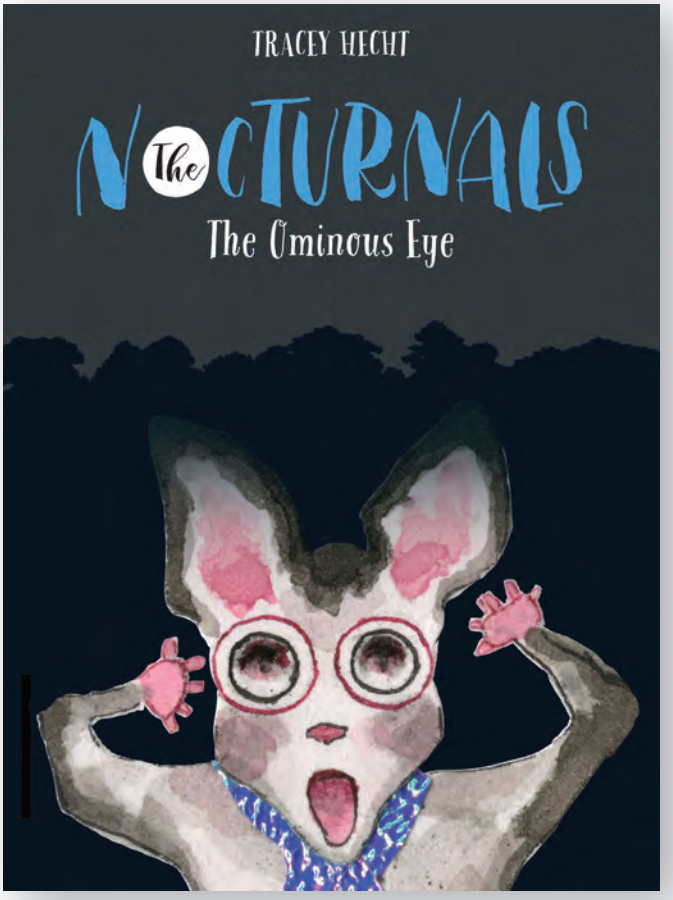
EDUCATOR'S SCIENCE GUIDE

The Nocturnals: *The Ominous Eye*



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About the Book

In *The Ominous Eye,* when a violent jolt fractures the earth, the Nocturnal Brigade sets out to investigate its source. Along their journey, Dawn, Bismark, and Tobin meet an unfamiliar reptile—a tuatara named Polyphema—who reveals that a giant beast caused the destruction and will soon strike again. The tuatara, with her special insights, is the only one who can help them stop this fearsome predator . . . but can she be trusted? With help from an owl, the jerboas, and a few kiwis, a trap is set since surrender is not an option against this relentless beast.

Series Overview

The Nocturnals series features three unlikely friends: Dawn, a serious fox; Tobin, a sweet pangolin; and Bismark, the loud mouthed, pint-sized sugar glider. The stories all play out in their nighttime world with teamwork, friendship, and humor in every adventure.

For More Information:
www.nocturnalsworld.com

Next Generation Science Standards Alignments and Activities

The activities in this guide have been correlated with the Next Generation Science Standards (NGSS), which were developed by the National Research Council (NCR) of the National Academy of Sciences. The NCR's Framework for K–12 Science Education combines practices, crosscutting concepts, and disciplinary core ideas to address relevant science, technology, engineering, and math (STEM) concepts that students should learn.

This guide was written by Erica Colon, the President and curriculum designer of Nitty Gritty Science, which she started as a way to share her passion for teaching. She received her Ph.D, M.Ed from University of Hawaii at Manoa, and her BS from SUNY at Oswego. She is a National Board Certified Teacher.

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Activity 1

An Interview with a Tuatara

1. Prior to conducting the activity, make copies of the "Tuatara: A Living Fossil" article and the Tuatara Interview worksheets.

2. As a class, read the first question in the reading and have students draw what they believe a tuatara looks like based on the description. Have students compare drawings and see what differences or similarities they may have.

3. Show students pictures of actual tuataras (see the references and helpful links below) and their actual size by using a ruler or meter stick.

4. Have students continue reading the article "Tuatara: A Living Fossil." Then give them the questions that are included in this activity, which will allow them to act as if they were interviewing a tuatara. Students can use the information in the article and/or online resources to help them with the tuatara's responses. References and helpful links include:

   - Science Learning Hub—Tuataras: **http://sciencelearn.org.nz/Contexts/Saving-Reptiles-and-Amphibians/Looking-Closer/Tuatara**
   - Victoria University of Wellington Library—Nesting and Clutch Size of Tuatara: **http://nzetc.victoria.ac.nz/tm/scholarly/tei-Bio-31Tuat01-t1-body-d2.html**
   - San Diego Zoo—Tuatara: **http://animals.sandiegozoo.org/animals/tuatara**
   - New Zealand Department of Conservation: **http://www.doc.govt.nz/nature/native-animals/reptiles-and-frogs/tuatara/**
   - New Zealand Department of Conservation—Tuatara video clip: **http://www.doc.govt.nz/get-involved/conservation-activities/meet-the-locals-videos/third-series/tuatara/**
   - Wildscreen Archive—Tuatara: **http://www.doc.govt.nz/nature/native-animals/reptiles-and-frogs/tuatara/**
   - A–Z Animals—Tuatara: **http://a-z-animals.com/animals/tuatara/**

NEXT GENERATION SCIENCE STANDARDS USED IN THIS ACTIVITY

3-LS3-1: Heredity: Inheritance and Variation of Traits

- Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

LS3.A: Inheritance of Traits

- Many characteristics of organisms are inherited from their parents. (3-LS3-1)

LS3.B: Variation of Traits

- Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1)

Student Activity 1

Tuatara: A Living Fossil

What does a Tuatara look like?

A tuatara is a reptile that can range in color from olive-green to gray, blackish-brown, or pinkish. Tuataras are marked with pale speckles on their bodies and have a crest of spiky scales, called spines, which runs down the center of their back and tail. Tuatara is a native Maori word meaning "peaks on back," which is how these creatures received their name. Tuataras have a large head, a stout body, sharp claws, and a thick tail. Male tuataras are larger than females and have more prominent spines that they can fan out to attract females. On average, a tuatara grows to fifty to eighty centimeters long and weighs between .45 and 1.3 kilograms.

An extraordinary characteristic of tuataras is their "third eye" on top of their head. Although it has a retina, lens, and nerve endings, this eye is not used for seeing. It is called a parietal eye, which is sensitive to light and helps the tuatara judge what time of day or what season it is.

Where do tuataras live?

They can only be found in New Zealand. Tuataras were once found across the New Zealand mainland, but now they can only be located on its offshore islands. They live in coastal forest areas where there is low scrub and crumbly soil into which they can burrow. Tuataras will either build their own burrows or will move into one of a nesting seabird

How old can tuataras live to be?

These incredible animals are believed to have life spans of up to one hundred years in the wild. They grow slowly and don't stop growing until they are approximately thirty years old. Tuataras reach maturity when they are between thirteen and twenty years old.

How do tuataras prepare nests for their eggs?

Females dig a shallow nest chamber in sunny, open patches of soil or gravel. Nests are approximately eight to ten centimeters wide and ten centimeters or less in depth. Nesting occurs between early October and mid-December. Every two to five years, female tuataras lay one to nineteen white, soft-shelled eggs in nesting burrows. This egg clutch is usually covered with leaves and grass and left alone to incubate. Twelve to fifteen months later, the eggs will hatch. The temperature

of each egg during incubation determines if the hatchling will be male or female. Warmer temperatures tend to produce males, and cooler temperatures tend to produce females.

What do tuataras eat?

Tuataras have two rows of teeth on their upper jaw and one row on their lower jaw, and these teeth are used for eating. They primarily eat insects, especially beetles, but have been known to eat lizards, birds, and bird eggs. Tuataras will come out of their burrow during the day to bask in the sun but are more active at night when their food is more readily available. However, young tuataras will hunt during the day to avoid being eaten by the adults.

What dangers to tuataras face?

The most serious threat to tuataras is rats. Two specific types of rats introduced to New Zealand have become the tuataras' main predators. Kiore rats are nest robbers and will take eggs and small hatchlings. Norway rats will eat and destroy whatever is available. Because of their length of incubation, eggs and hatchlings are more vulnerable to predators. Tuatara populations dwindle when rat populations are high.

Another threat to the tuatara is habitat destruction. People are constantly building and expanding. With the building of structures such as lighthouses, the tuataras' habitat is decreasing.

Global climate change is also having an effect on the tuatara population. Temperatures have been increasing leading to a low genetic diversity. More males are being born than females.

Is the tuatara a lizard?

Although the tuatara looks like a lizard, it is a reptile. Tuataras are quite different from lizards in that they have no external ears, they like cooler weather, and they are nocturnal.

Why do people call tuataras "living fossils"?

Tuataras are one of the most unique animals in the world. Their closest relatives are an extinct group of reptiles that lived around the time of the dinosaurs, 200 million years ago.

Tuatara Interview

1. I read a description of what you look like. This is my drawing I wanted to share:

2. I understand you are usually awake at night. I appreciate you staying up to help me with my interview. First, can you introduce yourself and share how old you are?

3. Could you describe what you like to eat at meals?

4. I think it's cool you have a third eye! What do you use it for?

5. Where are you from? What does your home look like?

6. What do you do to keep busy during the night?

7. How can we, as humans, help so that you are not an endangered species?

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Activity 2

Nesting Sanctuary for Tuatara: A Laboratory Investigation

1. Pass out the letter from the University of Nocturnals Department of Conservation requesting help from the students. Support students by helping them understand what the letter is asking of them.
2. Place students into groups and give each group the laboratory investigation. Discuss the lab safety rules and behavior expectations, especially when using thermometers and heat lamps.
3. Students can collect materials, or you can have materials already at stations. *Please note that, because the true ground covering found in the actual tuatara ecosanctuaries is not available, there is not a correct or incorrect answer to this investigation. This investigation is truly meant for students to collect data and use evidence from their findings to support their argument on which ground covering to use. So, for this reason, you may use different ground coverings than the ones that are listed in the materials list if you so choose.
4. Allow students to conduct the investigation and collect data. Depending on the age level of your students, you may want to cut out the holes in the cardboard box for the heat lamp ahead of time.
5. After the completion of the investigation, you may want students to write a formal letter to the Department of Conservation that includes their findings and drawings of their lab setup to help them start drawing and labeling as scientists do when conducting research. References and helpful links include:

- Science Learning Hub—Tuataras: **http://science-learn.org.nz/Contexts/Saving-Reptiles-and-Amphibians/Looking-Closer/Tuatara**
- Victoria University of Wellington Library—Nesting and Clutch Size of Tuatara: **http://nzetc.victoria.ac.nz/tm/scholarly/tei-Bio31Tuat01-t1-body-d2.html**
- San Diego Zoo—Tuatara: **http://animals.sandiegozoo.org/animals/tuatara**
- New Zealand Department of Conservation: **http://www.doc.govt.nz/nature/native-animals/reptiles-and-frogs/tuatara/**
- New Zealand Department of Conservation—Tuatara video clip: **http://www.doc.govt.nz/get-involved/conservation-activities/meet-the-locals-videos/third-series/tuatara/**
- Wildscreen Archive—Tuatara: **http://www.doc.govt.nz/nature/native-animals/reptiles-and-frogs/tuatara/**
- A–Z Animals—Tuatara: **http://a-z-animals.com/animals/tuatara/**

NEXT GENERATION SCIENCE STANDARDS USED IN THIS ACTIVITY

3-5-ETS1-1: Engineering Design

- Define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

3-LS3: Heredity: Inheritance and Variation of Traits

3-LS3-2: Use evidence to support the explanation that traits can be influenced by the environment.

- The environment also affects the traits that an organism develops. (3-LS3-2)

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www.nocturnalsworld.com

The Nocturnals

Dear Student-researchers,

My name is Dr. Liz Ardy from the Department of Conservation at the University of Nocturnals. I am desperately seeking your help. We are currently constructing a sanctuary to help protect the endangered tuatara. The sanctuary is located on a secure island that is free of predators and does not allow construction of any kind. We are currently in the final stages of adding the ground covering of the nesting enclosure, which is why I've reached out to you.

The scientists here are asking you to research the best possible nesting material for the tuatara in the hope that you find a suitable land material to produce equal numbers of males and females. As you may or may not know, tuatara generally lay their eggs in one to three layers. The temperature of the nest determines if a hatchling will be a male or female. Warmer temperatures produce males, and cooler temperatures produce females. At the sanctuary, we have nesting sites that will allow tuatara to lay two layers—the first layer at two centimeters below ground level and the second layer at eight centimeters below ground level.

You will need to investigate which ground material will give you the largest temperature difference between the two layers. This will give us the best chance for female-producing eggs at the lower temperatures and male-producing eggs at the higher temperatures. The nesting site will need to be as similar to the tuatara's natural habitat as possible, so a heat lamp will be added to model the sun and provide warmth at least twelve hours of the day.

Please complete your research using the ground material provided. We look forward to your report findings and conclusions.

Sincerely,

Dr. Liz Ardy

Nesting Sanctuary for Tuatara: A Laboratory Investigation

Overview

The determination of whether a tuatara egg is male or female is dependent on the temperature of the ground surrounding the egg. Due to recent climate change, temperatures have been increasing, which is affecting nests of tuatara. The result is that more males are produced than females, leading to low genetic diversity.

Problem

What ground covering would offer the greatest range of temperature at different layers to provide the best opportunity to produce both male and female eggs?

Inquiry-based skills

Data collection, metric measurement, controlling variables, analyzing data, drawing conclusions

Materials

- 3 styrofoam cups
- Heat lamp with 100-watt lightbulb
- Cardboard box
- 3 thermometers
- Scissors
- Stopwatch or clock
- Metric ruler
- Marker
- 3 types of ground covering (sand, soil, leaf litter)

1. Fill each Styrofoam cup to the top with one of the ground coverings provided by your teacher. Label each cup.

2. Make a prediction of which ground covering would be the best choice to help produce the most equal numbers of male and female eggs. Give an explanation for your choice.

   _____

   _____

3. Take the cardboard box and turn it on its side so the opening is facing you. Cut a hole in the top of the box about an inch smaller than the diameter of the heat lamp, so the lamp can sit on the top of the box.

4. Use your ruler to measure two centimeters and eight centimeters on the thermometer. Mark each spot with a pencil or tape.

5. Take an initial temperature recording of each of the ground coverings at both two centimeters and eight centimeters. Record your data in the table provided.

6. Place all three cups inside the cardboard box under the heat lamp. Allow them to sit undisturbed for ten minutes. When the timer goes off, take the temperature again at both two centimeters and eight centimeters. Note: Only remove one cup at a time from under the heat lamp so that the remaining two maintain their temperature as you take measurements. Record your data in the table provided.

Data Table

Ground covering	Initial temperature (°C)		Temperature after heating for 10 minutes (°C)	
	2 cm	8 cm	2 cm	8 cm

Analyze and Conclude

1. Which ground covering offered the greatest temperature range between the two different layers? Did this agree with your prediction? Explain.

2. This investigation only provided two environmental factors—ground covering and heat. What other environmental factors could potentially affect temperature change in a tuatara's nesting site?

3. Do you feel that the ground covering that showed the greatest temperature range would also be the safest choice for a tuatara nesting site? Why or why not?

4. Using your findings, write a statement explaining your recommendation to Dr. Liz Ardy.

Activity 3

Make a Model of a Volcano and Learn about The Ring of Fire!

1. WHAT IS A VOLCANO?

Deep inside the Earth is an extremely hot core, which heats a layer of the Earth called a mantle. The mantle is made up of very hot rock that is continuously moving in convection currents. These currents allow the rock of the mantle to soften when it's closer to the core. As the softened mantle mixes with gasses and water, it becomes less dense, slowly rises and magma is formed. Magma usually stays below the Earth's surface, or its crust. Sometimes the molten magma finds a weak spot in the crust and comes to the surface forming a volcano.

HOW IS IT FORMED?

All volcanoes are formed over a pocket of magma, which geologists call a magma chamber. With enough pressure, the magma will move upwards through a pipe in the center of the volcano, until it can leave through vents. At the top of a volcano there is a main vent and many small vents along the slopes. Once the magma leaves the vent onto the Earth's surface, it is now called lava, which pours out of the vents until the pressure inside the volcano is released.

2. Use the materials and instructions below to create a model of a volcano and show your children a demo of how a volcano erupts.

MATERIALS NEEDED:

- Baking pan
- Soda can
- Moist soil or play dough
- Baking soda
- Vinegar
- Red food coloring

PROCEDURE:

Step 1: Place the baking pan on a level surface. Set the soda can in the middle of the pan.

Step 2: Mound and shape the moist soil or play dough around the can to form a mountain. Bring the soil (or play dough) right up to the top of the soda can's opening. Be careful not to get any soil or play dough inside the can.

Step 3: Pour one tablespoon of baking soda into the soda can.

Step 4: Color one cup of vinegar with red food coloring.

Step 5: Pour the colored vinegar into the soda can. Have your children observe the red foam that spills out of the top and down the soil like lava from a volcano.

3. Explain what's going on to your children. Explain that the baking soda is reacting with the vinegar to produce carbon dioxide gas and that the gas builds up enough pressure to force the foaming liquid out of the top of the can.

4. Discuss what the foaming liquid represents—inside the volcano it's called magma, but once it reaches the surface it's called lava. References and helpful links include:

- **https://www2.usgs.gov/faq/taxonomy/term/9819**
- **http://kids.nationalgeographic.com/explore/science/volcano/#volcano-explode.jp**

NEXT GENERATION SCIENCE STANDARDS USED IN THIS ACTIVITY

4-ESS2-2: Earth's Systems

- Analyze and interpret data from maps to describe patterns of Earth's features.

ESS2.B: Plate Tectonics and Large-Scale System Interaction

- The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features where people live and in other areas of Earth. (4-ESS2-2)

Student Activity 3

Find The Ring of Fire!

OVERVIEW: Earth's tectonic plates are constantly in motion, driven by convection currents in the mantle. As the plates move, they collide, pull apart, or grind past one another. Plate boundaries push together or pull apart, causing cracks that allow magma to reach the surface. Magma is a hot, molten rock mixture formed deep within the Earth. When magma comes through a weak spot in the Earth's surface, this forms a volcano, and the magma is now called lava. Geologists have recorded that roughly seventy-five percent of all active volcanoes on Earth occur in what is known as the "Ring of Fire." The Ring of Fire is a major volcanic belt around the rim of the Pacific Ocean. You will recognize that volcanoes occur along plate boundaries.

1. Where are volcanoes found? Explain that there are about 600 active volcanoes on Earth's surface that occur in belts that extend across continents and oceans, and that one major volcanic belt is the Ring of Fire, which is formed by many volcanoes that rim the Pacific Ocean. Explain that volcanic belts occur along tectonic plate boundaries where the Earth's crust is diverging (pulling apart) or converging (coming together).

2. Prepare your children for "The Ring of Fire" activity by using a large map to review the terms latitude and longitude, and give examples of coordinates to let students practice how to use the lines to determine locations on the map. Help them understand the values of the latitude and longitude lines and that the numbers move away from zero on both sides.

3. Have your children complete "The Ring of Fire" activity in which they will plot coordinates of known volcanoes that are located within the Ring of Fire.

4. References and helpful links include:

- National Geographic: **http://nationalgeographic.org/encyclopedia/ring-fire/**
- National Oceanic and Atmospheric Association (NOAA): **http://oceanexplorer.noaa.gov/facts/rof.html**
- National Geographic Channel: **http://channel.nationalgeographic.com/videos/ring-of-fire/**
- US Geological Survey (USGS): **https://earthquake.usgs.gov/learn/glossary/?term=Ring%20of%20Fire**

PROBLEM: Where are most of Earth's volcanoes found?

INQUIRY-BASED SKILLS: Interpreting data

MATERIALS NEEDED:

- Colored pencils
- World map

PROCEDURE:

1. Locate volcanoes on the world map using the latitude and longitude coordinates found in Table 1. Mark the locations of volcanoes with a red colored pencil.

2. Use a yellow colored pencil to connect the dots in order to reveal the belt that is referred to as the Ring of Fire.

ANALYSIS AND CONCLUSIONS

1. What is a volcano?

2. Where do volcanic belts form?

3. If more locations of volcanoes were added to the data table, do you think the overall pattern of the location of volcanoes would change? Explain your reasoning.

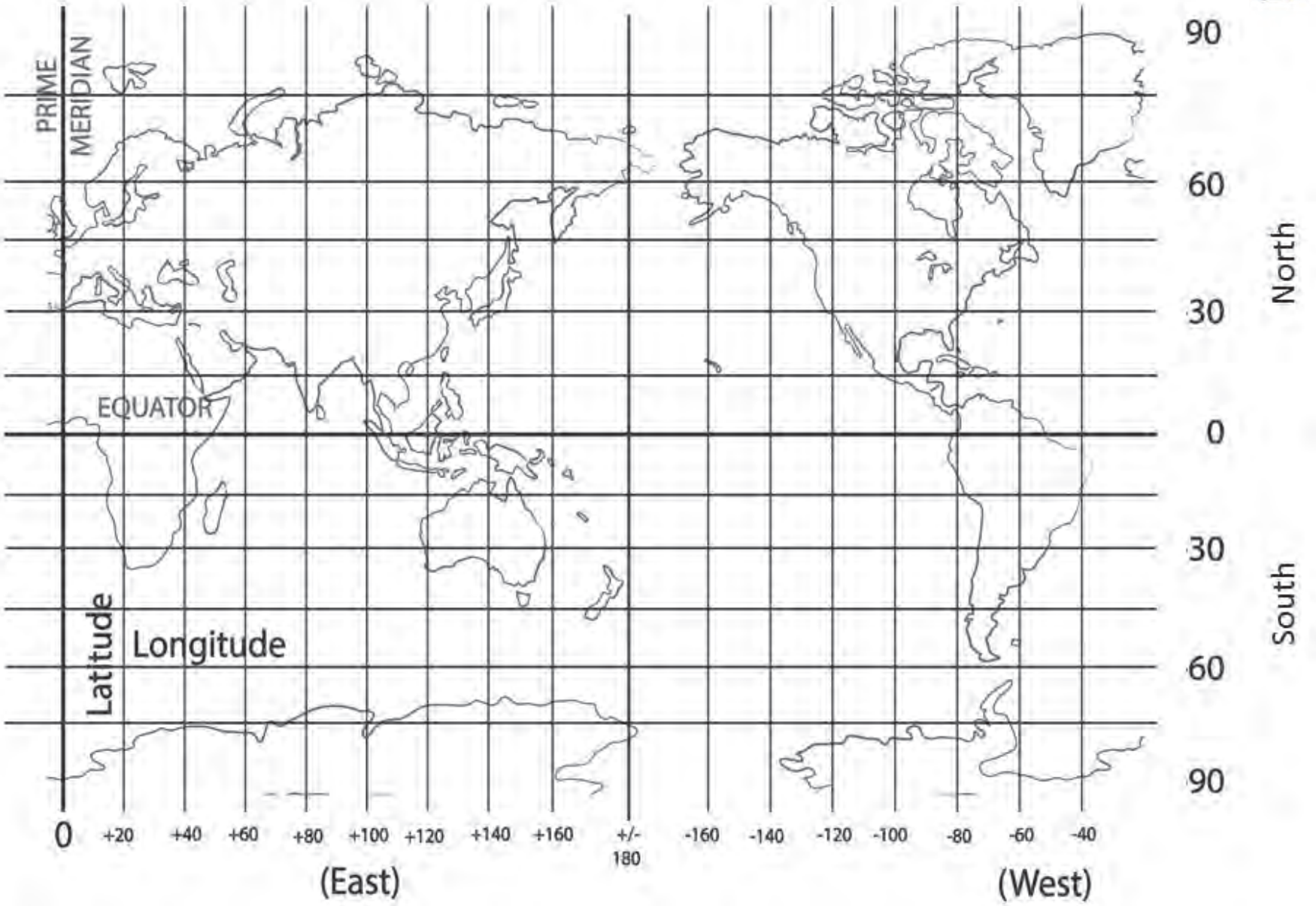
VOLCANOES		
	Latitude	Longitude
1	27° S	69° W
2	10° S	77° W
3	0°	78° W
4	20° N	105° W
5	41° N	122° W
6	46° N	122° W
7	60° N	138° W
8	56° N	162° W
9	35° N	138° E
10	7° N	125° E
11	3° S	120° E
12	5° S	152° E
13	38° S	178° E

GOING FURTHER

Research the location of the following structures found along plate boundaries. Once you determine the locations, draw and label each structure on your map.

- Marianas Trench
- Rocky Mountains
- Himalayan Mountains
- San Andreas Fault
- Challenger Deep Trench
- Mid-Atlantic Ridge
- Andes Mountains

Find The Ring of Fire!



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