Water on the Earth

by Elaine Mao

Water makes up nearly three-quarters of the Earth's surface, but it does more than just cover our planet - it also plays a vital role in shaping it.

Consider the Grand Canyon. Measuring 277 miles long, 18 miles wide and more than 1 mile deep, it is considered one of the Seven Natural Wonders of the World and attracts more than 5 million visitors per year. This geological marvel was created by the waters of the Colorado River through the processes of weathering and erosion. Weathering is the process by which moving water breaks down soil, rock and minerals, and erosion is the process by which the flowing water transports soil and rock from one spot and deposits it elsewhere. The two processes often occur in conjunction.

Weathering and erosion are very slow processes. Geologists believe the Colorado River has been flowing through the Grand Canyon for at least 17 million years, and it has been gradually shaping the canyon this entire time. The flowing water of the river and its tributaries has carved away at the rock of the Colorado Plateau, creating the sight we are familiar with today.

Caves and caverns are another example of weathering and erosion. Limestone caves, such as the Carlsbad Caverns in New Mexico, are formed when rainwater mixes with carbon dioxide in the ground and wears away at the limestone. Sea caves, which can be found along coastlines, are formed when powerful waves crash against the shore and break away chunks of rock. Ice caves are formed when glaciers melt, and the ice melt flows across the ground as a stream.

You don't have to travel very far to see the effects of weathering and erosion for yourself, though. If you've ever been to the beach, you've already seen evidence of how powerful of a force moving water can be-and all you had to do was look down. The sand covering the beach is actually the

result of rocks being broken down into tiny pieces and then washed ashore by the waves.

Although weather and erosion are responsible for creating beautiful sights such as sandy beaches and the Grand Canyon, there are many negative consequences as well. Landslides are some of the most dangerous side effects of erosion. When hillsides or mountainsides are gradually worn away, they can become unstable and break down, especially when triggered by extreme weather such as floods, heavy rain or snow. Every year, landslides cause massive amounts of property damage and casualties.

Erosion is a natural process, and it is often beneficial for the planet. However, excessive erosion can cause major problems, including desertification and the ecological collapse of entire areas. If erosion happens at a pace faster than the land can regenerate itself, this can render the land desert-like and incapable of supporting life. Believe it or not, soil is actually a valuable and nonrenewable resource, as it contains nutrients and minerals crucial for agricultural productivity. It takes thousands and thousands of years to build up enough soil in a region for the land to be productive, but erosion can wear it away much faster than that, especially at the rate it has been occurring in recent decades. Over the past 40 years, the world has lost 30 percent of its agriculturally productive land as a result of erosion.

Although erosion occurs naturally at a very slow rate, human activities have sped up the process by an estimated 10 to 40 times globally. The biggest culprit is unsustainable agricultural practices and the industrialization of agriculture. The mechanized equipment used in modern agriculture allows for deep plowing of the soil. This breaks the soil into finer particles, which is desirable for agriculture because it facilitates planting and also increases the plants' access to oxygen. However, deep plowing also increases the amount of soil that is vulnerable to being washed away by erosion. Throughout much of history, plowing had to be done manually, and it was a labor-intensive process. With the mechanization of agriculture, farmers are able to plow much deeper and more often than ever before, resulting in disastrous consequences for soil quality.

The effect of erosion on soil productivity has been felt all over the world, in Africa, Asia, Australia, New Zealand, the United States and Southern and Eastern Europe. In more affluent countries, the use of artificial fertilizer has become more prevalent as a way to offset the reduction in soil quality that occurs when the nutrient-rich layers of topsoil are washed away. However, this in turn has created a new set of problems. Over-application of fertilizer is common, and much of the excess gets washed away and transported to nearby bodies of water, where the nutrients in the fertilizer can upset the local ecosystem.

Deforestation has also played a role in the rapid increase in erosion globally. Trees and plant roots naturally bind the soil and anchor it to prevent too much from being washed away. They also provide cover and reduce the speed at which rain hits the ground, absorbing much of the impact. This allows the water to trickle to the ground and absorb slowly, rather than flow over the surface and wash away the soil. Deforestation of lands for agriculture and development has rendered large regions of the world unproductive. The effect is amplified in areas that are used for urban development, where the ground is covered with a layer of asphalt or concrete. These surfaces make it difficult for water to penetrate the ground, and increase the volume of runoff to surrounding areas. In addition, the runoff from urban areas is often polluted with fuel, oil and other chemicals.

Lastly, climate change has led to more extreme climate events, including extreme rainfall and hurricanes. Scientists predict that increased rainfall intensity and quantity will lead to greater rates of

erosion. Rising sea levels have also increased the rate of coastal erosion, which has been increasingly problematic for low-lying developed areas along the coast, such as in Florida and Hawaii.

As erosion has become a bigger problem in past decades, scientists have been working to better understand the phenomenon. In 1965, American scientists came up with the Universal Soil Loss Equation, a way to estimate soil erosion by raindrop impact and surface runoff. The mathematical equation has since been applied all over the world, helping scientists predict which conservation measures will have the greatest impact on reducing soil loss.

Scientists have found that the most effective way to reduce soil loss from erosion is to increase the amount of vegetative cover (from grass, plants and trees, for example) on the ground. In recent years, there has also been a gradual shift toward more ecologically conscious agricultural practices. Societies around the world have begun to feel the devastating effects of decades of unsustainable agricultural practices and deforestation, and many have started taking preventative measures. As the consequences of modern industrial agriculture have become apparent, farmers have been encouraged to take steps to reduce erosion. It is now considered good practice to minimize plowing of the land to preserve the integrity of the soil. Crop rotation is a good alternative: planting different kinds of crops can improve soil structure and keep the soil enriched with necessary nutrients and minerals, and with better soil, frequent plowing becomes less necessary.

However, despite all measures to prevent soil loss, it's important to remember that humans will never have complete control over the processes of weathering and erosion. Water will continue to shape the world we live in, sometimes for better and sometimes for worse, and it's up to us to simply make the best of it.

Name: _____ **Date:** _____

1. What are the processes by which water can shape the Earth?

A. deforestation and climate change

B. weathering and erosion

C. soil productivity and fertilization

D. deep plowing and agriculture

2. What does the author list and describe in the passage?

A. the positive effects of industrialization

B. the tourism industry around the Grand Canyon

C. the history of climate change

D. the ways that moving water can shape and change the land

3. Excess erosion can be a large problem. What details from the text support this conclusion?

A. Rapid erosion can leave the land desert-like and unable to sustain life.

B. Beautiful and massive structures like the Grand Canyon are made by erosion.

C. The Universal Soil Loss Equation estimates soil erosion by raindrop impact and surface runoff.

D. Weathering and erosion turn rocks into sand.

4. How does the author present the Grand Canyon and the Carlsbad Caverns?

A. as effects of landslides

B. as geological mysteries

C. as negative effects of erosion

D. as positive effects of erosion

5. What is the main idea of this passage?

A. Erosion is a natural process, and it is often beneficial for the planet.

B. Agricultural practices and industrialization are changing to address the issues of erosion.

C. Erosion and weathering are powerful effects of water that can have harmful effects.

D. Deforestation has played a role in the rapid increase in erosion globally.

6. Read the following sentences: "In recent years, there has also been a gradual shift toward more ecologically conscious agricultural practices. Societies around the world have begun to feel the devastating effects of decades of **unsustainable** agricultural practices and deforestation, and many have started taking preventative measures."

As used in the passage, what does the word "**unsustainable**" mean?

A. dangerous to farmers
B. not able to be maintained
C. very important
D. unhealthy to animals

7. Choose the answer that best completes the sentence below.

Human activities have sped up the process of erosion by an estimated 10 to 40 times globally. _____, farmers have been encouraged to take steps to reduce erosion.

A. Before
B. Since
C. Consequently
D. Because

8. Describe how the Grand Canyon formed.

_____

_____

_____

9. What are some of the main reasons for the large global increase in the rate of erosion?

10. Has the rapid rise of erosion rates been adequately recognized by farmers and scientists as a problem? Use specific evidence from the passage to support your answer.

The Rise of Oxygen in the Earth's Atmosphere

by American Museum of Natural History
This article is provided courtesy of the American Museum of Natural History.

On a chilly October afternoon, Grant Young and Jay Kaufman stand along a busy roadside in northern Ontario, poring over their favorite Earth-history book. Young, a professor of geology at the University of Western Ontario, and Kaufman, a geoscientist from the University of Maryland, are among the leading scientists trying to attach firm dates to the rise of oxygen in Earth's early atmosphere - an event that, when it occurred more than 2 billion years ago, dramatically altered the planet's development.

The book they are reading is an ancient geological masterpiece: the Huronian Supergroup, a massive formation of rock laid down gradually between about 2.5 billion and 2.2 billion years ago, precisely the period when oxygen began to accumulate in the atmosphere. The Huronian Supergroup is 10 or 11 kilometers (six or seven miles) thick and extends well below ground. From atop a nearby outcrop, a viewer can survey the landscape for miles around. At the moment, however, Kaufman and Young are at road level, examining a segment of the outcrop that was exposed back when the highway was built. Individual layers of ancient sediment form horizontal stripes on the rock. From a few steps back, the rock wall looks like a cross-section of a giant, stone encyclopedia.

© AMNH

The Huronian Supergroup

"When we look at a sequence of rocks, it's like the pages of a book," Young says. "The page at the bottom is the oldest and the page at the top is the youngest. We read history by starting at the bottom layer and working our way up. The Huronian Supergroup is particularly exciting and interesting because, by chance, these rocks were laid down at a period when the atmosphere underwent a transition from containing no free oxygen to containing at least some free oxygen."

It may seem at first like an odd strategy: studying rocks in order to understand the atmosphere. It's one thing to examine fossils, the solid remains of ancient, solid creatures. But what can rocks reveal about something as formless as air, much less air that existed billions of years ago? How does one study the ancient atmosphere when no samples of it are left to collect?

Fortunately, the geological record contains a history of more than just rock. The atmosphere, then as now, constantly interacts with Earth's crust. As exposed rock weathers, its composition is altered by compounds in the air. This alteration is apparent even billions of years later and reveals important details about the atmosphere at the time. By studying a shoeprint in the mud, a police detective can determine not only the kind of shoe that made it, but also critical details about its wearer: size, weight, gender, even age, and whether or not he or she walked with a limp. The ancient atmosphere left an equally telling signature in the rock record. By flipping backward through pages of rock, a geologist can begin to form a picture of that atmosphere and how it changed through time.

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Jay Kaufman, of the University of Marylan, looking at Huronian stratigraphy.

"I've often wished that I had a time machine to go back and collect a sample of ancient atmosphere or an ancient bit of seawater," says Kaufman. "But we can't. All we can do is collect rocks that were formed under those waters and under that atmosphere."

Oxygen is a highly reactive element; it readily combines with other elements to form new compounds. As these compounds form, they become part of the geological record, leaving behind a trail of molecular "crumbs" that point to oxygen's whereabouts through history. One clue to the nature of the ancient atmosphere comes from rock formation known as "redbeds," the oldest of which date back about 2.2 billion years. Redbeds are sediments that were deposited on floodplains by water exposed to the atmosphere. They contain a mineral called hematite, a compound of iron and what must have been atmospheric oxygen. After 2.2 billion years ago, redbeds become increasingly common in the geological record.

"It's a very simple kind of test," says Young, who has studied redbeds extensively over the course of his career. "But it does give us at least a first-order idea as to whether there was free oxygen and whether there wasn't."

In recent years Kaufman's colleague James Farquhar, a geochemist at the University of Maryland, devised an even more precise method of dating the rise of oxygen. He collected rocks from the Huronian Supergroup and other deposits around the world, ground them to powder in the laboratory, and studied them for traces, not of oxygen, but of an entirely different element: sulfur. Sulfur compounds are emitted in vast quantities by volcanoes, which were especially active during Earth's youth. Like other airborne compounds, they undergo reactions in the atmosphere and eventually end up deposited in the geological record.

As it happens, there are four different kinds, or isotopes, of sulfur. By far the most common - about 95 percent of all atmospheric sulfur - is sulfur-32, or sulfur with an atomic weight of 32. The other isotopes are sulfur-34 (4.2 percent), sulfur-33 (0.75 percent), and sulfur-36 (0.02 percent). The relative proportion of these four isotopes has tended to remain steady over time. But Farquhar and his colleagues found that in rocks older than about 2.4 billion years, the proportion of sulfur-33 varied widely, whereas rocks younger than about 2.1 billion years showed no significant variation. What accounted for the variation, and for the change?

The answer, Farquhar and Kaufman believe, was oxygen. Early in the planet's history, before enough free oxygen had accumulated to form a protective layer of ozone (O3), Earth's atmosphere was scorched by intense ultraviolet radiation from the Sun. The UV radiation may have reacted with the atmosphere to produce some compounds with a high sulfur-33 to sulfur-32 ratio and other compounds with a low sulfur-33 to sulfur-32 ratio. Later, with the rise of oxygen and the formation of an ozone layer which blocked incoming UV radiation, that photochemical reaction stopped, and the ratio of sulfur-33 to sulfur-32 ceased to vary. Amazingly, these signatures of sulfur isotopes are recorded in the rocks. In old rocks, before the buildup of atmospheric oxygen, the ratio of sulfur-33 to sulfur-32 in rocks is variable; in young rocks it is constant and in the same ratio as today.

Farquhar's technique, though indirect, is remarkably exact: he has determined that free oxygen began to accumulate in the atmosphere about 2.45 billion years ago and was well established by 2.1 billion years ago. He also has been able, for the first time, to provide a rough measure of how much oxygen there was compared to today. "The sulfur research probably provides the strongest evidence for the buildup of oxygen in the atmosphere," Farquhar says. "The change from a large signature to a much smaller signature is a result of a large change in atmospheric oxygen content, from levels 100,000 times less than present to levels within about 100 times less than the present level."

"The most exciting thing to me about this research is that it quantifies amounts of oxygen in the atmosphere," Kaufman adds. "Before, we just had this qualitative sense of, well, it was low here, it must have risen here. But the signatures that we're seeing allow us to actually get at numbers - to get at the timing of this rise, so it's not just a fairytale. We can actually write some sentences on the pages of the book of atmospheric oxygen."

Name: _____ **Date:** _____

1. Why is the Huronian Supergroup rock formation particularly interesting to scientists?

A. because it looks like a cross-section of a giant, stone encyclopedia

B. because it formed during the period when oxygen began to accumulate in the atmosphere

C. because it contains unusually large amounts of oxygen and sulfur

D. because it dramatically altered the planet's development when it first formed

2. In this article the author explains what scientists are trying to find out. What are the scientists in the article trying to find out?

A. how the proportions of different sulfur isotopes change in the geologic record

B. when oxygen increased in Earth's early atmosphere

C. when sulfur first appeared in Earth's early atmosphere

D. how the ozone layer formed and the effects of its formation

3. Read these sentences from the article.

"I've often wished that I had a time machine to go back and collect a sample of ancient atmosphere or an ancient bit of seawater," says [Jay] Kaufman. "But we can't. All we can do is collect rocks that were formed under those waters and under that atmosphere."

Which conclusion does this statement support?

A. Scientists are skeptical about their ability to determine when oxygen levels in the Earth's early atmosphere rose.

B. Scientists are unable to study what the Earth was like millions of years ago because they do not have the materials needed to do so.

C. Scientists study the atmosphere in order to learn what the Earth's seawater was like millions of years ago.

D. Scientists study rock formations in order to learn what Earth's atmosphere was like millions of years ago.

4. Read these sentences from the article.

"Individual layers of ancient sediment form horizontal stripes on the rock. From a few steps back, the rock wall looks like a cross-section of a giant, stone encyclopedia."

Why might the author have included this description of the rock wall?

A. to explain why the author quotes scientists in the article

B. to demonstrate why the author explains two different methods used to date the rise of oxygen in the atmosphere

C. to show why the author presents information about different compounds in the article

D. to clarify why the author compares studying a rock formation to studying a book

5. What is the main idea of this article?

A. Scientists learn about sulfur by studying ancient rocks.

B. Scientists learn about the history of oxygen in Earth's atmosphere by studying rocks.

C. Scientists learn about redbeds by studying the history of Earth's atmosphere.

D. Scientists learn about the history of sulfur in Earth's atmosphere by studying oxygen.

6. The author asks these questions in the article.

"But what can rocks reveal about something as formless as air, much less air that existed billions of years ago? How does one study the ancient atmosphere when no samples of it are left to collect?"

Why might the author ask these questions? Consider both the questions themselves and their context in the article.

A. to get the reader thinking about something that will be explained later in the text

B. to force the reader to come up with ways to study the ancient atmosphere without collecting samples

C. to invite the reader to learn more about the questions scientists ask themselves

D. to suggest to the reader that it's impossible to learn about the ancient atmosphere using today's rocks

7. Read this sentence from the article.

"As exposed rock weathers, its composition is altered by compounds in the air."

Which of the following words could replace "its" without changing the meaning of the sentence?

A. the rock's
B. the weather's
C. the Earth's
D. the compounds'

8. In order to determine when oxygen levels increased in the Earth's atmosphere, which element did James Farquhar and his team search for in rocks?

_____

_____

_____

9. Jay Kaufman said that while scientists cannot collect and study samples of the ancient atmosphere, they can "collect rocks that were formed... under that atmosphere." Why are scientists able to learn about the ancient atmosphere by studying the rocks that came into contact with the ancient atmosphere?

_____

_____

_____

10. Explain what scientists might be able to learn about the seawater that existed millions of years ago by studying rocks that came into contact with seawater at that time in the past. Use evidence from the text to support your inference.

THE WALL STREET JOURNAL.

NASA Probe to Explore the Sun's Atmosphere for the First Time

Parker Solar Probe named after University of Chicago scientist who first wrote of solar winds in 1960s

By Shibani Mahtani
May 31, 2017

CHICAGO -- NASA announced Wednesday that it will launch an unprecedented mission to fly directly into the sun's atmosphere, zooming within 4 million miles of the surface and withstanding temperatures of up to 2,500 degrees Fahrenheit.

The mission has been named the Parker Solar Probe after Eugene Parker, a solar astrophysicist at the University of Chicago who in 1968 wrote a seminal paper about solar winds and the solar magnetic system. The launch is planned for between July 31 and Aug. 19 of 2018.

This is the first time a satellite will fly directly into the sun's atmosphere, with the aim of answering questions including why the atmosphere, known as the corona, is hotter than the surface of the sun itself and other questions about space weather. The spacecraft will be protected by a 4.5-inch-thick carbon-composite shield, NASA said.

"We have not been able to answer these questions without being able to take a probe at the sun," said Nicola Fox, the mission project scientist for the solar probe. Answers to these questions are "key to us being able to put the last pieces together" about the sun's atmosphere, she added.

The mission will also produce the first-ever close-up view of a star, providing a deeper understanding of the physics of stars.

The mission, which will launch from the Kennedy Space Center in Florida, is fully funded, costing about $1.5 billion from development to launch.

About eight weeks after the launch, the satellite will encounter Venus and do a flyby of the planet, and eight weeks after that, it will encounter the sun's atmosphere for the first time. Traveling at 430,000 miles an hour, the satellite will continue making orbits around the sun, using instruments to measure the atmosphere.

The whole mission will take about seven years, Dr. Fox said.

NASA says the mission was 60 years in the making, bolstered by Dr. Parker's transformational research, in which he predicted the existence of solar winds. His research changed the way scientists perceive space and formed the basis for the solar probe.

The mission is a culmination of research in the field of solar and heliophysics since then, said Thomas Zurbuchen, association administrator for the Science Mission Directorate at NASA's Washington headquarters. "We want to go down there . . . we built the machines robust enough to do that."

Understanding weather patterns in space, scientists say, will have real-life applications, since plasma and radiation from the sun could affect our planet. Space weather can influence everything including electrical grids and GPS systems, and further understanding of the atmospheric changes will help scientists find ways to minimize disruptions to these systems on Earth.

The mission can also help support space travel overall by providing a deeper understanding of the risk to astronauts posed by storms in space, scientists said.

The Parker Solar Probe is the first time that a NASA mission has been named after a living scientist.

"One would like to have some more detailed measurements of what's going on in the solar wind," Dr. Parker said. "I'm sure that there will be some surprises. There always are."

Name: _____ **Date:** _____

1. What unprecedented mission is NASA going to launch?

A. a mission to fly by Venus

B. a mission to fly out of the solar system

C. a mission to fly directly into the sun's atmosphere

D. a mission to fly to and land on the sun

2. What does this article describe?

A. the mechanism and technology that make the Parker Solar Probe mission possible

B. the risks and danger associated with the Parker Solar Probe mission

C. the purpose and applications of the Parker Solar Probe mission

D. the biographies of the scientists working on the Parker Solar Probe mission

3. Please read these sentences from the text.

"This is the first time a satellite will fly directly into the sun's atmosphere, with the aim of answering questions including why the atmosphere[...] is hotter than the surface of the sun itself and other questions about space weather. [...] 'We have not been able to answer these questions without being able to take a probe at the sun,' said Nicola Fox[.]"

What conclusion can be drawn based on this evidence?

A. This satellite was built to answer questions about the sun that previously had never been asked by scientists at NASA.

B. This satellite will give us information about the sun and space weather that we've never had access to before.

C. This is the first time the sun's atmosphere has been cool and calm enough to allow a satellite to enter it safely.

D. Sending a satellite to the sun's atmosphere is the only way to learn anything about the sun or space weather.

4. Why might the Parker Solar Probe be the first time a satellite will fly into the sun's atmosphere?

A. because this is the first time the technology has been available to allow a satellite to get very close to the sun

B. because scientists only recently became interested in learning more about the sun and its atmosphere

C. because the sun's atmosphere has only recently cooled down enough to allow satellites to get close to it

D. because scientists did not need satellites to learn about the sun's atmosphere until recently

5. What is the main idea of this article?

A. For the first time, NASA is sending a probe to the sun's atmosphere to take measurements and help answer questions about the sun's atmosphere and space weather.

B. Scientists at NASA want to learn more about the sun's atmosphere and space weather because of the applications that knowledge would have on Earth.

C. A new mission at NASA has been named after Eugene Parker, who wrote an important scientific paper about solar winds and the solar magnetic system.

D. Scientists are sending a satellite into the sun's atmosphere in order to confirm information about space weather that they have gathered using other methods.

6. Please read these sentences from the text.

"About eight weeks after the launch, the satellites will **encounter** Venus and do a flyby of the planet, and eight weeks after that, it will **encounter** the sun's atmosphere for the first time. Traveling at 430,000 miles an hour, the satellite will continue making orbits around the sun, using instruments to measure the atmosphere."

What does the word **encounter** mean as used in these sentences?

A. exit quickly

B. avoid

C. stay in

D. come across

7. Please choose the answer that best completes the sentence.

Plasma and radiation from the sun can affect our planet; _____, understanding weather patterns in space will have applications for Earth.

A. however

B. therefore

C. because

D. although

8. What are scientists hoping to learn about through the Parker Solar Probe mission?

_____

_____

_____

9. Identify two things on Earth that can be affected by space weather.

_____

_____

_____

10. How might the Parker Solar Probe mission affect regular people on Earth? Support your answer with evidence from the text.

The Meteor

by ReadWorks

Sergei Bobunets, lead singer of a Russian rock band, had just stepped outside when the sky fell apart.

"I looked up, and suddenly the sky lit up with a bright light, and something that looked like the sun fell," Bobunets said, trying to make sense of one of the most powerful events on Earth: a meteor strike. Bobunets was standing 125 miles north of Chelyabinsk, a city in Russia which on February 15, 2013, witnessed perhaps the best-documented meteor fall in human history.

Eyewitnesses recorded the fireball with their phones and digital cameras. A European weather satellite took a photo of the meteor as it streaked through the atmosphere, and a Chinese satellite captured the meteor's vapor plume. Thousands of people saw the flash of light and felt the shock wave after the meteor crashed into Earth.

"I looked out the window and saw a huge line of smoke, like you get from a plane, but many times bigger," Sergei Serskov, an office worker in Chelyabinsk, told the BBC. "A few minutes later the

window suddenly came open, and there was a huge explosion, followed by lots of little explosions. It felt like a war zone."

The meteor was not very big. It was about 57 feet long, a little longer than a normal city bus. But it was super dense, weighing about 11,000 tons-more than the Eiffel Tower. And it was moving extremely fast. Scientists estimated its speed at 41,000 miles per hour, or about 50 times the speed of sound. Its tremendous speed was the main factor in its enormous destructive power. When the meteor exploded 14 miles above the Earth it released a bright flash of light, a powerful heat wave, and a shock wave with roughly 20 to 30 times more energy than the atomic bomb detonated at Hiroshima. The explosion damaged 7,200 buildings in six cities and about 1,500 people were injured, mostly from flying glass.

"My eyes are still hurting," an eyewitness wrote on an Internet forum soon after the impact. "Oh, my God, I thought the war had begun."

The widespread destruction caused by the Chelyabinsk meteor gives proof to the rule of physics that the faster an object is moving, the more energy it has. A bus on the street that loses control could slam into a building and kill a few people. A bus flying through space at 50 times the speed of sound could wipe out an entire city.

The Chelyabinsk meteor is also an example of how energy moves. First there was the meteor itself, which was moving energy simply by its movement through space. As it encountered Earth's atmosphere, the meteor ran into increased resistance from air and dust molecules, which released some of its energy in the forms of heat and light. And when it exploded, the meteor radiated its energy over the Russian sky in the forms of blinding light, piercing sound, a shock wave strong enough to collapse buildings and knock people off their feet, and continued physical motion in the form of thousands of rocks falling to the ground. The only known type of energy the meteor did not give off was electricity.

While the Chelyabinsk meteor was the best-documented in history, it was not especially large or powerful as meteors go. The most destructive event in recorded history is believed to have been a meteorite that crashed into Earth above Russia's Tunguska River in 1908. Scientists estimate the object was about 330 feet across. It flattened 80 million trees over 830 square miles of forest, and created a destructive force 1,000 times more powerful than the atomic bomb dropped over Hiroshima. The shock wave shook buildings and knocked people off their feet hundreds of miles away. For the next few nights, night skies across Europe and Asia glowed, possibly caused by sunlight bouncing off particles left by the meteor's tail and dust raised by its impact.

Widespread casualties were avoided because the area was so thinly populated, but there were eyewitnesses to the explosion. "The sky split in two, and fire appeared high and wide over the forest," a witness named S. Semenov told a researcher. "At that moment I became so hot that I couldn't bear it, as if my shirt was on fire...I wanted to tear off my shirt and throw it down, but then the sky shut closed, and a strong thump sounded, and I was thrown a few meters."

No other object visible to humans travels as fast or carries as much energy as meteors do. As the world fills with electronic cameras and sensors, we may be able to learn more about smaller meteors such as the one at Chelyabinsk before once more facing the destructive power of a mammoth meteor like the one at Tunguska.

Name: _____ **Date:** _____

1. What did Sergei Bobunets witness?

A. a meteor strike

B. a plane crash

C. the bombing of Hiroshima

D. the sun falling

2. How does the author describe the meteor strike at Chelyabinsk?

A. The meteor strike had very few witnesses and was not well documented.

B. It was the most destructive meteor strike in documented history.

C. The meteor strike created a bright flash of light, a heat wave, and a shock wave.

D. The meteor strike was in a thinly populated area and did not hurt anyone.

3. The Chelyabinsk meteor was a little longer than a normal city bus and moved at 50 times the speed of sound. A bus on the street that loses control could slam into a building and kill a few people. A bus flying through space at 50 times the speed of sound could wipe out an entire city.

Which conclusion does this information best support?

A. Objects release energy.

B. The faster an object is moving, the more energy it has.

C. Bus-sized objects can be dangerous.

D. The size of an object determines how fast it can move.

4. When did the Chelyabinsk meteor most likely contain the most energy?

A. after it exploded

B. when it exploded

C. as it encountered Earth's atmosphere

D. before it encountered Earth's atmosphere

5. What is this passage mostly about?

A. Sergei Bobunets

B. atomic bombs

C. meteor strikes

D. astrophysics

6. Read the following sentence: "As the world fills with electronic cameras and sensors, we may be able to learn more about smaller meteors such as the one at Chelyabinsk before once more facing the destructive power of a **mammoth** meteor like the one at Tunguska."

What does "**mammoth**" mean in this context?

A. very, very large

B. a hairy animal from the Ice Age

C. something frightening

D. lacking in force

7. Choose the answer that best completes the sentence below.

When a meteor explodes in the sky, it radiates its energy in various forms, _____ light, sound, and heat.

A. consequently

B. above all

C. currently

D. including

8. What object visible to humans travels the fastest and carries the most energy?

_____

_____

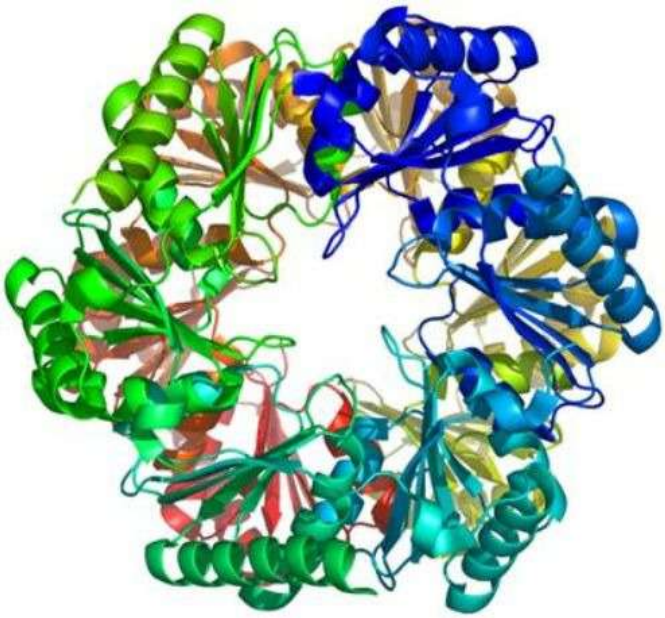
_____

9. What were the differences between the meteor strikes at Chelyabinsk and Tunguska?

10. Explain why it is important to study meteors. Support your answer with details from the passage.

Processes

by ReadWorks



There's a deep and complex relationship between living creatures, inorganic material such as rock and minerals, and the climate conditions we experience, such as rain and wind. These relationships are not always easy to see. Sometimes, the relationship operates on a level that is microscopically small, such as the way plants transform sunlight into nutrients. Other times, the relationship can be observed only across a hugely long span of time-hundreds, thousands, or even millions of years. But the connection is there, and we're in a unique and privileged position to see and appreciate it.

If you could overcome these two limitations of everyday seeing-if you could see things that were very small and subtle, and if you could see things that occurred over a very long stretch of time-what would you see?

It's a matter of debate, but there's certainly a good case to be made that photosynthesis may be the most exciting earth process we know of. We know that plants are capable of converting water, carbon dioxide, and sunlight into oxygen. They are able to achieve this remarkable feat with a relatively small number of separate parts, and have done so, very reliably, for ages. Anyone who's ever had a household plant, watered it, set it near light, watched it grow, and felt the air in her home to be cleaner has experienced this magic firsthand. But if you could see this process on a microscopically small scale, this abstract magic would be revealed as an extraordinary set of mechanisms.

What if you could see photosynthesis working over the span of billions of years? This is the other remarkable thing: This mechanism, which operates on the smallest scale imaginable, has consequences that are literally global in scope, and span ages. If you could watch the earth evolve, you could see how, over two-and-a-half billion years ago, before the emergence of plants that could release oxygen, there simply wasn't much of it at all in the atmosphere. Not much oxygen in the atmosphere meant there were nowhere near the number and variety of creatures we've come to know today.

Over the course of hundreds of millions of years, you'd slowly begin seeing the emergence of tiny organisms capable of producing oxygen. However, you'd also notice that most of that oxygen was captured by minerals and other organic matter, never growing to very high levels in the atmosphere. Sooner or later, though, these organic and inorganic matter would reach their saturation point-the moment when they simply could not absorb any more oxygen. That's when the oxygen created by organisms would become free oxygen. Free oxygen for everyone!

Then, as an observer across the ages, you'd begin seeing the atmosphere change, from one dominated by methane and other elements, to one plentiful with oxygen. As we know, this is what set the stage for a huge diversity of mineral and organic life to emerge, including, many billions of years later, human beings. All of us, along with the foods we consume and the ground we walk on, are the direct descendants of a process that began billions of years ago, and that continues today, all across the planet, on a microscopically small level. What could be more exciting than that?

Of course, if photosynthesis is the most exciting earth process we enjoy, then its energy from the opposite direction-heat from the Earth's core-that's the most mysterious. That's because it originates, at least in part, from events that occurred at the very formation of the planet.

Can you imagine such a thing as "pre-earth" space? It's a pretty heavy concept. But imagine the part of the universe where the earth would soon be, but wasn't yet. There, when the hot gases and particles were pulled together by gravity to create the early earth, immense heat was generated, and the resulting planetary core continues to cool to this day, radiating heat outward. The movement of more and less dense parts of the earth's core produces heat. Most of all, there are massive amounts of radioactive material deep in the earth's core, decaying slowly and releasing heat as they do.

While energy from the sun sets in motion extraordinary interactions between the atmosphere, organisms and minerals, energy from the earth's core profoundly affects the shape of the ground we walk on-literally. Again, imagine having the power to see very small and very slow. Processes that result from earth's energy operate at these levels. We're all familiar with the most visible results: earthquakes and volcanoes, which can be mighty indeed! But energy from the earth's core is also responsible for the shift of tectonic plates, that is, the very placement of one continent relative to another, and, as a result, the emergence of mountains, chasms, oceans, and myriad more aspects of the environment.

This is what it really means to contemplate the origins of the planet and the universe. It's not simply a matter of the far-away cosmos and their relationship to us. It's the question of how it came to be that events occurring unimaginably long ago, and taking place at a rate so slow it's impossible to see, have come to shape the ground we walk on. The decay of radioactive material deep in the earth's core is responsible for not only the Rocky Mountains, but the formation of cities and societies that have lived there for generations, such as Rocky Mountain National Park, which serves as a beacon to the natural wonders of America and Canada. It's responsible for mountains that serve as barriers, bringing to life divisions in culture unique to each side, while also posing a challenge to be crossed and burrowed into, spurring on scientific innovation in the process.

So many aspects of what it means to be human, from the way cities are constructed, to the way nations are organized, are influenced by our natural environment, by the vast and complex set of processes that have shaped the earth since its inception, and will continue to do so long into the future.

Name: _____ **Date:** _____

1. Photosynthesis is an example of what?

A. one of philosophy's big ideas

B. one of Earth's key processes

C. one of humankind's best inventions

D. one of science's most well-known innovations

2. In this passage, the author provides a list of what?

A. ways that the earth has been shaped by ancient natural processes

B. ways that the earth has been shaped by scientific innovation

C. ways that our lives have been shaped by philosopher's theories

D. ways that our lives have been shaped by cultural events

3. Photosynthesis is an important process that supports many kinds of life. What evidence from the text supports this conclusion?

A. Photosynthesis may be the most exciting earth process we know of.

B. Photosynthesis produces oxygen, which allowed diverse mineral and organic life to emerge.

C. Photosynthesis operates on the smallest scale imaginable.

D. Photosynthesis is a process by which plants convert water, carbon dioxide, and sunlight into oxygen.

4. What do processes on Earth have an impact on?

A. living things only

B. living things and the non-living environment

C. the non-living environment only

D. climate conditions only

5. What is this passage mainly about?

A. the consequences that arise from the earth's tectonic plate shifts

B. the early organisms that helped to populate the earth with oxygen

C. how the development of the earth has been impacted by its natural processes

D. the history of the planets and moons within our solar system

6. The author describes processes that involve changes happening on a small scale, and over billions of years. How does the author help the reader to understand those processes?

A. The author includes graphs, charts, and a timeline.

B. The author includes detailed illustrations to show these processes.

C. The author describes what one would see as an "observer across the ages."

D. The author describes instructions for conducting one's own experiments.

7. Choose the answer that best completes the sentence below.

Energy from the sun sets in motion extraordinary interactions between the atmosphere, organisms and minerals. _____, energy from the earth's core profoundly affects the shape of the ground we walk on.

A. Consequently

B. Meanwhile

C. In conclusion

D. For example

8. Human beings need oxygen to breathe. Why is photosynthesis essential to the survival of human beings?

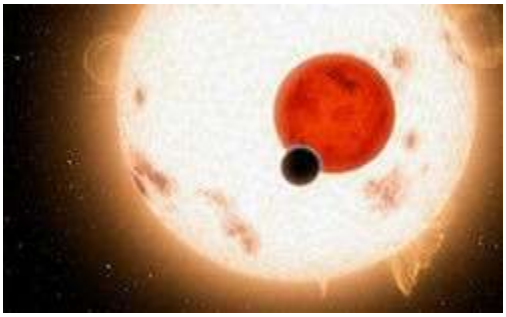
9. Explain how the earth's core has impacted human life. Use evidence from the text to support your answer.

10. Could humans survive on Earth over two-and-a-half billion years ago, before the emergence of plants? Why or why not? Use evidence from the text to support your answer.

In Our Galaxy, Far, Far Away

NASA Announces the Discovery of a Planet That Orbits Two Stars, But There May Be More ...

In the film *Star Wars: Episode IV -A New Hope* , a future Jedi named Luke Skywalker watched as two suns set on his home planet, Tatooine. When that film was made some 30 years ago, the existence of a planet with two stars was pure science fiction. Now, astronomers say, it's a scientific fact.



NASA/JPL

On September 15, 2011, NASA, the U.S. space agency, announced the discovery of Kepler-16b, a circumbinary planet, or a planet in the orbit of two stars. Scientists had previously discovered a few other objects orbiting two stars, but Kepler-16b is the first confirmed planet.

"It's the best example we have of a Tatooine-like world from *Star Wars*," says Nick Gautier, a scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. "Now we don't expect Luke Skywalker or anything else to be living on Kepler-16b, but if you could visit there, you would see a sky with two suns just like Luke did."

Star Power

The discovery was made by the Kepler space telescope, which is on a mission to find Earthlike exoplanets-planets in orbit around stars other than the sun. Kepler-16b is the 21st confirmed planet that Kepler has detected since its launch in March 2009.

Lucas Film/20th Century Fox/The Kobol Collection

Luke Skywalker watches a double sunset on his home planet of Tatooine.

Kepler-16b's star system is located between the constellations Cygnus and Lyra, about 200 light-years from Earth. A light-year equals the distance light travels through space in a single year, or about 5.9 trillion miles. The planet is about the size of Saturn, but, because it's gaseous, scientists don't believe it to be habitable.

Although it has two stars, Kepler-16b is probably much colder than Earth because neither star is as powerful as Earth's sun. One star is 69 percent of the mass of the sun. The other is only 20 percent of the mass of the sun. The two stars-together called a binary star-orbit around a common center. They cross paths every 41 days. The planet orbits around both stars every 229 days.

"We have two stars dancing around each other, and in our line of sight, they eclipse each other," says Laurance Doyle, principal investigator for the SETI (Search for Extraterrestrial Intelligence) Institute in Mountain View, Calif. "Then we have this exquisite little pirouette of the planet going around both of them."

The Light Stuff

Scientists are doing much more than admiring the fancy footwork of this dance in space.

EADS Astrium/Corbis

This artist's rendering shows the Kepler space telescope. Kepler has the largest camera ever launched into space.

"One way to find exoplanets is to find stars whose planets orbit so they cross in front of the star visible from Earth," says Gautier. The Kepler telescope monitors the brightness of stars, he explains.

When a planet crosses in front of a star during an eclipse, it dims some of the star's light for a few hours. By analyzing the changes in light, scientists can accurately determine the size and mass of the planet.

Astronomers hope that further study of binary star systems will help shed light on how planets are formed. "There are as many binary stars as single stars and over 2,000 eclipsing binary stars within Kepler's line of view," says Gautier. "So this could be very common."

Looking For Life

Kepler's main mission, however, is to find Earth-sized planets that are the right distance from a star to have a livable temperature. In February,2011, NASA announced the discovery of 1,235 possible exoplanets. Now the challenge is to find one that could potentially support life.

To date, Kepler has detected large gaseous planets like Jupiter that, because of their distance from their respective stars, would be as hot as Mercury. The telescope also has spied gas planets scope similar in size to Neptune in close orbit around stars. Kepler has even found rogue planets, planet-sized objects that appear to have broken free from the gravitational force of their stars so that they are no longer in orbit.

NASA/JPL

An artist's rendering shows Kepler-16b, the first known circumbinary planet.

The discovery of Kepler-16b opens up a whole new world of possibilities.

"This is an example of another planetary system. A completely different type that we've never seen before," says Doyle. "Nobody's ever seen a place like this before-with one exception. I seem to remember seeing a place like this before about 30 years ago [when *Star Wars* premiered] in a galaxy far, far away."

Name: _____ **Date:** _____

1. What fictional planet does the writer compare Kepler-16b to?

A. Pluto

B. Lyra

C. Tatooine

D. Cygnus

2. How does the author describe Kepler-16b?

A. as a rocky planet that orbits two stars

B. as a moon that crosses the path of several stars

C. as a planet probably much warmer than Earth

D. as a gaseous planet about the size of Saturn

3. Which of the following conclusions about the Kepler space telescope is supported by the passage?

A. NASA will stop searching for planets with the telescope.

B. The telescope will soon find that Kepler-16b supports life.

C. Kepler-16b is the last planet the telescope will discover.

D. The telescope will most likely discover more planets.

4. Read this sentence from the passage:

"The planet is about the size of Saturn, but, because it's gaseous, scientists don't believe it to be habitable."

In this sentence, the word **habitable** means

A. growing in size

B. carefully observed

C. suitable to live on

D. covered with holes

5. Which statement best describes the main idea of the passage?

A. The Kepler space telescope is on a mission to find Earthlike exoplanets.

B. Scientist Nick Gautier is studying exoplanets to learn how planets form.

C. Kepler-16b's star system is located about 200 light-years from Earth.

D. NASA recently announced the discovery of a circumbinary planet.

6. What is a light-year?

7. How might Laurance Doyle, principal investigator for the SETI Institute, have felt when he learned of the discovery of Kepler-16b? How do you know?

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

Rogue planets are no longer in orbit _____ they have broken free from the gravitational force of their stars.

A. before

B. however

C. because

D. although

How to Make a Better Robot

by ReadWorks

Many people think that robots are an inevitable part of the future. It would be pretty cool to have a droid friend around to save the day, or even just to keep you company when you got bored. While it may seem like something out of science fiction, researchers are already imagining a world in which robots become a more integrated part of our lives. We already have robots among us: some are designed to work in factories, creating uniform products continuously. You may even have one in your home, in the form of a little vacuum cleaner that self-drives itself around the floor.

But for robots to make it to the next level, scientists think they'll need to be a bit more versatile. The robots scientists are imagining look nothing like the stiff creatures you might be thinking of. No need for an awkward robot with stiff legs that attempts to walk and act like we walk and act-researchers are hoping to cook up something entirely different from what we're used to seeing.

How to Design a Robot

A group of researchers at Cornell University thinks the future of robots will actually be full of softbots. A softbot is simply a robot made out of soft tissue, so it can move more flexibly than a hard-bodied robot. And with the rise of 3D printers, building softbots is easier now than ever before. The question that remains is: what will these robots look like? How will they move? How will they carry things, or navigate small quarters?

These are precisely the questions these scientists are trying to answer. It's easy enough to build a robot that mimics a human. We already know what we look like and how we move. But how do we know this is the best way for robots to move? To put it simply, we don't.

The researchers are trying to figure out all the different ways robots could move. They're basically in the middle of a very long brainstorming session. Once they realize what the options are, they can figure out which motions are best suited to which actions, and create a final model that will perform the best in all scenarios.

In order to do this, they've built a computer program that simulates the growth and movement of several kinds of softbots. They can use animated tissue, muscle, and bone to build a large number of different kinds of softbots. Then the computer program runs the robots through tests, checking out things like balance, coordination, or noisiness. In one example, they're looking for speed, so the fastest robots get to stick around, while the slowest robots get cut.

The Possibilities

We're going to take a look at all of the different options for how a robot can move from one point to another-this is the speed test. Scientists run a computer program several times, and each time, the robots are a little bit different. Sometimes, they focus on giving the robots legs-either two legs like humans have, or four, like many animals have. And sometimes they see if they can make a mover without legs.

The fastest robot they created has legs and runs in a bounding motion-the front legs move together and the back legs bound forward, similar to how a cheetah moves. Another robot was made to have long legs that were mostly made of bone. These legs became long and skinny, so it wasn't surprising when the robot started to gallop like a horse.

Other times, they try to make robots that can move in non-traditional ways. In one instance, they created a funny sort of robot that doesn't have very much structure, just a big blob of muscle. This robot moves by inching its body forward, pulling its body in tight, and then releasing it to go long, much like an inch worm. It's not a very fast robot, but it does have an advantage, the researchers realized. If they picked this robot up and dropped it randomly somewhere else, the robot would just keep on moving as if nothing had happened. The researchers realized this trade-off-the bot may not be very fast, but it certainly is durable.

They even make some robots that seem almost silly from the outset. For example, some of their creations are designed to have no legs at all, but they still had to figure out a way to move them forward. One of the designs that resulted from this is a big robot that, instead of legs, has two large wings, and it flaps them back and forth to move. The design is almost like a gorilla relying primarily on its arms to move, but it's a bit bulkier. Another robot that came out of this is a little guy who looks like

an open jack-in-the-box. The bottom of the body is box-shaped, but at the top, out pops two little arms. This robot moves by flailing its arms back and forth, which make the little guy slowly progress forward. It may seem silly, but an advantage this robot has is that it could easily hold things in its hands, or its empty lower-box while still moving forward.

Putting Ideas into Action

Now that the researchers have a number of ideas in mind, they can start performing other tests to see which robots perform better at tasks besides moving themselves along. Maybe they'll have to measure how much energy the robot requires to function for a long period of time, or how much space it takes up. All three of these aspects will play into the future success of the robot, so it's important to consider them all separately. Even if something ends up looking silly in a trial, the underlying reason behind its success may still warrant a characteristic to be considered for the final design.

For example, perhaps one of the softbot's tasks will be to take out the garbage (wouldn't that be nice?). For that, you'd want a robot that could carry things and one not likely to fall. You'd also want a robot that was pretty quick, but you'd have to balance your desire for speed with steadiness. If the bot drops its load half the time, on average, it won't be so fast. Therefore, you have to incorporate a number of skills.

When making the robot, the researchers will have to look through all of the ideas they've created in their computer program, and pick and choose which characteristics will work best together to create a robot that can easily take out the garbage. They'll have to balance their desire for speed with a steady hand, and the ability to carry heavy loads with a desire to make the robot light enough for a human to move around if the robot's turned off.

A good way to think about it may be through imagining yourself picking out your favorite clothes to wear. One day you may be torn between wearing the T-shirt that's extra soft, so it's really comfortable to wear, and another shirt that's your favorite color. Having to pick between these options will probably convince you to eventually find a new shirt that is both the fabric that you like and the color that you like. Now this new shirt will probably be your favorite, since it has all of the positive qualities you love.

The Final Product

Going back to designing our robot that will help take out the trash, it might be nice for the robot to be fast, but is that really the most important thing? It might be better to have a slower robot take out the trash. That way, there's less of a chance the robot will fall and drop the trash (making it necessary for you to clean it up). In that case, let's go back to the robot that moves sort of like an inchworm. That robot had a lot of body mass on the ground, so it was tough to tip over-think about tipping over a butter dish versus a candlestick.

Maybe when the robot has taken the trash out, you will want it to be fast. The best thing to do then is allow it to separate its front section into two legs, and its back section into two legs. Then it can move

in that cheetah-like style, going faster. Perhaps the design of incorporating both ideas into one will result in a final product that isn't completely an inch-wormer, and isn't completely a cheetah either. The robot's body is a little too sleek to be a worm and a little too lumpy to be a cheetah. But the beauty of the final design is that the robot is more versatile, and can do everything you need it to do.

Hopefully, these types of robots will enter our lives soon. The Cornell researchers will just have to keep brainstorming different types of robot bodies, so we can always have the best selection of traits to pick from.

Name: _____ **Date:** _____

1. What are scientists at Cornell University trying to figure out?

A. how to build a computer program that simulates the movement of softbots

B. all the different tasks robots could perform

C. all the different materials robots could be made of

D. all the different ways robots could move

2. Why does the author describe the different robots scientists are creating with a computer program?

A. to show that scientists are unsure about what type of robot to build

B. to show how complex these computer programs can be

C. to show that the scientists' brainstorm session will take a long time

D. to show a variety of ways that robots could move

3. Scientists must consider a variety of factors when designing a robot. What evidence from the text supports this conclusion?

A. Researchers are already imagining a world in which robots become a more integrated part of our lives.

B. Scientists at Cornell University have built a computer program that allows them to simulate the movement of a robot before they develop a final design of the robot.

C. If a softbot is being designed to take out the trash, the softbot's ability to be steady must be balanced with its ability to be quick.

D. The fastest robot created by scientists runs in a bounding motion, similar to how a cheetah moves.

4. What can be concluded about the purpose many robots will have in the future?

A. Robots will be created to allow scientists to use computer programs.

B. Robots will be created to move in non-traditional ways.

C. Robots will be created to make life easier for humans.

D. Robots will be created to help scientists brainstorm.

5. What is this passage mainly about?

A. scientists who work at Cornell University

B. the process scientists are using to design robots

C. computer programs scientists are using to design robots

D. robots that can move like humans

6. Read the following sentences: "But maybe when the robot has taken the trash out, you will want it to be fast. The best thing to do then is allow it to separate its front section into two legs, and its back section into two legs. Then it can move in that cheetah-like style, going faster. Perhaps the design of **incorporating** both ideas into one will result in a final product isn't completely an inch-wormer, and isn't completely a cheetah either."

What does the word "**incorporating**" mean above?

A. crushing

B. eliminating

C. combining

D. explaining

7. Choose the answer that best completes the sentence below.

Scientists have built a computer program that simulates several kinds of softbots, _____ they can figure out which model works best.

A. however

B. so

C. although

D. after

8. After scientists have a number of ideas about robot movement in mind, what types of tests do they then perform?

9. According to the passage, what would be a good design for a softbot that would take out the trash?

10. Scientists need to test different abilities of the robots. While scientists perform these tests, they measure how much energy the robots require to function for a long period of time and how much space they take up.

Why do the scientists run these tests and track these measurements to create a final model? Use evidence from the text to support your answer.

Short Circuits

by Charles Piddock

How small can transistors get?

Ladies and gentlemen, boys and girls, consider the amazing shrinking transistor! Watch it contract a million times until it becomes a tiny dot visible only under a powerful microscope!

We all know that technological progress is not an actual magic show. Still, it almost seems like magic the way the *transistor*, the main component in all modern electronics, has diminished in size since being invented in 1947.

The first transistor, made of gold, plastic, and *germanium* (a metallic crystal), was about the size of an adult's fingernail. Today's transistors, etched on silicon wafers, can't be seen with the naked eye. The minimum size of a transistor is now 45 *nanometers*. A nanometer is one-billionth of a meter-roughly the width of three or four atoms.

Computer engineers are trying to make transistors even smaller. How tiny can they go?

Chip Switches

Every transistor has the same basic properties: It can both conduct and stop the flow of electricity. The word *transistor* is a combination of two words: *transfer* and *resistor*.

All transistors are made from materials called *semiconductors.* A semiconductor is a cross between a good conductor (such as copper) and a good insulator (such as rubber). It can be made to accept or reject the flow of electrons in a circuit. Germanium, used in the first transistors, is a semiconductor. So is silicon, widely used today.

A transistor's ability to control the flow of electricity has made possible our entire computerized world. All computers depend on the *binary system* to convert electric signals into useful information. The binary system has only two numbers: 1 and 0. When a transistor allows electricity to flow through, it registers a 1. When the transistor stops the flow of electrons, it registers a 0. Millions or billions of those 1s and 0s, flashing off and on hundreds of millions of times a second in programmed patterns, enable your computer to do everything it does-from allowing you to play *World of Warcraft* to letting you type up a school science report.

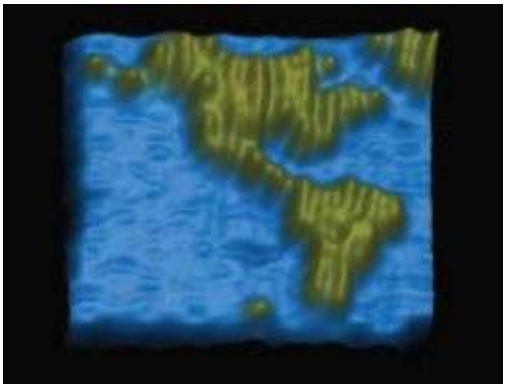
Paul W.K. Rothemund and Nick Papadakis

DNA strands twisted into smiley faces (above) and a map of North and South America (below)

Inner Limits

A transistor that is only a few atoms wide is incredibly small. But researchers want to make transistors even smaller and cheaper to produce. Chip-making technology has run into a big problem, however. Transistors smaller than 45 nanometers and etched on silicon chips don't work very well. They tend to leak electrons, making them less efficient.

To get around that problem, scientists are using *nanotechnology* to look at new materials and new methods to produce transistors. Nanotechnology is the engineering of materials on the atomic level, building new materials from the bottom up by manipulating atoms and molecules.



Paul W.K. Rothemund

One promising area of nanotechnology is the use of *graphene*, a carbon fabric that is only one carbon atom thick. Graphene is strong, stable, and can act as a semiconductor. If researchers can find a practical way to etch transistors onto graphene, smaller and immensely faster computer chips can be more cheaply made.

"[The ultimate goal] of electronic engineers is the so-called ballistic transistor," physicist Andre Geim, a graphene researcher at the University of Manchester, told *LiveScience.* "It would be very, very fast, ultimately fast, in fact."

Another promising area of nanotechnology research involves using strands of *deoxyribonucleic acid* (*DNA*) to build transistors. DNA is the genetic material that determines the makeup of all living cells. Researchers can now take strands of DNA from bacteria and manipulate them into almost any shape they want. California Institute of Technology researcher Paul Rothemund has helped pioneer that technique. He has twisted DNA strands into smiley faces and maps of North and South America. Rothemund coined the phrase *DNA origami*, after the Japanese art of paper folding.

Rothemund and others are looking to shape DNA strands into a kind of scaffolding that could be attached to silicon wafers to make transistors. Because DNA does not conduct electricity, scientists are experimenting with ways to combine DNA with atoms of conducting materials, such as gold, to build transistors. DNA *replicates* (copies) itself. So if researchers can produce a DNA transistor, all they have to do is add the right "soup" of chemicals, and the DNA would reproduce itself, making millions of new nano-sized transistors at little or no cost.

Science Photo Library/Photolibrary

This is a microprocessor, the brain of a computer. It holds data and instructions, performs calculations, and organizes operations. In most computers, the microprocessor is a chip made of a semiconducting material. Etched onto that chip are millions of transistors, which control the flow of electricity through the microprocessor. Today's microprocessors can each contain up to 1 billion transistors. Intel Corporation is now working on a microprocessor that has more than 2 billion transistors.

Smart Dust

Making transistors much smaller and much more cheaply could transform our lives. Tiny, smart nanomachines could do any number of things quickly and invisibly. Their greatest use might be in medicine. Swallowed in a pill or injected, tiny, computerized "nanobots" might be able to repair damaged cells one at a time, restoring health invisibly and painlessly before destroying themselves.

The nanobots might repair pipes, bridges, airplane engines, and electrical equipment too. They might even help with housework. Kris Pister, a University of California physicist, envisions what he calls smart dust-nanobots that move around the house at night, eating dirt and generally cleaning up.

Such things are possible in your lifetime-all because scientists are now "thinking small."

Left: Mesoscopic Physics Group/University of Manchester; Right: Kris Pister

Left: A closeup of a graphene semiconductor. 1 nanometer = 1 billionth of a meter. Right: The smallest experimental model of smart dust, shown on a penny

Name: _____ **Date:** _____

1. When was the transistor invented?

A. 1947

B. 1945

C. 2007

D. 2000

2. How does the author describe the changes transistors have undergone over time?

A. Transistors are used for the same things they were used for when first invented.

B. Transistors haven't changed much since they were invented.

C. Transistors have shrunk in size and become less useful.

D. Transistors have shrunk in size but increased in usefulness.

3. How do you think the author feels about the future of transistors and nanotechnology?

A. hopeful and excited

B. concerned and worried

C. cautious and uncertain

D. to little information to determine

4. Read the following sentences and answer the question below:

"Ladies and gentlemen, boys and girls, consider the amazing shrinking transistor! Watch it contract a million times until it becomes a tiny dot visible only under a powerful microscope!"

What does the word **contract** mean?

A. agreement or pact

B. form an agreement

C. shrink

D. to get or incur, as in a virus or disease

5. This passage is mostly about...

A. technology

B. nanotechnology

C. transistors

D. science

6. How are today's transistors different from the first ones that were invented?

7. What does the author mean by the use of the word "soup"?

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

If scientists can figure out how to etch transistors onto graphene, _____ they will be able to create much smaller and much faster computer chips.

A. but

B. then

C. so

D. however

THE WALL STREET JOURNAL.

The Fault Line Threatening Dams

Deficient structures, earthquake risks raise possibility of potentially catastrophic flooding

By Jim Carlton
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FREMONT, Calif.-The coastal mountains that frame this working-class city next to San Francisco Bay harbor a hidden menace: a reservoir 10 miles away that sits next to an active earthquake fault, which experts say could cause a dam break and flood thousands of homes.

The potential threat is so severe, the owner of the Calaveras Reservoir decided to build a replacement dam. But seven years after that work began, the dam is unfinished and isn't expected to be complete until 2019 -- four years behind schedule.

The issues hampering the Calaveras Reservoir project show how difficult it can be to repair or replace an old dam, which is of growing concern nationally.

An estimated 27,380 dams, or 30% of the 90,580 listed in the latest 2016 National Inventory of Dams, are rated as posing a high or significant hazard. Of those, more than 2,170 are considered deficient and in need of upgrading, according to a report by the American Society of Civil Engineers. The inventory by the U.S. Army Corps of Engineers doesn't break out which ones are deficient.

But funding and inspection staffing are considered inadequate, the civil engineers' report said. An estimated $64 billion is needed to upgrade those dams, including $22 billion for those posing the highest hazard, according to the Association of State Dam Safety Officials, a nonprofit group in Lexington, Ky.

"It's a huge problem with limited resources," said Ivan Wong, a consulting seismologist from Walnut Creek, Calif., who works on dam projects nationally. "We can barely pay for our schoolteachers, but if a dam fails and there's a population downstream, we're talking about a disaster. We have to fix our dams, there's no doubt about it."

At the Calaveras dam, California's Division of Safety of Dams in 2001 ordered the San Francisco Public Utilities Commission to keep its 31 billion-gallon capacity Calaveras Reservoir no more than 40% full.

Utility officials say the extra time is needed to make the dam -- with a 1,200-foot- wide base and spillway walls up to 4 feet thick -- hopefully fail-proof.

"It's better to plan for the worst and hope for the best," Dan Wade, who oversees the $800 million project, said on a tour on Wednesday. The cost is double the original $400 million estimate.

Earthquakes pose especially big risks for dams. The seismic threat is highest along the West Coast, including Washington and Oregon, which scientists say could see rare but potentially catastrophic quakes.

Few states face as much of an earthquake threat as California, where nearly three- fourths of the state's 1,585 dams are rated as having high or significant risk of failure.

Like its predecessor and many others in California, the new Calaveras dam is being constructed largely out of rock, dirt and other natural materials. Engineering experts say earthen dams of sufficient size are designed to withstand most earthquakes. The Calaveras dam is being strengthened, in part, by having zones of compacted material, including a thicker core of impermeable clay.

One problem, experts say, is that many were built decades ago, when less was known about what a strong earthquake could do.

Engineers didn't realize then that the loose rock and soil they used to form the base of some dams could liquefy in a strong earthquake, potentially causing the top of the structure to deform and spill.

State officials have determined the 220-foot- high Calaveras Dam poses a flooding threat because the base of the 92-year- old structure was built atop loose earth on the site of a previous failed dam. About 300,000 people live in a flood zone along Alameda Creek below.

"It would be disastrous if this thing were to fail, because you have huge urban areas downstream," said Jeff Miller, executive director of the Alameda Creek Alliance, a nonprofit environmental group.

Name: _____ **Date:** _____

1. A new replacement dam for the Calaveras Reservoir is being built. Where is the Calaveras Reservoir located?

A. It is located in Fremont, California, next to an active volcano.

B. It is located in Fremont, California, next to an iceberg.

C. It is located in Fremont, California, next to an active earthquake fault.

D. It is located in Fremont, California, next to a popular beach.

2. The text describes a major problem affecting a significant number of dams throughout the United States. What is this problem?

A. Manydams are built with a thicker core of impermeable clay.

B. Many dams need to be upgraded but funding and inspection staffing is limited.

C. Many dams are strengthened by zones of compacted material.

D. Many dams are built in areas with lots of storms, and are likely to overflow.

3. Read the following sentences:

> One problem, experts say, is that many [dams] were built decades ago, when less was known about what a strong earthquake could do.
>
> Engineers didn't realize then that the loose rock and soil they used to form the base of some dams could liquefy in a strong earthquake, potentially causing the top of the structure to deform and spill.
>
> State officials have determined the 220-foot- high Calaveras Dam poses a flooding threat because the base of the 92-year- old structure was built atop loose earth on the site of a previous failed dam. About 300,000 people live in a flood zone along Alameda Creek below.

Based on this information, what might an earthquake cause to happen if it takes place near a dam that is poorly constructed?

A. The earthquake may end up causing the base of the dam to become more compact and stronger.

B. The earthquake may end up causing the dam to be able to hold more water.

C. The earthquake may end up causing the dam and the water inside it to heat up.

D. The earthquake may end up causing the dam to break and the water to flood nearby areas.

4. Based on the text, why might the California's Division of Safety of Dams have ordered in 2001 that the Calaveras Reservoir be kept at no more than 40% full?

A. to limit the potential flooding damage that could be caused if an earthquake happens and the dam spills over

B. to increase the potential flooding damage that could be caused if an earthquake happens and the dam spills over

C. to limit the amount of water being used during a time when the state was experiencing a drought

D. to decrease the chances of an earthquake taking place and causing the dam to spill over

5. What is the main idea of this text?

A. Many dams in California are at a greater risk of breaking and flooding areas because they are located near active earthquake faults. For this reason, the Calaveras dam in Fremont, CA is being replaced with a new one that is better built.

B. Thirty percent of the dams in the United States are rated as posing a high or significant hazard. Many of these dams have bases formed from loose rock and soil, which could liquefy in a strong earthquake.

C. Billions of dollars and inspection staffing is needed to repair and replace many damaged dams across the United States. Many states do not have the funding or the resources for these big construction projects.

D. When many of the country's dams were built, engineers didn't understand the extent of the damage earthquakes can cause them. Since then, we have more information about how earthquakes can impact dams.

6. Throughout the text, the author provides quotes from different people. Why might the author have included these quotes?

A. to allow the reader to feel a personal connection with the people in the text they probably do not know

B. to present to readers information that contradicts the facts and ideas shared in the text

C. to help readers understand how quotes can be used correctly in news articles

D. to add the perspectives and insights of people who are involved with or understand the issues discussed in the text

7. Choose the answer that best completes the sentence below:

The new Calaveras Dam has been engineered to prevent it from breaking during an earthquake. _____, it is being strengthened, in part, by having zones of compacted material, including a thicker core of impermeable clay.

A. On the other hand

B. However

C. For example

D. In conclusion

8. Why did the owner of the Calaveras Reservoir decide to build a replacement dam?

_____

_____

_____

9. Why is it especially dangerous that close to 1,100 dams rated as having high or significant risk of failure are located in California? Use evidence from the text to support your answer.

_____

_____

_____

10. Imagine you've been placed in charge of a large project to repair or replace over 2,170 dams in the United States that are considered deficient.

Explain what you would consider in your decision about which dams to repair or replace first.

Use information from the text to support your answer.

Expedition to a Modern Pompeii

by American Museum of Natural History
This article is provided courtesy of the American Museum of Natural History.

Museum Geologist on the Scene of a 1902 Disaster

On May 14, 1902, Museum geologist Edmund Otis Hovey boarded the U.S. cruiser *Dixie*, bound for the Caribbean. He had been sent by Museum President Morris K. Jesup to investigate volcanic eruptions that had killed nearly 30,000 people in less than 24 hours the previous week.

The first came on the afternoon of May 7, when Mt. Soufrière, on the island of St. Vincent, erupted in a boiling mudflow of steam and ash, killing 1,565 people. The next morning, 75 miles to the north on Martinique, Mt. Pelée exploded in a cloud of hot gases, volcanic ash, and rocks. Traveling at a speed of 300 miles an hour, the searing mass rushed down the mountainside, incinerating everything in its path, including the picturesque seaside town of Saint-Pierre and nearly all the ships in the harbor. Within two minutes, some 27,000 people were dead. On May 20, the day before Hovey's arrival in Martinique, a second equally powerful eruption covered the now uninhabited town of Saint-Pierre again.

The scene he encountered defied words. "The devastation wrought by the eruption cannot be appreciated from a verbal description," Hovey wrote in *The American Museum Journal* of 1902, "and even photographs do not convey an adequate idea of what has happened" to a city that had enjoyed a reputation as the Paris of the Caribbean. Once a hub of trade in rum, sugar, cocoa, and coffee, its boulevards lined with handsome homes and showy shops, Saint-Pierre, as Hovey found it, was now a smoldering ruin with barely a brick left standing. Lying as the city did in a cul-de-sac in the path of incandescent volcanic discharge, Hovey wrote, Saint-Pierre and its residents had been "as helpless as an animal in a trap."

Left: Rubble covers a side street in northern Saint-Pierre in 1902. Right: Museum geologist Edmund Hovey, second from right, at Mt. Soufrière volcano in 1902.

The eruptions were of a type called *nuée ardente*, French for "glowing cloud." Magma or molten rock, supercharged with gases, is less dense than rock and so rises to the surface through cracks and

crevices. If the gases can boil off gradually at the surface, the potential force is diffused, sometimes creating the effusive flow of lava we tend to associate with volcano eruptions. But in a *nuée ardente*, the gaseous magma is blocked and pressure builds until it is eventually released as a dense, swirling mass of hot gas, incandescent dust, and rock fragments known as a pyroclastic flow.

The explosive cloud can first rise high into the air and then collapse downward, as Pliny the Younger observed in what is thought to be the earliest recorded description of a volcanic eruption. In letters written years after the AD 79 eruption of Vesuvius, the Roman magistrate gave a remarkably detailed description of what he had seen as an 18-year-old across the bay. Vesuvius is sited east of what is now Naples, Italy, and the AD 79 *nuée ardente* killed some 20,000 people in the towns of Pompeii and Herculaneum.

Add water to the mix-as at Mt. Soufrière, which was known for its beautiful crater lake-and the result is the addition of a mudflow, or lahar. The mass of gaseous magma also can create chemical changes that eat away at rocks, weakening them, until the cloud of ash and gas blows out the mountainside before rushing fast and furiously downward. This was documented firsthand at Mount St. Helens in 1980 and is believed to have happened at Mt. Pelée in 1902.

"This type of volcano is the most explosive, literally analogous to twisting off the top of a soda bottle," explains geologist James Webster, curator in the Department of Earth and Planetary Sciences. "When the mountain is ripped open, the volcanic blast is faster and potentially more deadly because it has less distance to travel to reach the surface... What Hovey observed about trees at Mont Pelée is consistent with Mount St. Helens."

Hovey described an odd sight. "The line between scorched and unscorched areas was strikingly sharp," he wrote. "In many places the line of demarcation passed through single trees, leaving one side scorched and brown while the other side remained as green as if no eruption had occurred."

During his Martinique expedition, Hovey also collected and sent back to the Museum invaluable specimens, molten household objects, pulverized street signs, and lumps of half-melted lava-called "bread-crust bombs" for their cracked tops- which had been thrown out of the volcano during the eruption. [A number of these artifacts will be on view in the Museum's special exhibition *Nature's Fury: The Science of Natural Disasters*.]

Left: A stack of café glasses were fused together by the heat of the deadly volcanic cloud. Right: This "bread-crust bomb" was formed when a partly molten mass of lava cooled and contracted causing the solid exterior to crack.

Left: Heat and pressure softened and twisted this champagne bottle. Right: A glass doorknob melted on one side, just as trees observed by Hovey were scorched on one side and, on the other, "green as if no eruption had occurred."

At the time, volcanology was still in its infancy. A crude seismometer was first introduced in 1840, but even with that technology, scientists simply lacked a clear understanding of

how volcanoes erupt. "Since that time we have learned much more about gases, the relationship between seismic activity and magma movement, even about gas opening the rock and providing a pathway for magma to follow," says Dr. Webster.

Hovey's research was part of that long, steady progression toward a better understanding of volcanoes, of which better prediction is the goal and in which the Museum continues to play an important role. Webster, for example, has explored Vesuvius eight times and teaches a course in Naples every fall. The Museum's collection of samples from Vesuvius is among the best in the world, after the University of Naples Federico II and the University of Pisa.

With little knowledge of how volcanic eruptions occurred, the residents of Mt. Pelée woefully underestimated the risks of living in its vicinity and ignored signals that it was still active. Occasional spewings of steam and ash were taken less as a warning than an occasion for picnics near the mouth of the volcano. As J. Chatenay of Seaboard National Bank, who had lived in Saint-Pierre until shortly before the 1902 eruption, told *The World* newspaper on May 10, 1902: "No one ever thought of fearing the volcano, which all thought to be extinct...The people wandered about by thousands, never dreaming that there was any danger."

Even ominous signs in the months and weeks before the May 8 eruption failed to raise adequate alarm. On April 23, earthquakes dislodged dishes from shelves in Saint-Pierre. The next day, fine ash fell for two hours on a town nearby. On May 2, a lightning-lit column of ash and fumes rose nearly two miles high above the mountain, and an inch of ash covered Saint-Pierre. On May 5, a mudflow from the volcano killed 23 people north of the city, and a tsunami reached the harbor 15 minutes later. On May 6, the mountain flung huge molten rocks in the air.

Given the state of the science in the 1900s, the people of Saint-Pierre couldn't possibly have foreseen what was to befall them. But even today, with better science to back up predictions, an

estimated half a billion people live within range of an active volcano, including more than 4,000 townspeople of the rebuilt Saint-Pierre and, perhaps more strikingly, roughly 4 million people who live in and around Naples. In fact, Naples recently built an emergency response hospital on the slopes of Vesuvius. "It's a strange concept," says Webster. "The first place you'd go is the first place that would be destroyed."

Bear in mind that as natural disasters go, the risks worldwide associated with earthquakes and hurricanes are orders of magnitude greater in loss of life and property damage than those associated with volcanic eruptions. Earthquakes alone affect the lives of some five million people a year. And where volcanoes are being monitored, scientists can generally predict eruptions in advance.

Still, the prospect of evacuating a population as dense as that around Vesuvius is daunting. In modern history, Vesuvius had relatively large eruptions in 1631 and 1944, with smaller ones in between-so it is by no means dead. But complicating the assessment of actual risk is the difficulty humans have appreciating geological timescales in which patterns are measured not in decades but in thousands and tens of thousands of years. In addition, even scientists disagree. Vesuvius operates on a very long cycle of major eruptions every 500 to 1,000 years, says Webster, and there is one camp that theorizes a large eruption is not imminent and another that believes Vesuvius could erupt catastrophically soon.

Asked which side he falls on, he says, "I don't know enough. But it definitely warrants heavy monitoring."

This reading was adapted from Rotunda*, the member magazine of the American Museum of Natural History. Fall 2014.*

Name: _____ **Date:** _____

1. Why did geologist Edmund Hovey travel to the Caribbean in May 1902?

A. to investigate recent volcanic eruptions on the islands of St. Vincent and Martinique

B. to investigate the historic volcanic eruption of Mount Vesuvius

C. to try and predict when the next eruption of Mt. Pelée would occur

D. to try and help any survivors of the volcanic eruptions of Mt. Pelée and Mt. Soufrière

2. Towards the end of the article, the author draws comparisons between the risks of which two volcanoes?

A. Mount St. Helens and Mount Vesuvius

B. Mt. Pelée and Mt. Soufrière

C. Mt. Pelée and Mount Vesuvius

D. Mt. Soufrière and Mount St. Helens

3. Mt. Pelee and Vesuvius both had *nuée ardente* eruptions, the most explosive and deadly type of volcanic eruption. In this type of eruption, a cloud of hot ash and gas blows out of the volcano, then rushes very quickly down the volcano's side. What conclusion can be drawn from this evidence?

A. People living near Mt. Pelée and Vesuvius should have known that these volcanoes were active and likely to erupt.

B. The*nuée ardente* type of volcanic eruption is less dangerous to humans than other types of volcanic eruptions.

C. The*nuée ardente* type of volcanic eruption is incredibly dangerous to humans living near a volcano.

D. The areas surrounding Mt. Pelée and Vesuvius are unlikely to be damaged by future *nuée ardente* eruptions.

4. Based on the text, why might predicting volcanic eruptions be an important goal of scientists studying volcanoes?

A. because knowing when volcanoes might erupt will allow scientists to help warn people to leave the area in time to save their lives

B. because knowing when volcanoes might erupt will allow scientists to gain more information about how volcanoes work

C. because knowing when volcanoes might erupt will allow scientists to better understand past eruptions

D. because knowing when volcanoes might erupt will allow scientists to collect helpful samples for museums

5. What is a main idea of this article?

A. The eruption of Mt. Pelée in 1902 was similar to the eruption of Mount Vesuvius in AD 79, and should have been better predicted.

B. The eruption of Mt. Pelée in 1902 caused massive destruction and death, partly because people at the time did not know much about volcanoes.

C. It can be very exciting to live near an active volcano, which is why people currently live near volcanoes that may erupt in the near future.

D. A geologist went to study volcanic eruptions in the Caribbean in 1902 to see how they compared to the eruption of Mount Vesuvius.

6. Read the following sentence from the text.

"With little knowledge of how volcanic eruptions occurred, the residents of Mt. Pelée woefully **underestimated** the risks of living in its vicinity and ignored signals that it was still active."

Based on this sentence, what does the word **underestimate** mean?

A. to predict correctly

B. to analyze completely

C. to take something too seriously

D. to not take something seriously enough

7. Choose the answer that best completes the sentence below.

Thousands of people lived near Mt. Pelée in 1902 _____ the volcano's signals that it was still active.

A. in spite of

B. because of

C. as a result of

D. resulting in

8. Describe three warning signs of the 1902 eruption in Saint-Pierre that people ignored at the time. Use details from the text to support your description.

_____

_____

_____

9. Scientists today hope that their knowledge of volcanoes can help save human lives from future volcanic eruptions. What is one problem that might make it difficult to save lives from a future eruption?

_____

_____

_____

10. Can scientists' current understanding of how volcanoes work prevent another terrible loss of human life like the ones in Pompeii and Saint-Pierre? Why or why not? Use evidence from the text to support your argument.