruptions can shake things up. And creatures unlike anything on Earth's surface live in the depths. The deep sea is the largest **biome** on Earth.

Think of the ocean floor the same way you think about land on Earth. There are multiple levels: flat plains, gentle hills, towering mountain peaks, and deep **trenches**. There's a lot to learn about the world under the water's surface, so let's dive in!

FUN FACT

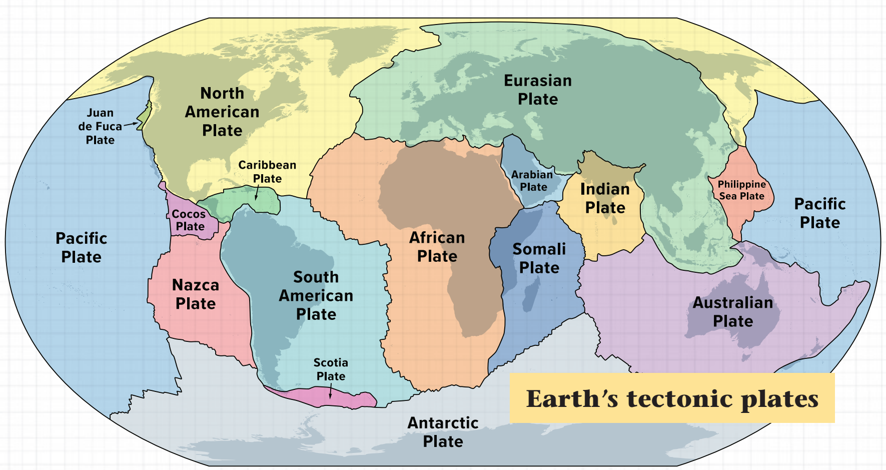
This 1972 photo of Earth from outer space is called *The Blue Marble*. In the image, you can see how much water makes up the planet's surface.

Oceanic Structure

If you're seeking the deepest valley on Earth, you won't find it on land. It's deep in the ocean! The deepest ocean trench reaches roughly 10,935 meters (35,876 feet) below the water's surface. The way ocean trenches form is tied to the structure of Earth's crust. The crust is a thin layer of rock that makes up Earth's surface. Continental crust exists on land, and **oceanic crust** exists at the bottom of oceans.

All of Earth's land—both above and below water—sits on tectonic plates. These are like huge puzzle pieces of Earth's crust. They are made of solid rock. Under each plate is a weaker layer of partially melted rock. For hundreds of millions of years, these plates have been shifting around and bumping into each other. As the plates move, the continents on them move, too. The theory of plate tectonics explains how plates move and interact with one another.

The structure of the oceans is caused by the way tectonic plates move over time. The shallowest parts of oceans are along the edges of continents. They are called *continental shelves*. They are extensions of what's found on the land around them. For example, shelves along the coastline of plains are flat or gently sloping. Shelves along mountainous coasts are steep. Shelves **descend** toward the deep ocean floor in what is called the *continental slope.*



Earth's tectonic plates

Ocean Depths

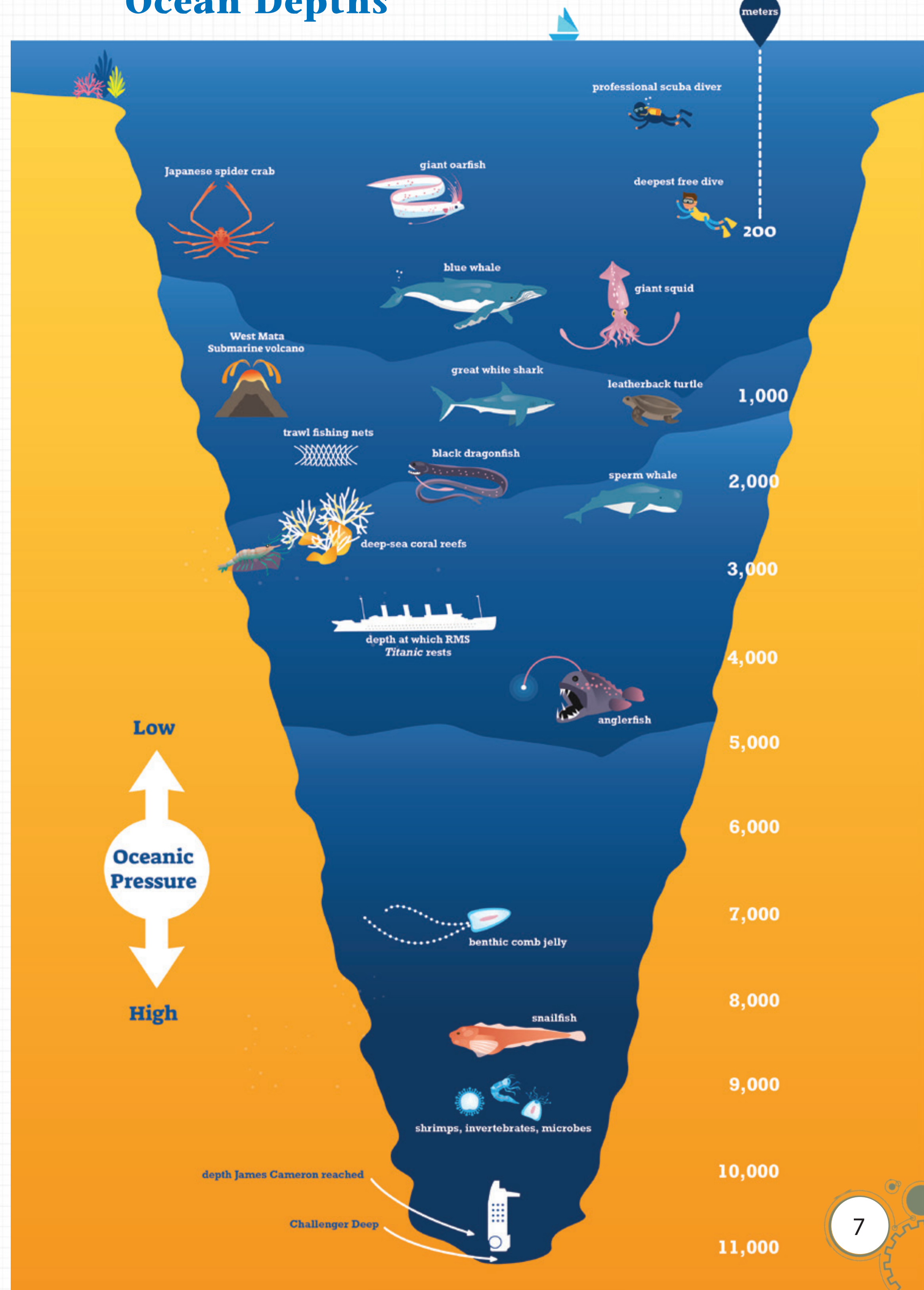
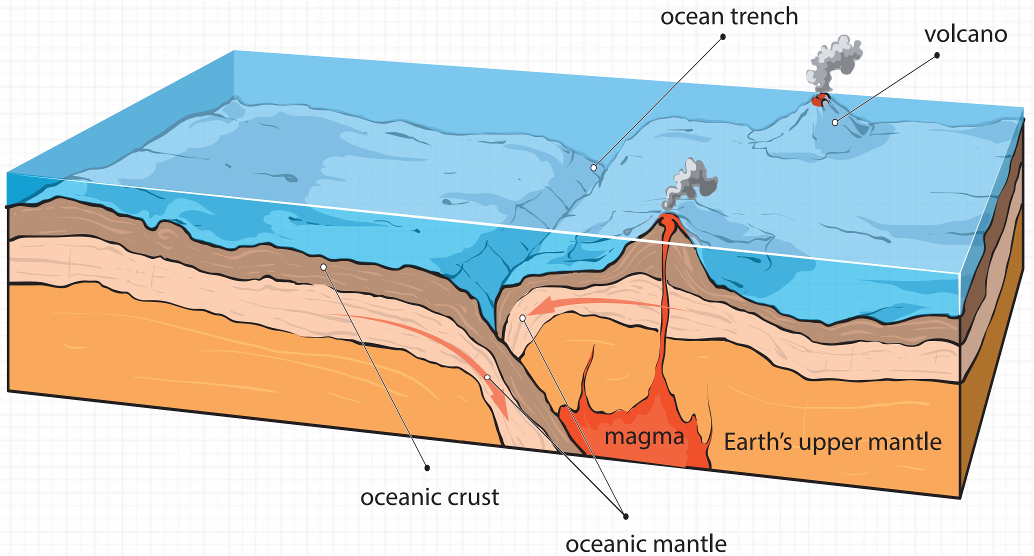


Plate Movement

The collisions of tectonic plates can cause earthquakes and volcanic eruptions, both on land and in the water. Underwater earthquakes can sometimes result in tsunamis. These are giant walls of water. When they crash ashore, they can cause widespread destruction.

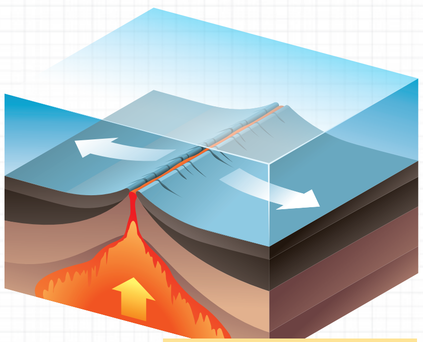
Sometimes, when the edges of tectonic plates rise up, underwater mountain ranges are formed. Other times, one plate may slide under another plate. Areas where this occurs are **subduction** zones. When two plates meet at a subduction zone, a deep ocean trench can form.



Seafloor Spreading

With tectonic plates sliding under each other, you might wonder why Earth isn't shrinking. That's because the plates sometimes pull apart instead. When that happens, it's called *seafloor spreading*. It may only be a few inches a year—but it adds up!

Seafloor spreading creates a new seafloor. You might expect valleys or trenches to form where plates pull apart. But instead, **magma** fills in the gaps. When seafloor spreading happens slowly, it can result in steep cliffs and mountains on the ocean floor. When it happens quickly, it can cause gentle slopes and result in new geographic features. For example, the Red Sea was created when the African plate and the Arabian plate split apart.

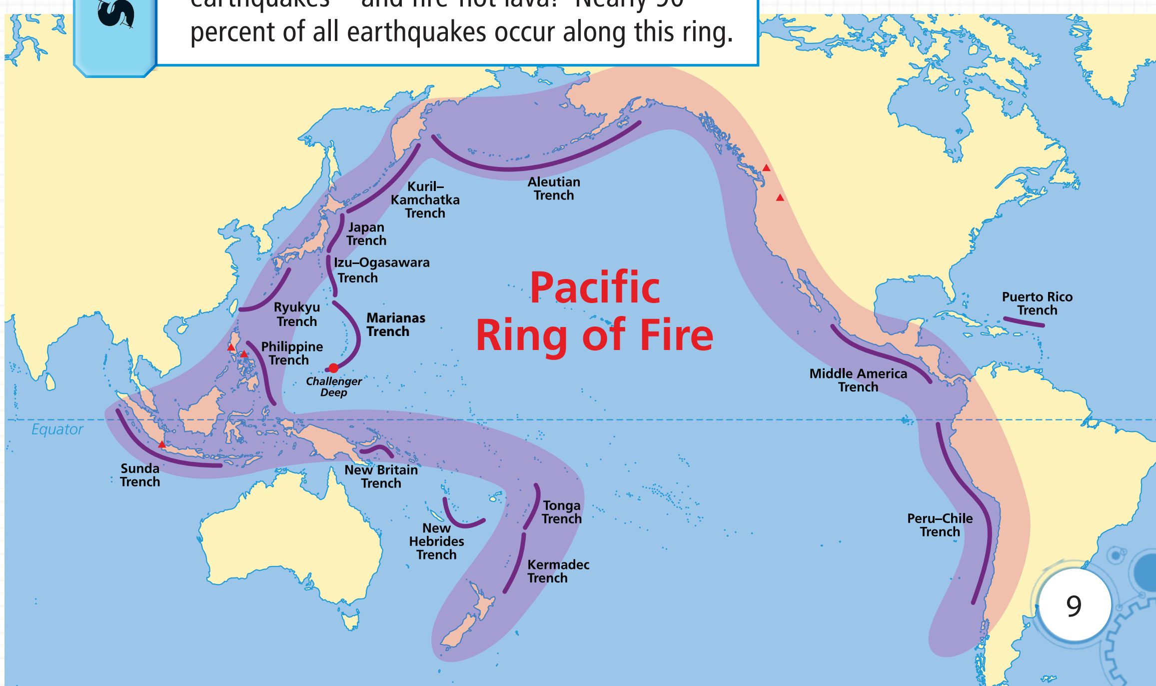


Seafloor spreading occurs when magma rises up to the boundaries of two tectonic plates.

SCIENCE

Ring of Fire

Deep trenches can be found in all oceans, but most are found in the Ring of Fire. This is a ring-like area around the Pacific Ocean. Its name comes from its many volcanoes and earthquakes—and fire-hot lava! Nearly 90 percent of all earthquakes occur along this ring.



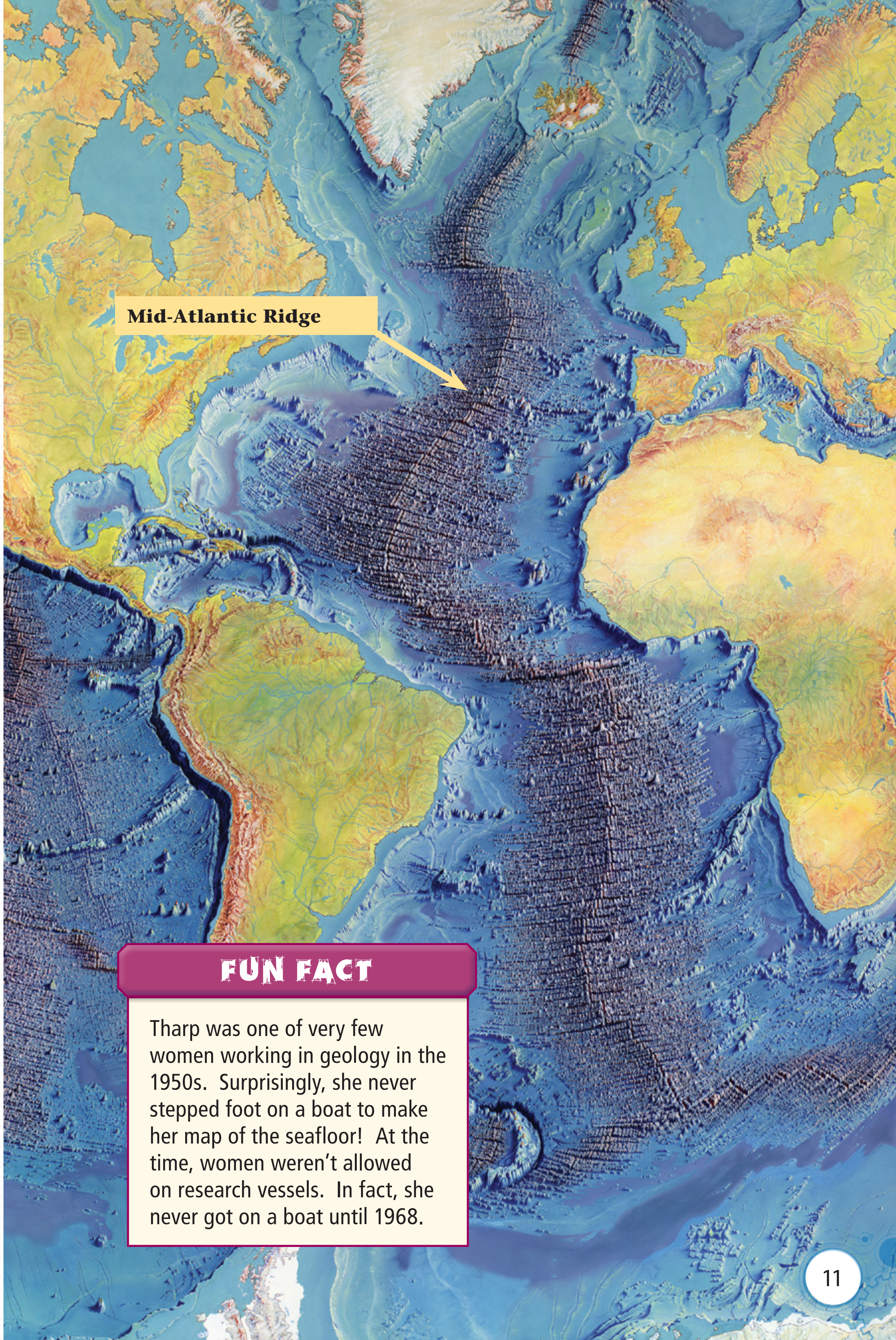
Discovering the Mid-Atlantic Ridge

Plate tectonics explains how Earth's surface is broken into larger pieces of crust that move. This theory gave **geologists** a way to understand how Earth's surface has evolved. Before scientists discovered plate tectonics, they assumed the seafloor was flat and unchanging. However, they couldn't have been more wrong.

In the 1950s, scientists began learning more about the ocean floor. A **cartographer** named Marie Tharp began mapping the ocean floor. She worked with her colleague, Bruce Heezen. Heezen went onto research **vessels** to collect data. These vessels collected **sonar** data. Then, Tharp examined the data and plotted it onto a map. Her findings surprised many researchers. Instead of a plain, flat environment, Tharp had charted something very different. The landscape she mapped was complex. Just like on land, there were steep mountains, deep trenches, and sprawling plains.

One of the pair's most incredible finds was the Mid-Atlantic Ridge. This huge underwater mountain range spans the entire length of the Atlantic Ocean! In some parts, it is up to 1,500 kilometers (932 miles) wide. It is the longest mountain range on Earth. It follows a curving path from the Arctic Ocean to the southern tip of Africa. Some of the mountains in this range go above the surface of the ocean to form islands. Iceland is one of the islands formed by this mountain range.

Marty Weiss, Al Ballard, and Marie Tharp work on the research ship USNS *Kane* in 1968.



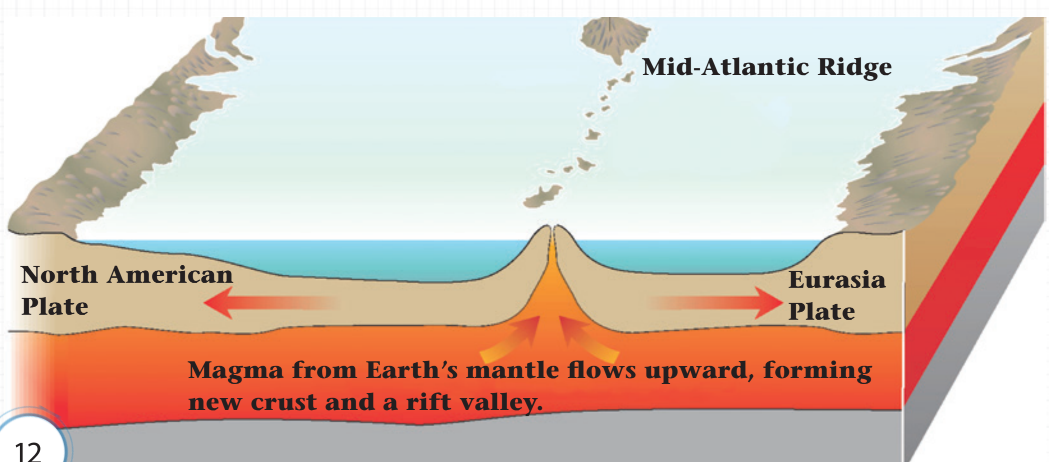
FUN FACT

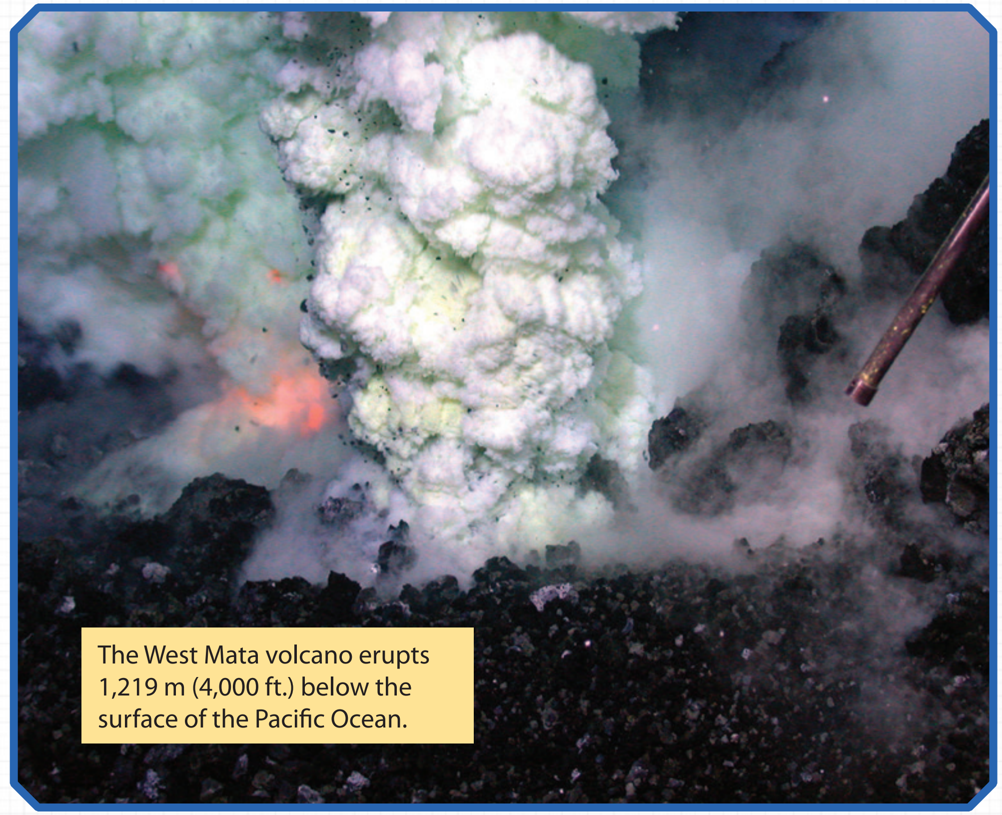
Tharp was one of very few women working in geology in the 1950s. Surprisingly, she never stepped foot on a boat to make her map of the seafloor! At the time, women weren't allowed on research vessels. In fact, she never got on a boat until 1968.

Evidence of a Rift Valley

At the time of Tharp's work, the idea of plate tectonics was controversial. So, when Tharp found evidence of a huge valley within the Mid-Atlantic Ridge, she was surprised. Her calculations pointed to evidence of a rift valley. This is a low-lying place on Earth that forms when Earth's tectonic plates rift, or move apart. Tharp kept rechecking her calculations. If there was indeed a valley, that would mean the mountains she was mapping included a place where the oceanic crust was spreading apart. It would support the idea of seafloor spreading *and* plate tectonics. But at first, no one believed what Tharp had found—not even Heezen! It took months for her to convince him. Once it became clear that this rift went through the entire ocean, Heezen and other scientists believed her.

Today, some scientists refer to the Mid-Atlantic Ridge as a spreading center. It is a place where the tectonic plates pull apart slowly, about 2 to 5 centimeters (0.8 to 2 inches) per year. The tallest parts of the ridge are connected by a deep rift valley between them. The valley is up to 3 km (2 mi.) deep. That is about the depth and width of the Grand Canyon! In this valley, magma comes to the surface of the ridge through Earth's crust. It is cooled by the deep ocean water and is pushed away, forming new crust.

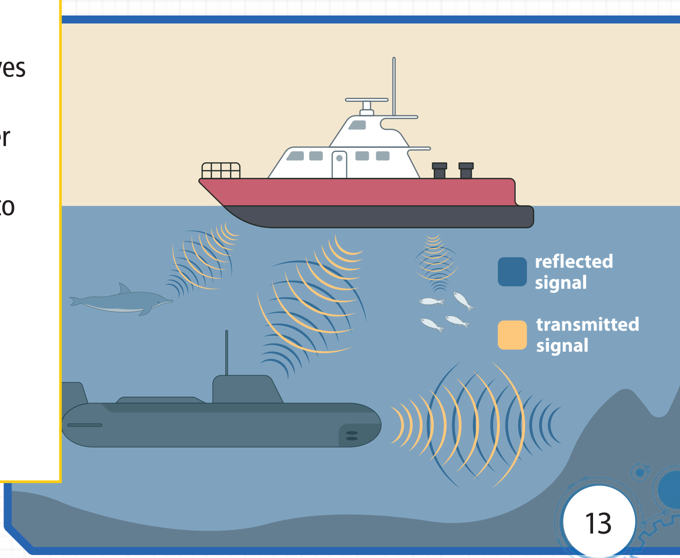



The West Mata volcano erupts 1,219 m (4,000 ft.) below the surface of the Pacific Ocean.

TECHNOLOGY

Sonar

Sonar uses sound waves to detect the location and size of underwater objects. First, sound waves are sent out into the water. When the waves hit an object, reflections, or echoes, return to a receiver. These reflections tell where and how far away an object is.



Challenger Deep

It's hard to fully grasp just how vast and deep Earth's oceans are. Over 70 percent of the planet is covered by the Atlantic, Pacific, Indian, Arctic, and Southern Oceans. The average depth of our oceans is about 3,600 m (11,811 ft.). But, there are spots that are much deeper—in fact, more than three times as deep.

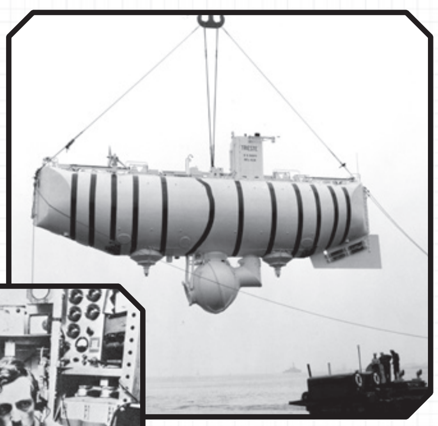
The deepest known point of our oceans is the Challenger Deep. It is part of the Mariana Trench in the Pacific Ocean, near the island of Guam. It is 10,935 m (35,876 ft.) deep. That is almost 11 km (7 mi.). It is so deep that you could fit Mount Everest inside. That is Earth's highest point on land. And still, Everest's peak would be more than a mile below the surface of the water! The Mariana Trench is long, too. It stretches for about 2,550 km (1,580 mi.) underwater.

The Mariana Trench formed from the movement of tectonic plates. Long ago, two plates collided. One plate was forced under the other. The old oceanic crust slid downward, creating a deep trench.

ENGINEERING

Exploring the Deep

Jacques Piccard and Lieutenant Don Walsh were the first people to go to the bottom of the Mariana Trench. They used a **submersible** called the *Trieste*. On January 23, 1960, they reached a depth of around 10,916 m (35,814 ft.). The whole journey took about nine hours to complete.



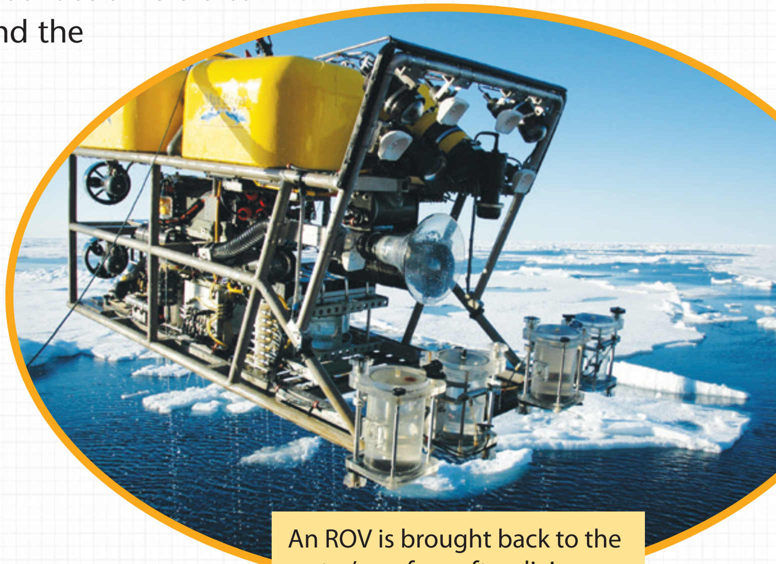
Piccard and Walsh travel in the *Trieste* (above).

Under Pressure

As of July 2022, just 27 people have traveled down to the depths of the Mariana Trench. A big reason why the deepest parts of our oceans are such a mystery is because they are not safe for humans and are difficult to access. Diving that deep means experiencing dangerous conditions. For example, underwater **vents** can spew out liquids that range from 60 °C (140 °F) to greater than 400 °C (752 °F). In other spots, the water is near freezing. Plus, there is no light. But the biggest challenge is the extreme pressure.

When diving to the bottom of a swimming pool, you may get an unpleasant feeling in your ears and sinuses. That is because the deeper you go, the more pressure there is. The weight of the water above pushes on any object below it. So, the lower a diver descends, the more water pushes down and against them. The farther down they go, the more intense the pressure. It is recommended that most advanced recreational divers only reach 40 m (130 ft.) deep. At the bottom of the Mariana Trench, the pressure can be about one thousand times the pressure at sea level!

Luckily, scientists have created other ways to explore the deepest parts of the oceans. Remotely operated vehicles, or ROVs, can survive the depths. These vehicles do not have people in them and are controlled from above the water. Specially built submersibles can also withstand the pressure. These vehicles allow scientists to take photos and measurements of the seafloor.



An ROV is brought back to the water's surface after diving deep in the Arctic Ocean.

MATHEMATICS

Dive In!

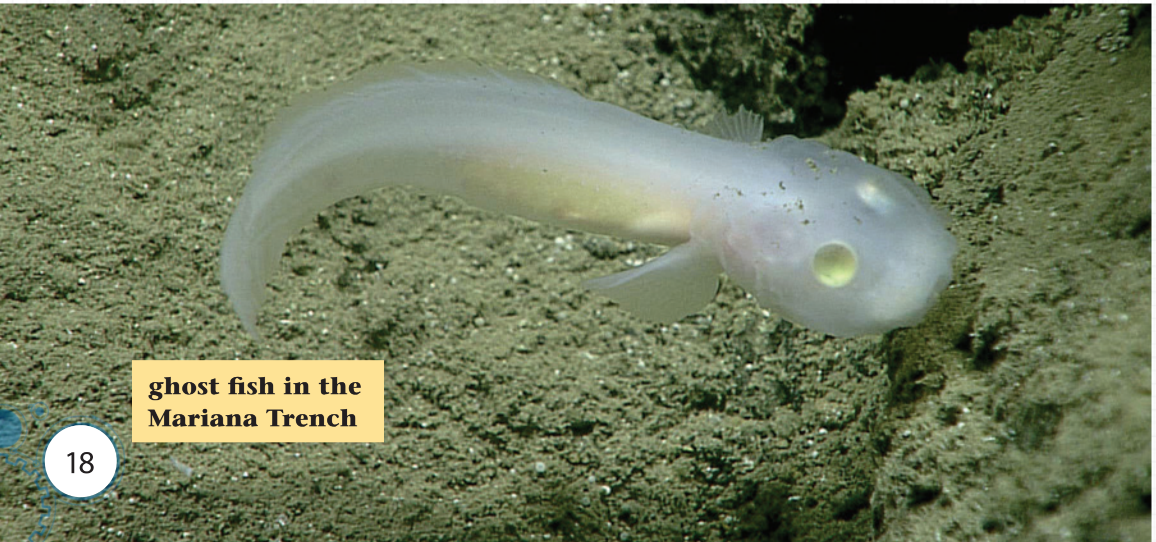
When divers jump off the side of a boat, math plays a big part in staying alive underwater. Divers prepare by studying temperatures and charts that help them calculate how many minutes they can safely dive at different depths. Due to the intense pressure, the deeper they dive, the less time they can safely stay under water. Plus, they can only carry so much air for their time underwater.

What Lives Down There?

What kinds of creatures could possibly survive the harsh conditions of the deep sea? They would have to be able to tolerate extreme heat and freezing cold. Don't forget the intense pressure and total darkness.

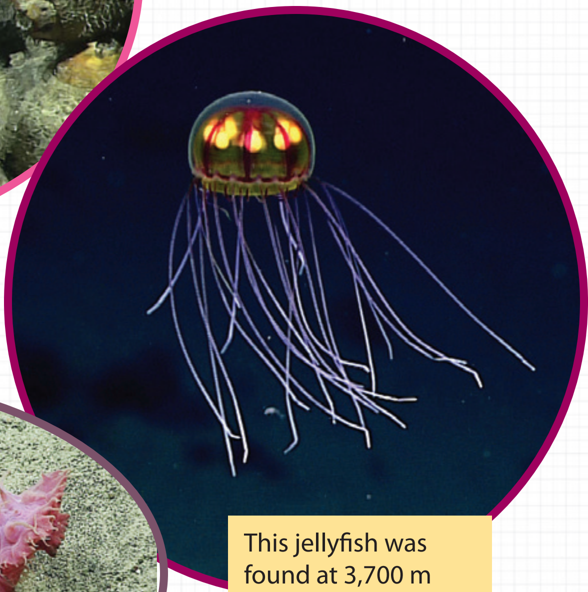
Believe it or not, the seafloor ecosystem is crawling with life. Scientists estimate that there are 2.2 million species in our oceans. And they have only identified a small fraction of them! Studying these species in the intense pressure of the deep sea is a difficult task. But what scientists have learned is that deep-sea species are unlike species in shallow waters. And those differences can tell us a lot about how the environment shapes life underwater.

Deep-sea species tend to have unusual appearances. There are hairy snails and ghostly shrimp. There are tiny octopuses and "zombie worms" that burrow into whale bones to eat the fat inside. Some of these organisms are **translucent**, so you can see their insides. This protects them from being spotted by predators in the darkness. A commonly found species is **xenophyophores**, which look like they would grow on a coral reef. Scientists have discovered small sea cucumbers and **amphipods**, which are little underwater scavengers.

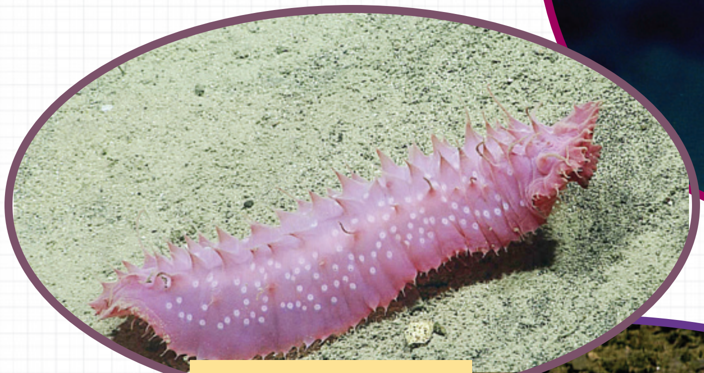


ghost fish in the Mariana Trench

Snails attached to hot water vents were found at a depth of 980 m (3,215 ft.).



This jellyfish was found at 3,700 m (12,139 ft.).



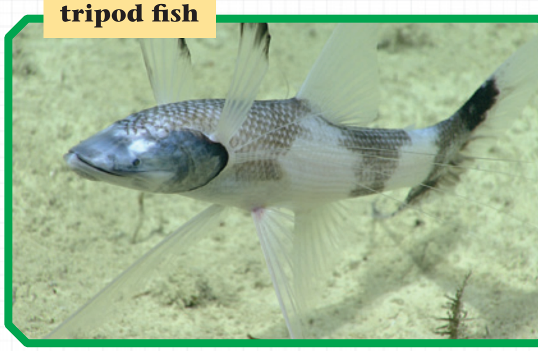
deep-sea cucumber

This blind lobster was found at 675 m (2,215 ft.).

Unusual Creatures Abound

Scientists discovered a new deep-sea species of octopus. They nicknamed the species the "flapjack octopus" because their bodies make them look like pancakes. Their bodies bounce when they swim, and they have webbing between their arms. Their fins are on their heads, and they help with swimming. This species is so cute that scientists considered giving it the scientific name *adorabilis*—a play on the word *adorable*.

A flapjack octopus can grow up to 50 centimeters (20 inches) in size.



tripod fish

The tripod fish gets its name from its long fins. It pumps fluid into its fins to make them look like stilts or a tripod. It rests on its fins and waits for prey to come by. Meanwhile, its top fins can detect predators swimming above it. Since this fish has very small eyes, it relies on its fins to sense the environment around it.

The Mariana snailfish is believed to hold the record for the deepest living fish on the seafloor. One was found at 7,966 m (26,135 ft.) deep! This species looks a bit like a tadpole. It has a bulging head and a partly transparent body. It has winglike fins that help it hunt for food, and it is thought to be one of the top predators along parts of the Mariana Trench.

The aptly named fangtooth fish has large, sharp teeth. This species only grows to about 15 cm (6 in.) long, but it can eat much larger fish because of its big jaw and large teeth. It has limited eyesight and finds its prey by sensing movement.

fangtooth fish

Inspiration of the Deep

Humans have always been intrigued by the mysteries of the oceans. But, it's not just researchers who have looked to the sea for inspiration—so have all types of artists. For centuries, images of the deep sea have been represented in our culture and art. Some of the first modern **atlases** included artwork of scary sea creatures. Earth's oceans have inspired some of our most famous literature, film, art, poetry, and music. The oceans are also well represented in the Bible and in Greek mythology. As long as humans have been on Earth, the deep sea has been a great source for stories.

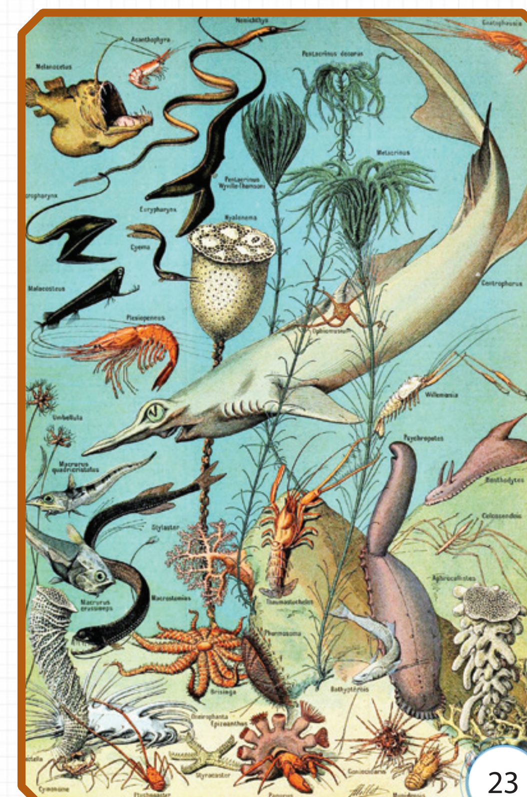
Some artists join research vessels and go on **voyages** to the ocean floor. Along the way, they see firsthand some of the creatures of the deep bathed in the vehicles' lights. Then, when they resurface, they paint these creatures so other people can truly appreciate the beauty of what lies below. Some artists have even used real **sediment** from the ocean floor in their artwork.

Scientists prepare for a dive in a submersible.

ARTS

Deep Reading

The deep sea provides the backdrop of some of the great literary classics. *Moby Dick* is a well-known novel by Herman Melville that was published in 1851. It tells the story of a sea captain's battle with a great white whale.

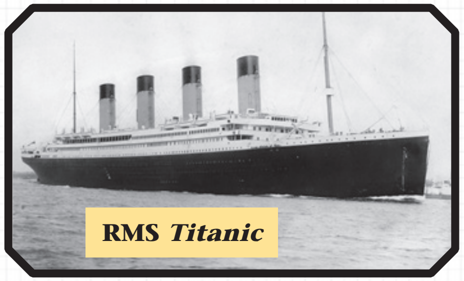


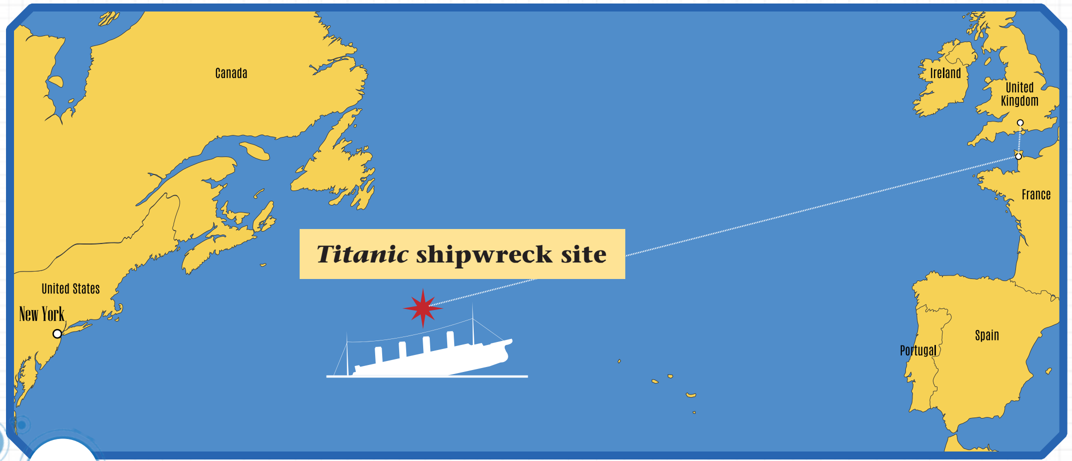
illustrations of deep-sea life from 1923

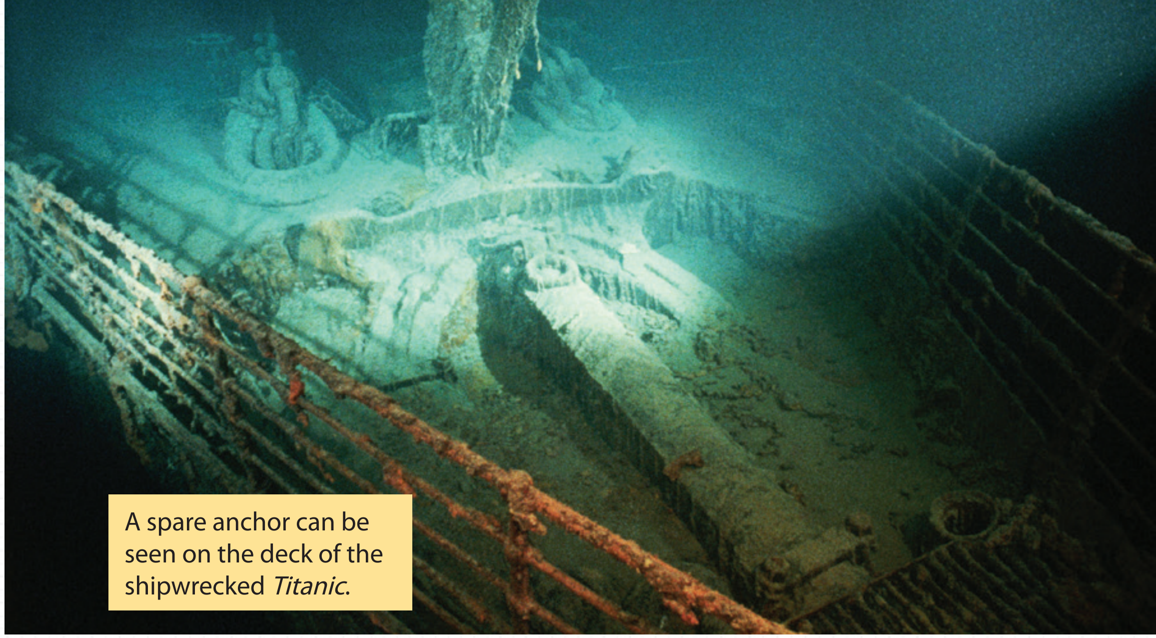
Exploring a Shipwreck

The true story of the RMS *Titanic* has inspired art and intrigue about the bottom of the sea. On April 14, 1912, this luxury passenger ship was on its first voyage. As it traveled from England to New York, it hit an iceberg and sank to the bottom of the Atlantic Ocean. More than 1,500 people lost their lives. Hundreds of people escaped on lifeboats.

Immediately, people wanted to bring the ship to the surface. But they couldn't figure out how to withstand the immense pressure of the seafloor. Plus, they didn't know the exact location or condition of the ship. For decades afterward, the exact site of the wreckage remained a mystery. In 1985, it was found at last. A marine geologist named Dr. Robert Ballard and an **oceanographer** named Jean-Louis Michel worked with a team of explorers. They found the wreckage at a depth of about 3,800 m (12,500 ft.). It was near the coast of Newfoundland, Canada. In 1986, a submarine and an ROV were used to explore the wreckage. Today, scientists around the world continue to study the *Titanic*.


RMS *Titanic*



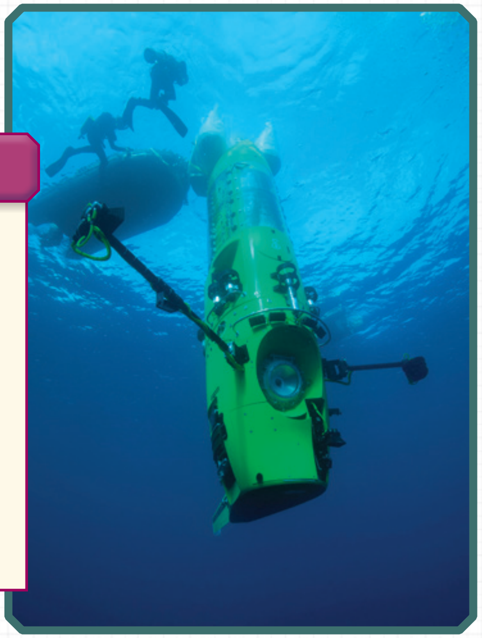

A spare anchor can be seen on the deck of the shipwrecked *Titanic*.

Since then, thousands of artifacts have been recovered from the ship. The story of the *Titanic* has inspired many works of art, including poems, songs, paintings, and films.

The 1997 hit movie *Titanic* was based on the disaster and the search for the wreckage. The director, James Cameron, made more than 30 dives to the wreckage site. His real-life search for the *Titanic* inspired him to make the film.

FUN FACT

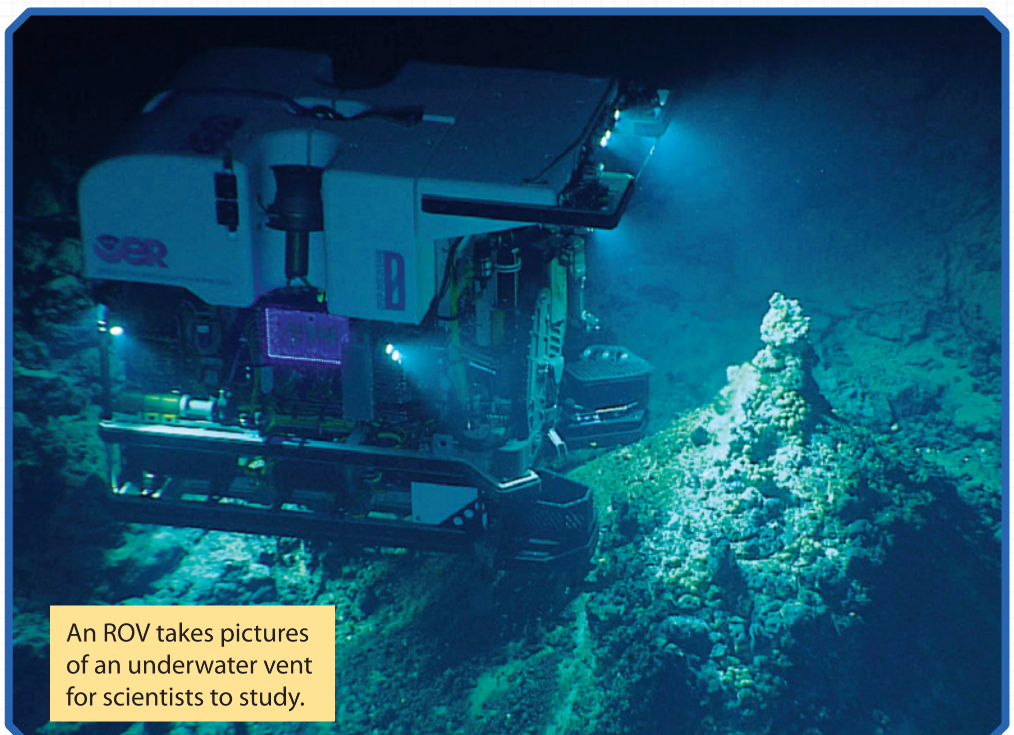
James Cameron is among the people who have traveled to the bottom of the Mariana Trench. He made the journey by himself in a special capsule. He discovered new species, including a sea cucumber and squid worm!



Mysteries of the Deep Remain

Earth's oceans have unique structures and are full of fascinating creatures. Scientists have only explored about five percent of our oceans. The intense pressure, coldness, and darkness of deep water make the oceans difficult to explore. Ocean trenches, the deepest parts of our planet, contain many unsolved mysteries.

Still, scientists do all they can to learn about these remote places on Earth. Scientists think ocean trenches could hold many answers to questions about how Earth functions. Trenches have shown us how the movement of tectonic plates causes continents to move over time. Deep water shows us how species can adapt to harsh conditions.



An ROV takes pictures of an underwater vent for scientists to study.

The ribbon sawtail fish is found at depths over 500 m (1,640 ft.).

In the past few decades, scientists have made huge advances in deep-sea exploration. What they have learned so far hints at the existence of previously unknown species and ecosystems. They also hint at how nature is affected by humans. The more we learn, the more we believe these remote areas may play a vital role in our lives on land. They may also provide insight into earthquakes and volcanoes. But until we find ways around the challenges of exploring the deepest points of the sea, more questions will remain than answers. As always, scientists continue to collect data on our underwater world, bringing light to the darkness.

STEAM CHALLENGE

Define the Problem

Near the Ring of Fire, nearly 20 different ocean trenches exist. This means that for people living in the area, earthquakes and tsunamis are a constant threat. Architects are seeking new construction ideas for buildings that can withstand earthquakes and tsunamis. To help the architects, you will design and test a structure model against both catastrophic events.

Constraints: You may only use the materials provided to you.

Criteria: Your structure must fit onto a paper plate and must be at least 46 centimeters (18 inches) tall. It must remain standing without structural damage during both the mock earthquake and tsunami.

1 Research and Brainstorm

How do earthquakes affect human-made structures? What are the current designs that architects are using? In what way do tsunamis damage structures? How can one design withstand both natural disasters?

2 Design and Build

Using your research, sketch a model of your structure. Be sure to label the materials you will need and how it will be fastened to your paper plate. Meet with your team members to discuss each of your ideas. Then, create one final design using the best ideas from all participants. Collect the materials needed and build your model.

3 Test and Improve

Two group members will place the model on a desk at the front of the room. Holding onto opposite sides of the plate, the group members will push and pull the plate for 15 seconds to simulate an earthquake. Then, they will place the plate into a bin filled with water and put a weight on top of the plate. Two group members will hold the sides of the bin, sloshing the water back and forth gently for 15 seconds to simulate a tsunami. After this, remove the model and inspect it for damage. What modifications can you make? Make adjustments and retest.

4 Reflect and Share

What surprised you during this challenge? What hardships did you and your team have to work through? How may different building materials play a part in how earthquakes and tsunamis affect them?

Glossary

amphipods—group of small crustaceans, or animals that have exoskeletons and two pairs of antennae

atlases—books of maps

biome—a major type of ecological community (such as a tropical rainforest)

cartographer—a person who makes maps

descend—to move downward

dynamic—characterized by constant change

geologists—scientists who study the history of Earth and its life, especially as recorded in rocks

magma—molten rock material within Earth

oceanic crust—the thin part of Earth's crust that is beneath the oceans

oceanographer—a scientist who studies the oceans

sediment—solid material (such as stones and sand) deposited by water, wind, or glaciers

sonar—a method for detecting objects underwater by sending out sound waves that are reflected back

subduction—process in plate tectonics when the edge of one tectonic plate slides under another

submersible—a small underwater craft used for deep-sea research

translucent—not transparent but clear enough to allow light to pass through

trenches—long, narrow depressions or ditches in the ground

vents—openings for the escape of gas or liquid, or for the relief of pressure

vessels—ships or boats

voyages—long journeys

xenophyophores—single-celled organisms that live at depths of 500 to 10,600 m (1,640 to 34,777 ft.) in the oceans

Index

CAREER ADVICE
from Smithsonian

Do you want to study the oceans?

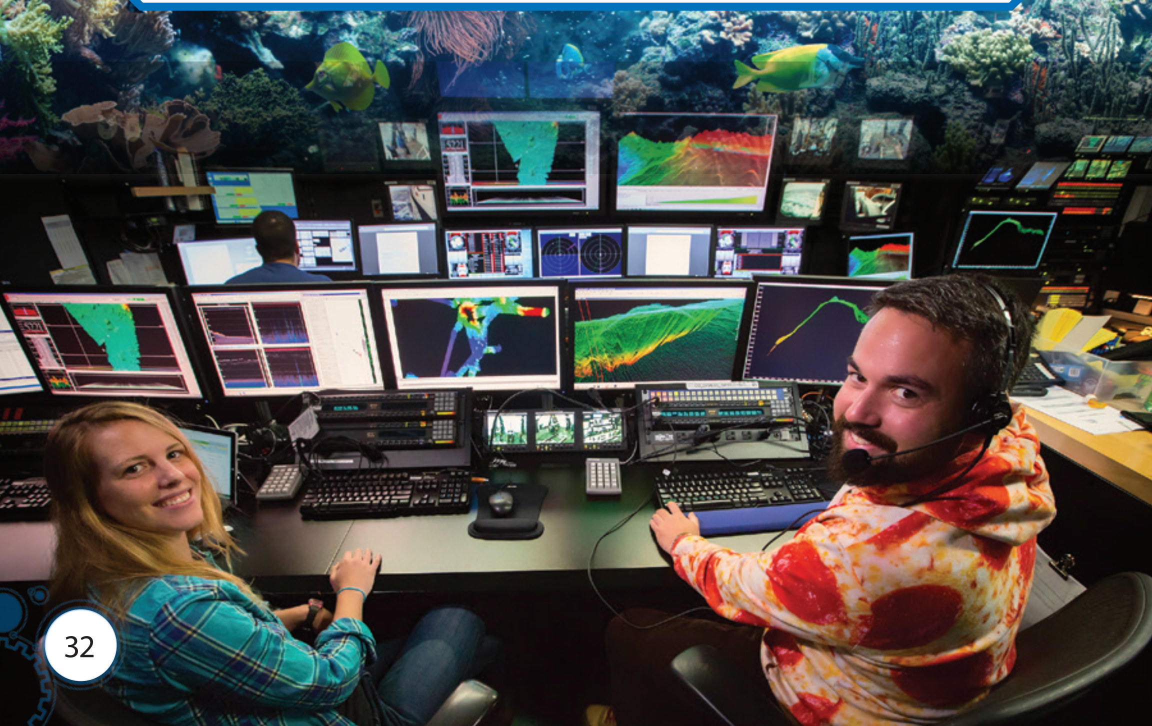
Here are some tips to keep in mind for the future.

"Build a model of an ocean trench using clay or sand. It's a fun way to visualize the incredible depths of our oceans."

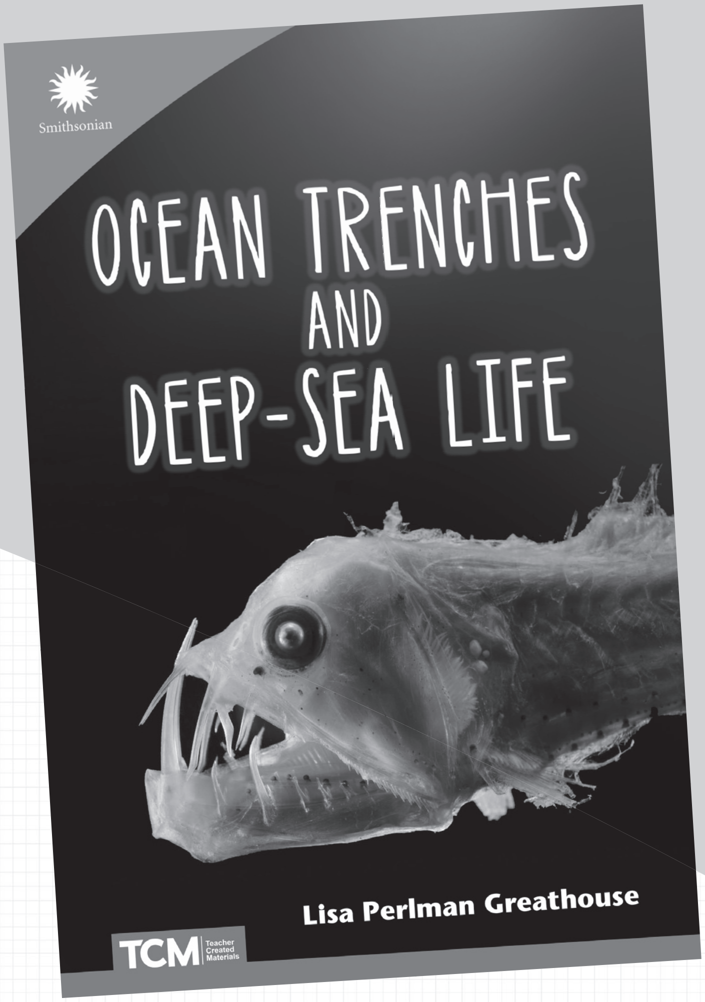
*– **Dr. Erin Dillon**, Postdoctoral Researcher, Smithsonian Tropical Research Institute*

"Examining maps of the ocean floor is an amazing way to explore our planet's underwater landscapes and ocean trenches."

*– **Dr. Kimberly García-Méndez**, Lab Manager, Smithsonian Tropical Research Institute*



EARTH & SPACE SCIENCE



Animals & Ecosystems

LESSON PLAN

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Ocean Trenches and Deep-Sea Life

Essential Question

What can Earth's oceans teach us about life on our planet?

Materials

- *Ocean Trenches and Deep-Sea Life* books
- copies of student activity sheets (pages 7–14)
- **STEAM Challenge materials include but are not limited to the following:**
  - ✓ balsa wood, assortment of sizes
  - ✓ disposable plastic plates
  - ✓ marshmallows, mini
  - ✓ masking tape
  - ✓ paper weights, water safe
  - ✓ plastic gallons of water to be refilled
  - ✓ plastic tub, 45-gallon
  - ✓ putty
  - ✓ spaghetti noodles
  - ✓ toothpicks

Learning Objectives

- **Reading:** Determine two or more central ideas in a text, and analyze their development over the course of the text; provide an objective summary of the text.
- **Science:** Examine how geologic processes continually generate new sea floor at ridges located near divergent boundaries and destroy old sea floor at trenches located near convergent boundaries.
- **Engineering:** Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

Phenomena

Earth's oceans are the world's largest biome, and they contain answers to many questions about life on our planet.

Lesson Time Line

Parts 1 & 2	Parts 3–5	Parts 6 & 7
Students discover how tectonic plates work and learn more about earthquakes and tsunamis caused by plate movements. They research current engineering ideas used in earthquake and tsunami regions to define the problem of designing buildings that withstand an earthquake and a tsunami.	Students read more about oceanic discoveries. They make plans and collaborate to design and create building models that can withstand mock earthquakes and tsunamis. They test their designs.	Students receive peer feedback on their building designs and redesign, rebuild, and improve their building models. They reflect on their learning and share their findings with others.

Ocean Trenches and Deep-Sea Life *(cont.)*

Part 1

Introductory Activity

1. Show students the video of Victor Vescovo's exploration of the Challenger Deep in the Mariana Trench at **tcmpub.digital/STEAM/ocean** or a similar video of the oceans. Facilitate a discussion about exploring the deepest parts of the ocean. Ask the essential question, *What can Earth's oceans teach us about life on our planet?*
2. Distribute the *Ocean Trenches and Deep-Sea Life* books. Read aloud pages 4–9.
3. Work with students to complete the Studying Words activity from *Reading Activities* (page 6).

Part 2

Define the Problem

1. Have students work in small groups to sketch their understanding of tectonic plates. They should be able to explain how plate movements cause earthquakes and tsunamis. Check and correct students' understanding of tectonic plates as the cause of these natural disasters.
2. Reveal the STEAM Challenge by displaying and reading aloud pages 28–29 of the book. You can also provide students with copies of the Challenge from this lesson (page 15). As you read, have students state the specific tasks they will accomplish during each step of the engineering design process.

Read and Brainstorm

3. Place students in pairs to conduct research about tsunamis and earthquakes and how buildings can be designed to resist such disasters. You could have students use the following guiding questions: *How do earthquakes affect human-made structures? What are the current designs that architects are using? In what way do tsunamis damage structures? How can one design withstand both natural disasters?*
4. For tsunami information, students could use the NASA Space Place website and the National Geographic Education website's Tsunami Science and Safety videos. For earthquake engineering information, they could use the San Francisco Exploratorium website.
5. Have partners brainstorm lists of features that will be important to incorporate into their building designs.

Additional Resources

These websites include content that extends the lesson.

- *Marine Snow*
  tcmpub.digital/STEAM/ocean1
- *Deep Reef Biodiversity*
  tcmpub.digital/STEAM/ocean2

Ocean Trenches and Deep-Sea Life *(cont.)*

Part 3

Reading Activity

1. Choose an activity from *Reading Activities* (page 6). Provide applicable instructions and materials for students to complete the activity as they read pages 10–17 of the book.

Make a Plan

2. Together, review the STEAM Challenge, and list materials where students can see them. Discuss how the various types of materials could be used for different purposes to build earthquake- and tsunami-resistant building models. Have students use *Make a Plan* (page 7) to independently sketch and label their designs.
3. Organize students into teams to share their designs. Then, have each group choose, sketch, and label a team design. Have each group submit their team design for approval.

Part 4

Reading Activity

1. Choose an activity from *Reading Activities* (page 6). Provide applicable instructions and materials for students to complete the activity as they read pages 18–27 of of the book.

Design and Build

2. Explain to students that when they build their building models, they must follow their design plans exactly. Explain that they will have an opportunity to change or improve their designs after they present them.
3. Review classroom expectations for working with materials. Give teams time to build models.

Part 5

Reading Assessment

1. Have student pairs work to answer the Read and Respond questions from the back of the book. Invite students to share their responses aloud.
2. Have students complete a short posttest, *Ocean Trenches and Deep-Sea Life Quiz* (page 10), to assess this lesson's reading objective.

Testing the Design

3. Tell students that each team will demonstrate how their models withstand natural disasters at the front of the room. Explain that other teams will offer feedback after each test.
4. Distribute *Structure Model Test Results* (page 11), and invite teams to present their designs. Ask them to identify key features of the designs by having a member of each team explain the special features of the model building that should help it withstand earthquakes and tsunamis. Ask students from other teams to provide suggestions for improvement and feedback on the designs.

Ocean Trenches and Deep-Sea Life *(cont.)*

Part 6

Rebuild and Retest

1. Provide time for teams to brainstorm ways to improve their designs based on test results and feedback. Ask them to revisit their initial designs and discuss features that proved successful and features that could be improved after testing.
2. Ask students to sketch their improved designs and explain any changes, including additional or different types of materials. Have students submit their improved designs for feedback and approval before building.
3. Have teams get materials to improve their designs.
4. Provide time for teams to retest their building models.
5. Invite students to provide feedback on improved designs, and ask team members to use evidence from the retests to reassess how well their designs meet the criteria.

Part 7

Reflect and Share

1. Ask students to share examples of specific contributions from their teams and feedback from members of other teams during the STEAM Challenge, including suggesting design ideas or improvements, listening to others while brainstorming, engaging with the materials, and working within their teams to build the earthquake- and tsunami-resistant building models.
2. Have each student answer questions and complete *Think About It* (page 12) to reflect on the success of their team's design and their individual contributions.
3. Have students complete the *Engineering Design Process Checklist* (page 13) and the *Teamwork Rubric* (page 14) to reflect on and evaluate their work and collaboration skills.
4. Read aloud and discuss with students *Career Advice* on page 32 of the book. Ask students to share whether they would consider a career in studying ocean life and why.

Ocean Trenches and Deep-Sea Life *(cont.)*

Reading Activities

Select one or more of these activities to do with students as they read the book.

Studying Words Place students in small groups. Have each group draw an underwater scene that includes images of the glossary words. Challenge groups to incorporate as many of the vocabulary words into their drawings as possible. Have groups label each vocabulary word in their scenes.	**Determining Central Ideas** Ask students to determine two central ideas and identify the supporting details after reading a portion of the book. They can use *Targeting Central Ideas* (page 8) for this activity.	**Summarizing** Have each student complete a countdown summary of the text. Instruct them to write 3, 2, and 1 on a sheet of paper, leaving 6–10 lines of space between numbers 3 and 2. Next to 3, students should write the three most important facts they learned about oceans. Next to 2, they should write two surprising discoveries about oceans. Next to 1, they should write one word that sums up oceans. Students can use *Countdown Summary* (page 9) for this activity.
Identifying Details Have students write a Deep Ocean Field Guide. A field guide is a book to help readers identify plants and animals in nature. Students should include pictures and detailed descriptions of the creatures that people might encounter in oceans.	**Creative Writing** Have students write imagined first-person accounts from a person who has explored Challenger Deep. The account should include scientific observations as well as the person's thoughts and feelings about the trip.	**Researching** Ask students to research 5–10 tsunamis in history. Have students find out the cause and the impact of each event. They can share their learning on posters or in slideshows.

Name: ______________________________ Date: ______________

Make a Plan

Directions: Summarize the challenge. Then, sketch your design to solve the challenge.

Challenge: ____

____

____

My Design

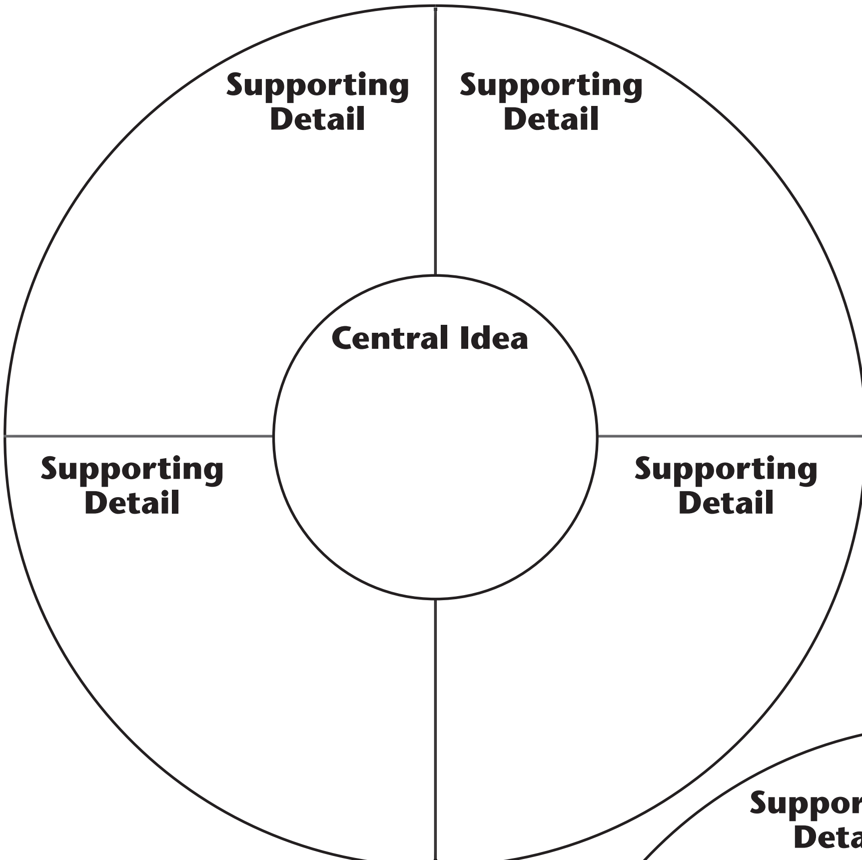
Directions: Sketch your team's design in the second box. Label the design with materials needed and the purpose of each part.

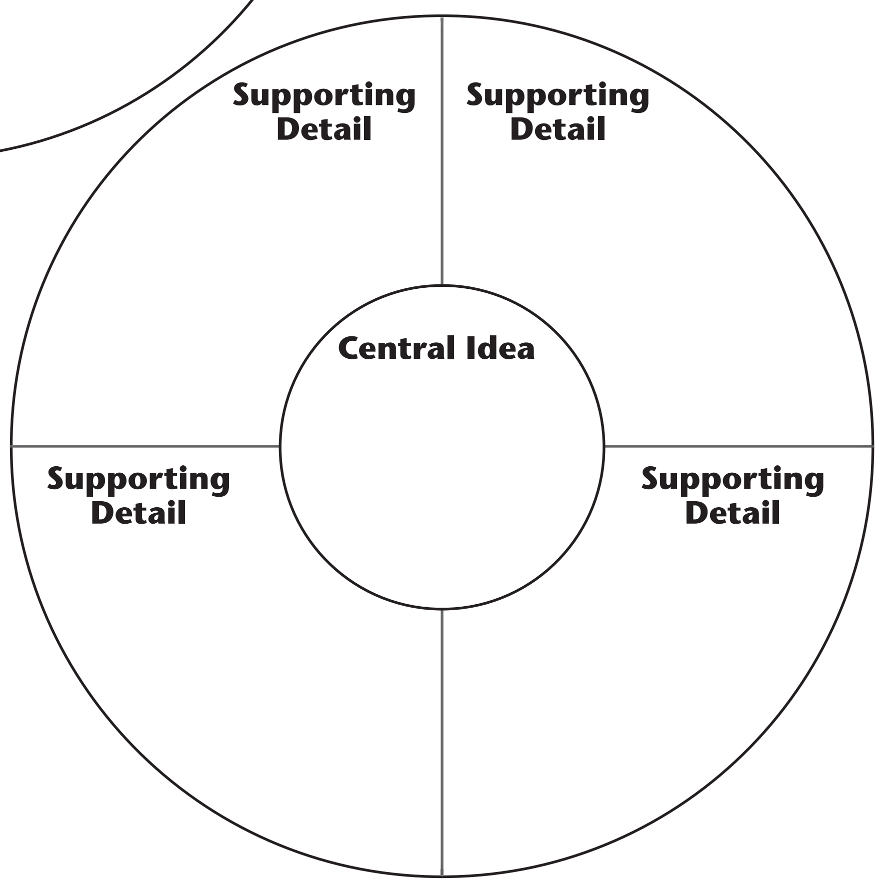
Team's Design

Name: ____________________ Date: __________

Targeting Central Ideas

Directions: After reading your assigned pages in *Ocean Trenches and Deep-Sea Life*, identify two central ideas. Then, write details from the text that support the central ideas.





Name:____ Date: ______________

Countdown Summary

Directions: Summarize what you learned from reading *Ocean Trenches and Deep-Sea Life* using the countdown prompts.

3 Key Facts About Oceans

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2 Surprising Discoveries About Oceans

____

____

____

____

1 Word That Sums Up Oceans

____

____

Name: ______________________________ Date: ______________

Ocean Trenches and Deep-Sea Life Quiz

Directions: Read each question or prompt. Fill in the bubble for the best answer.

1. What process created the structure of the seafloor?

- Ⓐ cartography
- Ⓑ plate tectonics
- Ⓒ underwater volcanoes
- Ⓓ climate change

2. How deep is the deepest part of the ocean, called the *Challenger Deep*?

- Ⓐ 950 meters
- Ⓑ 1,800 meters
- Ⓒ 10,935 meters
- Ⓓ 25,935 meters

3. The biggest challenge of deep-ocean exploration is the _____.

- Ⓐ cold temperatures
- Ⓑ underwater vents
- Ⓒ extreme pressure
- Ⓓ dangerous animals

4. What percent of Earth's oceans have been explored?

- Ⓐ 5 percent
- Ⓑ 25 percent
- Ⓒ 10 percent
- Ⓓ 50 percent

5. Explain why the seafloor is made up of trenches, mountains, and plains.

____

____

____

____

____

____

Name: ____ Date: ______________

Structure Model Test Results

Directions: Use the tables to assess and provide evidence for how each team's model meets the STEAM Challenge criteria.

Team:	**Special Features:**
Test Results ❏ fits on plate ❏ is 46+ centimeters tall ❏ remains standing without structural damage during earthquake ❏ remains standing without structural damage during tsunami	

Team:	**Special Features:**
Test Results ❏ fits on plate ❏ is 46+ centimeters tall ❏ remains standing without structural damage during earthquake ❏ remains standing without structural damage during tsunami	

Team:	**Special Features:**
Test Results ❏ fits on plate ❏ is 46+ centimeters tall ❏ remains standing without structural damage during earthquake ❏ remains standing without structural damage during tsunami	

Which team's building model was most successful? What about the design or materials used makes this model the most successful? Provide evidence to support your response.

____

____

____

____

____

Name: ______________________ Date: ____________

Think About It

Directions: Respond to the questions and prompts to reflect on the process you used to complete the STEAM Challenge.

1. Which feature of your team's design makes it most successful?

2. Which feature of your team's design makes it unique?

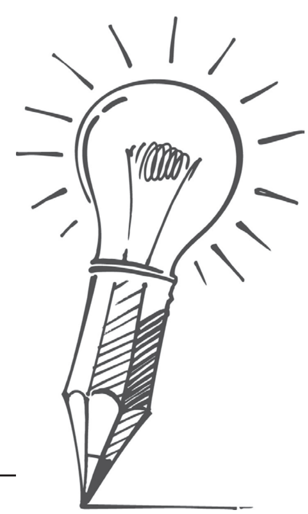
3. How did the design work to resist earthquake damage? How did the design work to resist tsunami damage?

4. During this challenge, I contributed by ______________________.

5. A surprise or issue that our team encountered during this challenge was ______________________.

6. Our team solved the issue by ______________________.

7. How would you modify the building model?



Name: ____ Date: _______________

Engineering Design Process Checklist

Directions: Check the boxes and answer the prompts to show that you completed each step.

Define the Problem

- ☐ I understood the design constraints.

State the purpose of the challenge in your own words.

____
____
____
____

Research and Brainstorm

- ☐ I identified and used research that helped inform my team's design.

List two features of your team's design that used ideas from research.

____
____
____
____

Design and Build

- ☐ I designed and built a model.
- ☐ I practiced each step of the engineering design process to complete this challenge.

Test and Improve

- ☐ I used criteria to evaluate designs.

List two examples of criteria you used.

____
____
____
____

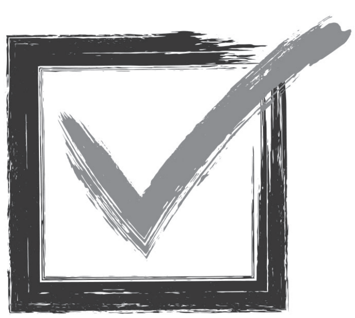
- ☐ I collected and organized my team's data.
- ☐ I improved designs based on test results.
- ☐ I used feedback from my team and from other teams to improve my design.

Reflect and Share

- ☐ I reflected on my work by analyzing data, writing, and discussing my results with others.

List at least one way you can improve your work on the next project you complete.

____
____
____
____



Name: ________________________________ Date: ____________

Teamwork Rubric

Directions: Think about how you worked in your team. Score each item on a scale of 4 to 1.

4 = Always	3 = Often	2 = Sometimes	1 = Never

I listened to people on my team.	4	3	2	1
I helped people on my team.	4	3	2	1
I shared ideas with people on my team.	4	3	2	1
We made choices as a team.	4	3	2	1

Total __________

What is one thing your team did well?

____

____

____

____

What could your team do better next time?

____

____

____

____

What else do you want your teacher to know about your team?

____

____

____

____

Name: ______________________________ Date: ______________

STEAM CHALLENGE

Define the Problem

Near the Ring of Fire, nearly 20 different ocean trenches exist. That means for people living in the area, earthquakes and tsunamis are a constant threat. Architects are seeking new construction ideas for buildings that can withstand earthquakes and tsunamis. To help the architects, you will design and test a structure model against both catastrophic events.

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---

4 Reflect and Share

What surprised you during this challenge? What hardships did you and your team have to work through? How may different building materials play a part in how earthquakes and tsunamis affect them?

Answer Key

Example responses are provided.

Targeting Central Ideas (page 8)

Central Idea: In the 1950s, Marie Tharp discovered that the seafloor was made up of trenches, mountains, and plains.

Details: Scientists once believed that the seafloor was flat. Tharp used sonar data to map the seafloor. She discovered the Mid-Atlantic Ridge in the Atlantic Ocean. She discovered a huge rift valley that supported the theory of plate tectonics.

Central Idea: Oceans are very deep.

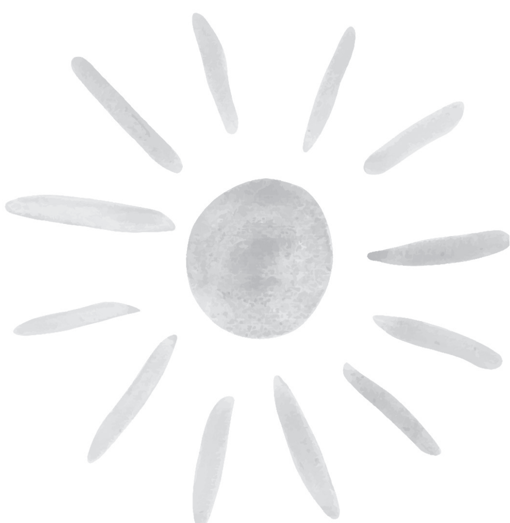
Details: The average depth of our oceans is about 3,600 meters. The deepest point of our oceans is called *Challenger Deep*, which is about 11 km (7 mi.) down. Challenger Deep is part of the deep Mariana Trench in the Pacific Ocean. If you put Mount Everest on the seafloor in Challenger Deep, it would still be more than a mile from the top of the mountain to the water's surface.

Countdown Summary (page 9)

3 Key Facts About Oceans: Oceans are very deep. The ocean floor is made up of trenches, mountains, and plains because of plate tectonics. Many ocean animals have unique adaptations that allow them to survive.

2 Surprising Discoveries About Oceans: All land on Earth sits on tectonic plates that are in constant motion. The Challenger Deep is the deepest part of our oceans at about 7 miles below the surface.

1 Word that Sums Up Oceans: mysterious



Ocean Trenches and Deep-Sea Life Quiz (page 10)

1. B
2. C
3. C
4. A
5. The collision of tectonic plates causes the edges of the plates to rise up and create underwater mountain ranges. Sometimes, one tectonic plate slides under another plate and forms a deep ocean trench. Plates can also pull apart and create seafloor spreading. Magma fills in the gaps caused by this spreading, which makes cliffs, slopes, and mountains on the seafloor.