LESSON PLANS, READINGS & ACTIVITIES

EARTH AND SPACE SCIENCE: PLATE TECTONICS

GRADE LEVEL: 6-8 | TIME REQUIREMENT: 2 HOURS

EARTH AND SPACE SCIENCE: PLATE TECTONICS

1 READING | 1 ACTIVITY

INTRODUCTION

The vast Pacific Ocean and the islands scattered across it were almost as tough an enemy as the Japanese forces that controlled much of that territory during World War II. Those islands were formed by forces not fully understood by science until decades later. The "Ring of Fire" is a term used to describe a huge circle of volcanic activity that forms a ring around the Pacific, from New Zealand in the south to the Aleutians in the north. In the region where most of the US battles in the Pacific during World War II took place, there are many active volcanoes, and there were dozens of earthquakes during that time. The islands varied greatly in their physical geography—in a manner that was only understandable once the theory of plate tectonics was formalized in the late 1960s.

The many volcanoes of the western Pacific are formed through a process known as subduction where one continental plate moves under another and sinks into the earth's mantle; magma from the subducted crust then bubbles up to the surface.

Most of the islands in this Ring of Fire formed when undersea volcanoes emerged from the ocean. Over time, coral reefs formed around them, and the volcanoes eroded to form rich soils. The youngest islands have high elevation and active volcanoes. The oldest have only a ring of reefs remaining. These oldest islands are referred to as atolls.

OBJECTIVE

Use these two resources to show the pattern of volcanoes and earthquakes in the South Pacific and then learn and make diagrams about plate tectonics. These are reversed in order from most of our sets—we suggest you use the activity first and then the reading. You can supplement with physical maps from these areas, and even use maps of volcanoes and at other plate boundaries as an extension.

STANDARDS

NGSS DCI ESS2.B
Plate Tectonics and Large-Scale System Interactions

NGSS DCI ESS3.B
Natural Hazards

NGSS SEP
Analyzing and Interpreting Data

NGSS SEP
Engaging in Argument from Evidence

NGSS CCC
Patterns

NGSS CCC
Stability and Change

PERFORMANCE EXPECTATIONS

MS-ESS2-3
Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS-ESS3-2
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

READING (1)

1. GEOLOGY AND HISTORY

Description
This resource is a reading for students to understand how active geologic features like volcanoes and earthquakes shaped some of the events in World War II. It has descriptions of the geologic forces acting in a region, and asks students to make a diagram based on the descriptions.

Supplies
Paper and colored pencils
Physical maps of the Philippines and Italy (optional)

Instructions
Have the students read the handout, then discuss it in small groups or the whole class. Have them follow the instructions to make a geologic diagram. The optional maps may help them to understand the plate tectonic forces in the regions discussed.

ACTIVITY (1)

1. MAPPING DANGER

Description
This is an activity in which students map volcanoes and earthquakes using a table of data. Students will explore and explain the pattern as seen in the data that they map.

Supplies
Pencils or pens in contrasting colors
Map of the South Pacific (that includes latitude and longitude grids)

Instructions
Show students how to use the latitudes and longitudes to locate the spots on the map. Have them mark earthquakes in one color and volcanoes in a contrasting color. To lighten the work load you could divide the data up so that some groups only do some lines of the data, and then put them together to make the bigger picture. With small modifications you could use Google Maps to map the data. In this case you need to change all S latitudes to a negative value.

READING

GEOLOGY AND HISTORY

On September 1, 1923, at 11:58 a.m., an earthquake with a magnitude of 7.9 occurred in a bay just south of Tokyo, Japan. Tokyo and Yokohama, a relatively young port city with a strong international influence, were the closest large population centers. After the earthquake struck, a tsunami with an 11-meter-high crest hit Yokohama and surrounding areas. Fires spread throughout Tokyo and Yokohama, and with water mains broken by the quake, there was no way to fight them. The earthquake lifted the shoreline up two meters higher compared to sea level and made a crack in the earth that was 4.5 meters wide.

Even though the earthquake lasted only 14 seconds, there was a huge amount of energy released: 570,000 homes were destroyed and more than 140,000 people were killed. With telegraph technology connected to radio, news from Japan to the countries of the West moved rapidly. The United States and other countries mobilized support for victims of the earthquake within 24 hours. Japan had annexed Korea more than a decade earlier, and in the months before, what came to be called the Great Kanto Earthquake, a group working for the liberation of Korea had been conducting terrorist attacks. Rumors spread in the aftermath of the quake that Koreans were looting and starting fires. Violent attacks on Koreans and anyone thought to be Korean followed. The Japanese government tried to protect Koreans, but also covered up any attacks that occurred. This event, and Japan's dependence upon the West for support in recovery, fueled growing nationalism. This influenced Japanese imperialism and expansionism in the decades before World War II.

Vesuvius erupting in the background as a truck passes. Naples, Italy, March 1944. *(Image: The National WWII Museum, 2007.243.080.)*

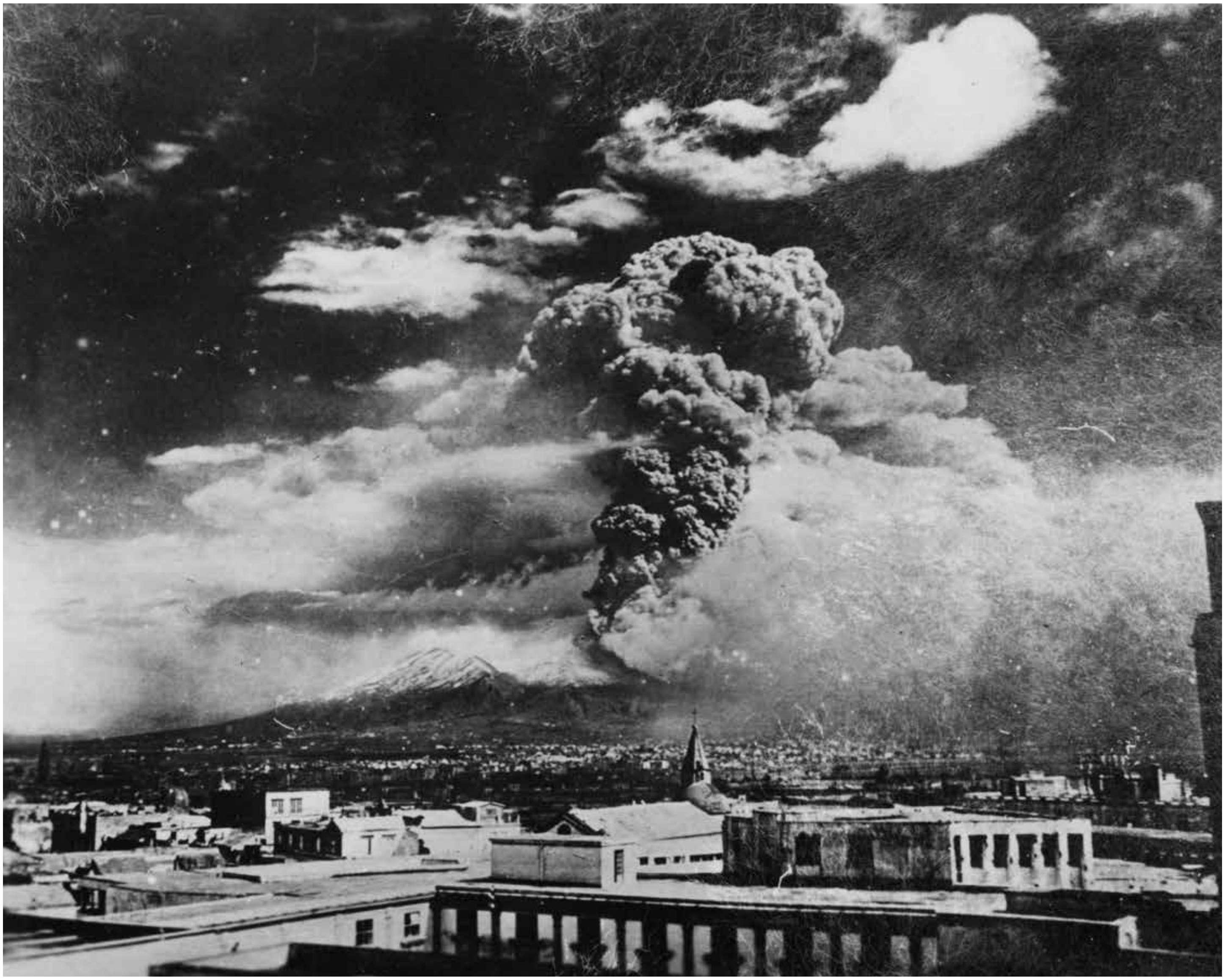
Earthquakes and volcanoes were, and still are, common in the Pacific. These geological factors shaped the Pacific islands, and when US troops fought there in World War II, these conditions shaped logistics and even the path of the war. There is a diamond-shaped continental plate—the Philippine plate—pinned between the much larger Pacific and Eurasian plates. The Pacific plate is moving slowly but relentlessly west, pushing the Philippine plate ahead of it. Where the plates meet, the Pacific sinks below both the Philippine and Eurasian plates, and the Philippine plate dives under the Eurasian plate. This pattern of plate convergence is called subduction and leads to earthquakes and volcanoes. Where the plates come together in the ocean, they form volcanoes, which can emerge from the ocean, slowly over time, creating islands. From New Guinea to the Marianas and Iwo Jima (on the east side between the Philippine and Pacific plates), from the Philippines to Okinawa and north (on the west side, between the Eurasian and Philippine plates), and to Japan (split by the Eurasian and Pacific plates), all of these islands were formed from volcanic activity. Some of those islands are very old, their volcanoes mostly dead. Coral reefs surround these islands (like Tinian or the Bikini atoll). Others are younger and form very high tropical peaks (like in the Philippines).

Iwo Jima, which in its original Japanese name means "sulfur island," was formed by slightly different volcanic activity that led to its peculiar geography. There is abundant groundwater on Iwo Jima, all of it very hot and enriched with minerals. The frequent volcanic activity there is mostly steam created by the interaction of groundwater and magma (molten rock).

The geological theory that explained volcanoes and earthquake patterns, called plate tectonics, wasn't solidified until the late 1960s. US troops went into this zone, where there were more than two dozen large earthquakes (> 6.0) between 1940 and 1946. Imagine the uncertainty this caused without any way to predict what was going on or without or any understanding of what each stop on the island-hopping path to Tokyo would bring.

Put together your knowledge of plate tectonics and the information in the passage you just read above. Draw a cross-section of the crust showing how the Pacific Plate, the Philippines Plate, and the Eurasian Plate interact. Indicate where volcanoes might form and earthquakes might occur.

NAME: **DATE:**



A huge plume of volcanic ash from Vesuvius in the background of an image taken of Naples, Italy, March 1944.
(Image: The National WWII Museum, 2009.046.219.)

Far, far away, in Europe, on March 17, 1944, Mount Vesuvius erupted. Mount Vesuvias is the volcano that destroyed Pompeii and other Roman cities in 79 CE. The volcano, which is in southern Italy near the western coast, is a very different kind of volcano than the ones you mapped in the Pacific.

Italy had surrendered to the Allies, but German forces still held the north of the country. A US air base was near Vesuvius, and the planes on the airstrip there were seriously damaged by the eruption.

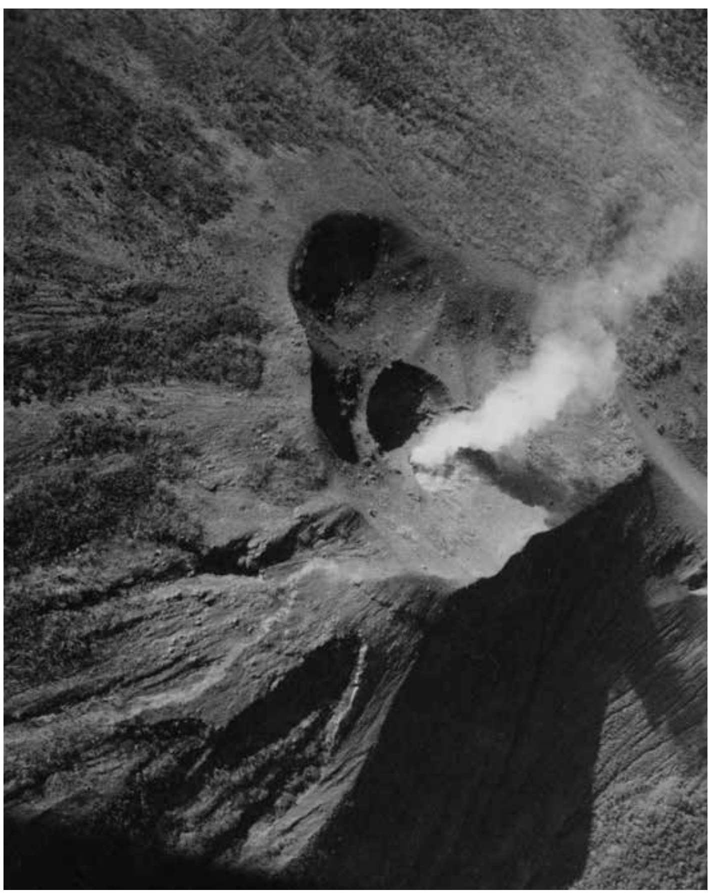
Do some research and try to figure out why there is a volcano in Italy. Are there others in Italy? Are there others in the Mediterranean region? Can you use plate tectonics to explain their pattern?

ACTIVITY
MAPPING DANGERS

INTRODUCTION

In World War II, our troops moved across the Pacific Ocean, exploring areas and islands that were very exotic. This area was known to be home to many volcanoes and frequent earthquakes. These natural hazards and the manner in which they shaped the landscape were very challenging in many ways to the soldiers and military planners and leaders. In those decades, there was really no understanding of why volcanoes occurred in these places or of what caused earthquakes.

On a map, place dots in one color for each location where there was an earthquake, and a use a different color to show every location where there was a volcano in this region during World War II.



Ash rising from a volcano in New Britain, the South Pacific, in August 1944.
(Image: The National WWII Museum, 2008.354.114.)

1. **What do you notice about the patterns of each type of hazard (earthquake or volcano) and of all the hazards together?**

2. **What could possibly be causing such a huge pattern on the surface of the Earth?**

3. **Imagine that the US commanders in World War II had understood what caused earthquakes and volcanoes. How do you think it would have changed their plans?**

NAME: **DATE:**

SELECT VOLCANOES IN THE PACIFIC THEATER

NAME	LATITUDE	LONGITUDE	LAST ERUPTION
Abu	34 N	131 E	9,000 ya
Adatara	37 N	140 E	1996
Agrigan	18 N	139 E	1990
Akagi	36 N	139 E	1938
Akan	43 N	144 E	1988
Akita Yakeyama	39 N	140 E	1997
Akuseki-Jima	29 N	129 E	?
Alamagan	17 N	145 E	1887
Ambrym	16 S	168 E	2015
Anathan	16 N	145 E	1993
Aso	32 N	131 E	1993
Bam	4 S	144 E	1960
Bamus	5 S	151 E	2006
Bulusan	12 N	124 E	1988
Canalaon	10 N	123 E	2016
Camiguin	9 N	124 E	1953
Dakatua	5 S	150 E	1895
Daisetsu	43 N	142 E	1739
Fuji	35 N	138 E	1708
Hibok-hibok	9 N	124 E	1953
Ioto (Iwo-jima)	24 N	141 E	2012
Iraya	20 N	122 E	1454
Kanlaon	10 N	123 E	2015
Kirishima	31 N	130 E	2011
Kamagatake	35 N	139 E	2015
Kusatsu-Shirane	36 N	138 E	1983
Lamington	9 S	148 E	1956
Loloru	6 S	155 E	1994
Long Island	5 S	147 E	1993
Lopevi	16 S	168 E	2007
Mayon	13 N	123 E	2014
Nikko-Shirane	36 N	139 E	1952
Ragang	7 N	124 E	1915
Suwanose-jima	29 N	129 E	2016
Yake-dake	36 N	137 E	1995

EARTHQUAKES IN THE PACIFIC THEATER

YEAR	LATITUDE	LONGITUDE	MAGNITUDE
1940	41 N	137.2	7.5
1940	4 S	152.8	7.1
1940	8 N	123.4	7
1941	32 N	130.2	7.7
1941	5 S	153.5	7.1
1941	4 S	151.6	7
1941	10 N	123.6	7
1942	12 N	121.2	7.4
1942	8 N	123.4	7.2
1943	8 N	124	7.8
1943	16 N	121	7.2
1943	40 N	143.1	7.2
1943	4 S	143	7.2
1943	35 N	134	7
1943	6 S	154.3	7
1944	32 N	138	8.1
1944	4 S	142	7.1
1944	2 S	152	7.1
1944	43 N	143.5	7
1945	5 S	149.8	7.8
1945	40 N	149.9	7.2
1945	24 N	141	7.2
1945	37 N	143.2	7.2
1945	43 N	147.2	7
1945	3.9 S	149	7

LESSON PLANS, READINGS & ACTIVITIES

EARTH AND SPACE SCIENCE: WATER CYCLE

GRADE LEVEL: 5-8 | TIME REQUIREMENT: 3 HOURS

EARTH AND SPACE SCIENCE: WATER CYCLE

1 READING | 2 ACTIVITIES

INTRODUCTION

Water is so ubiquitous that is easy to forget how important it is. Yet clean water was a very important part of logistics planning in World War II. Prior wars and the growth of urban areas had shown that deadly diseases like cholera can spread when clean water isn't available. Tropical diseases like malaria that are associated with stagnant water had killed millions in previous conflicts.

World War II covered territories from the deserts of North Africa, the arid Mediterranean, the mountains of the Alps, and the forests of Europe. The geography of the campaigns included the brutal ice of Greenland and the drenching rains of the tropical Pacific. In all these areas, troops needed clean water to drink and bathe to avoid disease.

OBJECTIVE

These resources focus on different aspects of the water cycle, framed by the challenge of finding potable water in the Pacific Theater during World War II. Testing water samples and building a solar still, students investigate the water cycle and the physical properties of water.

STANDARDS

NGSS DCI ESS2.C
The Roles of Water in Earth's Surface Processes

NGSS SEP
Developing and Using Models

NGSS SEP
Planning and Carrying Out Investigations

NGSS CCC
Systems and System Models

NGSS CCC
Scale, Proportion, and Quantity

PERFORMANCE EXPECTATIONS

NGSS 5-ESS2-2
Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

NGSS MS-ESS2-4
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

READING (1)

1. WATER EVERYWHERE

Description
This reading describes the Pacific Theater of World War II, which was dominated by expanses of ocean, drenched jungles, and wide rivers. In spite of all this water, finding clean water to drink and bathe in was a big challenge. You might use a diagram of the water cycle along with this reading. You could also perform a demonstration of the water distribution model. For this demonstration, start with a liter of water in a clear container so that students can watch. Remove the appropriate amounts of water, in sequence, into smaller and smaller containers, as outlined in the student handout. You could also have students make bar graphs of the relative amounts of water to practice their quantitative skills.

ACTIVITIES (2)

1. MEASURING WATER

Description
This is an activity that can be done in combination with Water Everywhere. This activity will require you or your students to collect samples of local water sources, on field trips, at school, or at home.

Supplies
Water Samples
pH paper
Thermometer
Other water quality tests (optional)

Instructions
You will need water samples that your students have collected. If that isn't possible, you could just make your own samples by adding dirt or other material to water or by taking it from a fish tank or other source. Recording temperature data only works if you are collecting water in the field. You will also need pH paper, which you can get inexpensively at a pet store or from a science materials supplier. You could easily add other water quality tests with some simple supplies. For example, pool and aquarium kits allow you to measure ammonium or salinity. Additionally, if you are in the field, you can use tools to measure how far into the water you can see or to record what animals and plants you see in the water.

2. SOLAR STILL

Description
This is an investigation activity that is perfect to follow the previous two. Please note that this activity is best done outside in groups on a warm, clear day. You can modify it to be done inside with heat lamps or an incandescent bulb.

Supplies
1 Small bucket
1 Small plastic cup
2 Cups of water, to which you have added some salt or dirt
Clear plastic (you may be able to use plastic wrap)
A small rock

Instructions
Have the students put the dirty water (or you can use salt water) in the bottom of the bucket. Then place the small cup upright in the middle of the bucket. Cover the bucket with the plastic, placing the weight on it in the middle so that the center of the plastic is lower than the edges. Then place the bucket in a warm spot outside. The water will slowly evaporate as it warms in the bucket, and some of it will condense on the plastic. Because the plastic is lower in the center of the bucket, the condensation will run down toward the center. If it is very warm and sunny outside, this will happen over a couple of hours. If it is cool, it may take longer.

To accelerate the process, you could add a heat lamp and keep it inside. When enough condensation builds up, it will drip into the cup. This is a model of the evaporation-condensation portion of the water cycle. This is also a rudimentary demonstration of a water purification method that was used by American servicemen during World War II.

READING

WATER EVERYWHERE, BUT NOT A DROP TO DRINK

Imagine that you are a pilot or a sailor during World War II, and you are sent to serve in the Pacific Ocean. You travel across the vast Pacific, dotted with islands, small and large. When you finally arrive at your base, by air or by sea, it's on an island, wet with soaking rains, green with lush plant life, and crossed by rivers and streams. But what can you drink? Can you drink the water from the ocean? Can you drink the water from the rivers and streams on the island, which might hold bacteria and protozoa that cause dysentery, cholera, and other illness? What can you drink?

During World War II, there were some water treatment plants that removed living things and contaminants from water so that it could be used by troops. There weren't very many places that had water treatment plants. Americans serving in World War II needed water to cook, to wash clothes and dishes, to drink, and to bathe. They conserved water by not bathing much. Sometimes they used water purification tablets to disinfect water in their canteens, but it was still extremely hard to get enough clean water.

The Earth is a water planet—most of its surface is covered by water, such as lakes, rivers, or oceans. Mountain ranges like the Himalayas and the Alps are covered in ice year-round. Antarctica in the Southern Hemisphere and Greenland and much of the Arctic in the Northern Hemisphere are covered in ice. Water flows through rocks underground on all the continents. But do we have enough water to drink? Let's look closer at all that water. Your teacher will demonstrate with a model.

To make it easier to think about, we'll use one L of water to represent all the water on Earth. That's 1000 ml (milliliters) of water.

Ninety-seven percent of the Earth's water is saltwater in the oceans. Of this 1000 ml, how many ml are saltwater? How many ml are fresh?

Of the fresh water on Earth, 69 percent is frozen in glaciers and ice caps; 30 percent is groundwater flowing through rocks underground; and one percent is surface water.

Of our original 1000 ml, many ml are frozen, how many ml are underground, and how many ml are on the surface?

The water on Earth isn't static—it moves. Lakes flow into rivers, and rivers into the oceans. Water on the surface, including the oceans, evaporates into the atmosphere. Some of what evaporates forms clouds and falls back to the surface as snow or rain. When rain falls on land it either runs over the surface and then sinks into groundwater, or it flows into rivers and lakes. This is called the water cycle.

Three United States Army Air Force engineers standing in front of a water distilling pump and generator, probably India. *(Image: The National WWII Museum, 2011.407.015.)*

View of a glacier in Iceland, 1943. *(Image: The National WWII Museum, 2013.606.084.)*

NAME: **DATE:**

1. Draw a diagram of the water cycle, showing the changing states of water and the locations of Earth's water:

2. All living creatures including humans need water to survive. How much fresh water is available and accessible to humans? Is that amount of fresh water significantly larger or significantly smaller than the amount of salt water?

3. Using what you know about the water cycle, brainstorm some ways that US troops in World War II could access clean water or to make water safe for use. Outline your best idea in the space below. If you are having trouble imagining that, pretend there is a natural disaster, and you need to get clean water. Brainstorm how you could collect water and clean it for your use.

ACTIVITY

MEASURING WATER

INTRODUCTION

Your class is going to learn about the characteristics of water from different sources in your community. Your teacher will give you specific instructions about how you will collect and test water.

If you can't see through your sample or if it has material still floating in it, leave it to sit undisturbed, and record how long it takes to settle.

TEMPERATURE	SECCHI DEPTH	DISSOLVED SOLIDS	pH

NAME: **DATE:**

1. Do you think the water from either of your samples is safe to drink? How could you know for sure?

2. If you answered no, how could you make it safe to drink?

3. Does water for different uses need to all be treated in the same way? For example, can water in a fishpond be the same as water to drink? Does water to drink have to be the same as water to irrigate crops?

ACTIVITY
SOLAR STILL

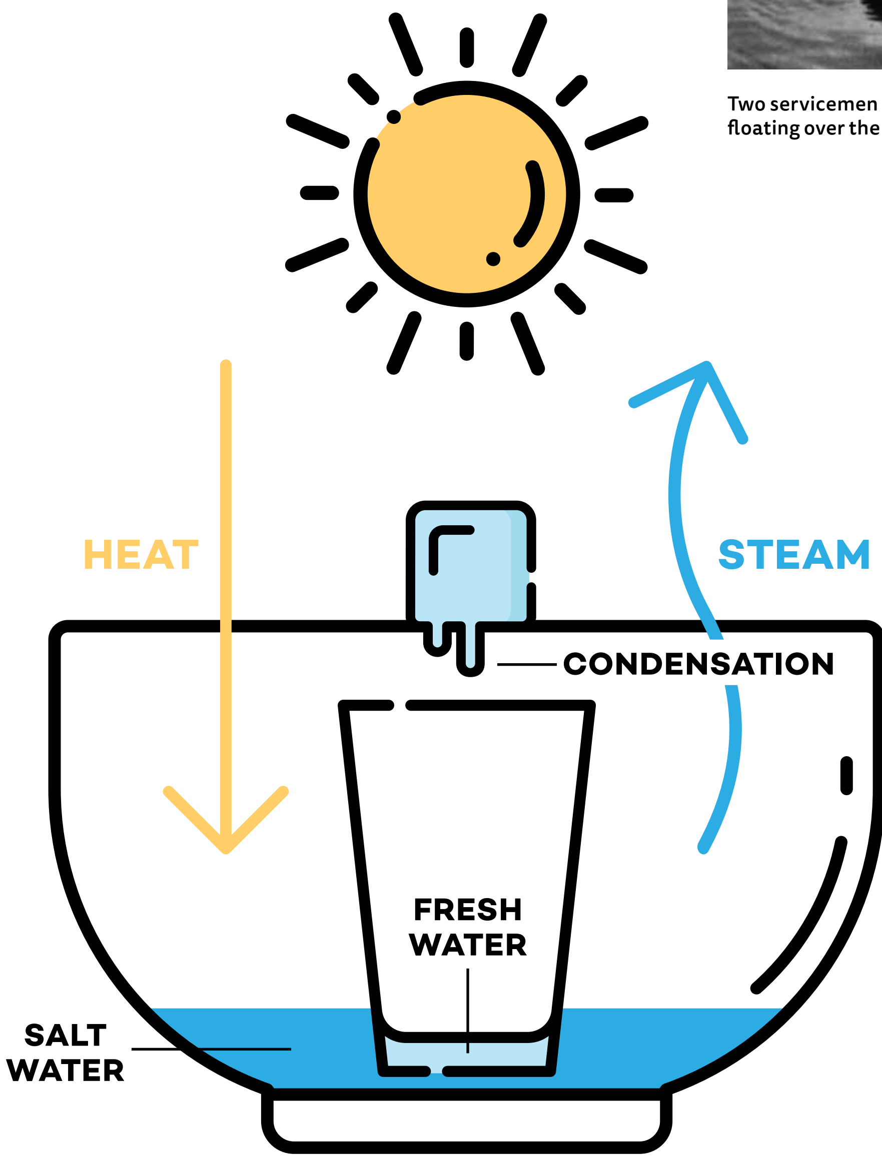
INTRODUCTION

In World War II, planes carried inflatable life rafts, flares, and solar stills. The solar still was used to make drinking water from sea water because crash survivors might be in the raft for a long time before being rescued.

In this activity you are going to making a solar still. It will use evaporation and condensation to remove the salt from sea water.

Your teacher will give you the materials to construct the device.

Two servicemen sitting in a raft on water, with emergency solar stills floating over the side. *(Image: The National WWII Museum, 2012.019.620.)*



NAME: **DATE:**

1. What might be in a sample of water before purification?

2. On the diagram of the solar still, show which parts correspond to the parts of the water cycle.

3. What might be dissolved in the water you collected from your solar still? Or is it pure water?

4. How long do you think it would take for you to collect enough water to survive using your solar still?

5. How could you make the solar still more efficient, collect clean water faster?

LESSON PLANS, READINGS & ACTIVITIES

EARTH AND SPACE SCIENCE: WEATHER

GRADE LEVEL: 5-8 | TIME REQUIREMENT: 2 HOURS

EARTH AND SPACE SCIENCE: WEATHER

1 READING | 1 ACTIVITY

INTRODUCTION

Weather is a core topic of upper elementary and middle school science. It also is a topic that allows you to revisit physical science concepts that underlie weather phenomena, such as the gas laws, solutions, and heat transfer.

Weather was certainly important to the military planners in World War II. For every invasion or large action in World War II, there were detailed weather forecasts made. Every flight crew went through detailed weather forecasts before taking off, and every ship had someone making or receiving forecasts of coming weather.

Weather is also something that students see and experience in their daily lives, which means that they can apply what they learn both immediately and constantly.

OBJECTIVE

The reading asks students to consider why and how we forecast weather. It introduces one of the most important weather forecasts in modern history—the forecast for D-Day in the English Channel and Normandy on June 6, 1944. The reading also asks them to apply skills of weather-map reading. Then students learn about and create simple versions of thermometers, barometers, and hygrometers. Each weather tool works in very unique ways due to the physical properties of materials.

STANDARDS

NGSS DCI PS1.A
Structure and Properties of Matter

NGSS DCI ESS2.D
Weather and Climate

NGSS SEP
Developing and Using Models

NGSS SEP
Constructing Explanations and Designing Solutions

NGSS CCC
Patterns

NGSS CCC
Energy and Matter

PERFORMANCE EXPECTATIONS

5-PS1-1
Develop a model to describe that matter is made of particles too small to be seen.

5-ESS2-1
Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-ESS2-5
Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

READINGS (1)

1. WHY WEATHER?

Description
This reading asks why weather is important and how it has made an impact on history. As students read ask: Why does weather matter? How can we predict the weather? What data do we need to predict the weather? Have students work in groups and use your preferred Kagan strategies or cooperative learning methods to organize productive student conversation.

ACTIVITIES (1)

1. WEATHER TOOLS

Description
This activity can be used in conjunction with the Why Weather reading as a way to introduce weather data collection. This lesson is a good example of how we can make measuring tools when we know the physical properties of materials. Students need to apply knowledge of what temperature, pressure, and humidity are; making the tools will help them remember.

Supplies
For all 3 tool-making activities, safety goggles or glasses are necessary

<u>Thermometer</u>
1 Clear small plastic bottle (too large and you'll use too much alcohol; a small 8-16 oz water bottle would work)
1 Clear plastic straw
1 Ruler
Rubbing alcohol, colored with food coloring
(can be only 50 percent)
Clay
Dropper

<u>Barometer</u>
1 Empty plastic bottle (an empty 16-20 oz bottle will work)
1 Length of plastic tubing (you can use aquarium tubing)
Water, colored with food coloring
Clay
Ruler

<u>Hygrometer</u>
1 Metal can (can be a bean or coffee can)
Water
Thermometer
Ice

Instructions
<u>Thermometer</u>
Have the students mark the straw in half-centimeter increments with the pen and ruler. Next, they will fill the bottle one-fourth full with alcohol, put the straw in the bottle, and seal the straw in the bottle's mouth with clay. The seal needs to be tight so that air can't get in or out of the bottle. The straw also needs to be straight and in the center of the bottle's mouth. Have the students fill the straw with alcohol so that the level in the straw is just a couple of centimeters above that in the bottle. This step is possible because the air in the bottle is trapped and pushing back against the added liquid in the straw.

Have the students hold the bottle in their hands or put the bottle in a sunny spot to see if the temperature changes. Finally, to calibrate the thermometer, have the students record the marks of the alcohol level at different temperatures.

<u>Barometer</u>
Have the students mark the tubing in half-centimeter increments with the pen and ruler. Then have them fill the bottle halfway up with water and put the tubing in the bottle. Students will need to make sure that the tubing is not pressed against the bottom of the bottle so that it will be able to suck the water up until it is a few centimeters above the level of water in the bottle. Finally they will seal the tube with clay.

Because the air pressure outside won't change quickly, students won't see changes in the barometer quickly. Students can watch how the level changes daily and correlate it with the weather.

<u>Hygrometer</u>
Have students fill the can about halfway up with water and place the thermometer in the can. They should watch the thermometer until it stabilizes (just a couple of minutes) and then observe if there is any condensation on the outside of the can. If not, add a couple of ice cubes to the water and stir it, watching until the temperature stabilizes. Is there any condensation on the outside of the can? Repeat as necessary until condensation is seen. The temperature where condensation occurs is the dew point.

Generally, the humidity will be below 50 percent in a well-regulated indoor environment. If the hygrometer is taken outside into a more humid place, it may produce better results.

READING
WHY WEATHER?

WHY ARE PEOPLE ALWAYS TALKING ABOUT THE WEATHER? DOES IT REALLY MATTER?

The weather forecast for a certain day in 1944 made a big difference and may have saved thousands of lives. That day is called D-Day. The Allies had to consider many variables when they were making plans to invade France and take it back from Germany in spring of 1944.

Because the Allies were landing most of the soldiers by boat, the tide had to be low so that they could see and avoid explosive mines and deadly obstacles. The Allies also planned to use paratroopers, so the moon had to be full so that the airplanes could navigate at night and the paratroopers would be able to see when they got to the ground. There would be only one week in early June where the tide was low and the moon full. If the invasion came much later, the Germans might notice, with spies and airplane reconnaissance, the large numbers of ships and troops that had assembled in southern England. If the invasion did not take place in early June, all could be lost.

In early June, the weather on the English Channel (the narrow strip of water that separates England from France and the rest of Europe) is often very stormy. Captain James Stagg was a British officer in the Royal Air Force. Stagg was in charge of assembling weather forecasts from all the different branches of service involved in the planning of the invasion, and Stagg had the responsibility to tell General Eisenhower, the US commander in charge of the operation, when the weather conditions would be favorable. Eisenhower and his team had initially chosen June 5 for D-Day. Allied troops were to be carried in landing craft from ships offshore to the beach. These landing craft were small, and rough seas and bad weather would have made it very hard for them to reach the shore. Many of them would have sunk if the weather were too stormy.

The Allies had weather stations in Canada, Greenland, and Iceland to collect data to support forecasts of weather. Since weather generally moves from West to East in the Northern Hemisphere, the open Atlantic is a challenge for gathering weather data. In the United States, for example, we can follow weather systems from the western to the eastern states easily. Since the Germans had many stations across Europe but very few in the Atlantic, they had an even harder time predicting weather. Today, satellites give us a huge amount of data that makes weather forecasting much more accurate.

Data from their weather stations told the Allies and their meteorologists that a series of low-pressure systems and fronts, each bringing stormy weather, were lined up across the Atlantic Ocean. One of these was arriving over England on June 3 and 4. US meteorologists were recommending that the invasion go ahead on June 5. However, British meteorologists insisted that the weather would be too severe on June 5 and that the invasion should be postponed. Some suggested that the earliest possible date would be around June 16. That option seemed too late for moon-tide alignment and for keeping the date secret. A few meteorologists from England suggested that there would be a short period of calm weather between the storms, and that June 6 could be the only window of opportunity for the next two weeks.

In his report to General Eisenhower, Captain Stagg recommended setting June 6 as D-Day, the launch day of the invasion. Eisenhower accepted that recommendation. He trusted that the British meteorologists, who had more experience predicting the weather coming across England from the Atlantic than the Americans, were making a more accurate forecast.

The Germans saw the storms in the Atlantic, but didn't have enough data on their size or exact location. Because of this lack of data, they thought it would be impossible for the Allies to invade before the middle of June. Based on this forecast, they actually moved some troops away from the coast of France and thus were less prepared for the invasion.

In the end, the weather on June 5 was terrible. The seas were rough and the winds high. Conditions were still a bit rough on June 6, but the landing craft were able to get through the waves to shore, and the planes were able to insert their airborne paratroopers from the sky. The Allies built a temporary floating port starting June 7. This port allowed them to put ashore many trucks, tanks, and supplies. Two weeks later, on the date that some officers suggested for the invasion, another large storm came through, and the temporary port was destroyed. Had the Allies not had Staggs' expert advice and good weather data, the effort might have failed.

A radio weatherman from the Weather Squadron in Italy, 1944.
(Image: The National WWII Museum, 2002.337.038.)

NAME: **DATE:**

1. Look at the WWII weather maps in the reading. What symbols represent low pressure systems?

2. What symbols represent weather fronts?

3. Do we use similar maps today? What is similar and what is different about how forecasts are presented today?

4. What data do you need to be able to forecast weather?

5. What innovations since World War II have improved our ability to forecast weather?

ACTIVITY

WEATHER TOOLS

INTRODUCTION

Knowing tomorrow's weather totally depends upon knowing what the weather was like in the past. Only by monitoring the weather can we understand its patterns and be able to predict what conditions will be like in the future. People have been collecting weather data for hundreds of years, and many of the tools they used in the past are similar to the ones we use today. These tools have of course been supplemented by modern technologies, and we now use computers to analyze weather data.

In this activity you will make three different weather tools. They won't be the most accurate tools you've ever used, but they WILL show you how the more accurate tools work and reveal some of science ideas behind these phenomena.

THERMOMETER

You will need the following from your teacher:

- **1 Clear plastic bottle**
- **1 Clear plastic straw**
- **1 Ruler**
- **Rubbing alcohol, colored with food coloring**
- **Clay**
- **Dropper**

1. Using a pen your teacher gives you, mark every half-centimeter increment on your straw.
2. Fill the bottle about 1/4 of the way up with alcohol.
3. Put the straw in the bottle and seal the top of the bottle with clay tightly. Make sure the straw is straight and goes through the middle of the clay lid.
4. With the dropper, add alcohol to the straw until the level is just a couple of inches above the level of the alcohol in the bottle.

Now you are ready to test your thermometer. Hold the bottle tightly in your hands to warm it up with your body heat. It may take a minute for it to absorb the heat from your hands, but watch the level of the alcohol in the straw. To test more extreme changes in temperature, try putting your thermometer in hot water or ice water. Calibrate your thermometer by indicating which line the alcohol level reaches at the different temperatures.

NAME: **DATE:**

BAROMETER

You will need the following from your teacher:

- **1 Empty plastic bottle**
- **1 Length of plastic tubing**
- **Water, colored with food coloring**
- **Clay**
- **1 Ruler**

1. Using a pen your teacher gives you, mark every half-centimeter increment on your tubing.
2. Fill the bottle about 1/2 of the way up with water.
3. Put the tubing in the bottle and secure it with tape so that the tubing doesn't touch the bottom of the bottle.
4. Now suck water up the tubing until it is halfway up the length of the bottle, and then seal the end of the tubing with the clay.

Changes in atmospheric air pressure are not immediate, so note where the water level in the tube is today and check it tomorrow. When the pressure goes up or down, do you notice a change in the weather? Air pressure changes in a place due to weather, but only by about 0.75 percent. Air pressure changes a lot by altitude—at the top of Mt. Everest the air pressure is only 1/3 of what it is at sea level.

HYGROMETER

You will need the following from your teacher:

- **1 Metal can**
- **Water**
- **Thermometer**
- **Ice**

1. First, put the water in the can, filling it about halfway up. Place the thermometer in the can.
2. Add a cube of ice to the water, and stir it as the temperature goes down and then stays constant.
3. Check to see if there is condensation on the outside of the can.
4. If there is condensation, record the temperature of the water in the can as the dew point. If not, repeat until there is condensation on the outside of the can.

It is usually not very humid inside, meaning that the dew point inside is very low. It may be easier to get a result if you go outside, unless you live in a part of the country that is very dry.