Earth & Space Science

Exploration of Extreme Environments: Oceans

Science and Mathematics
Education Research Group

Supported by UBC Teaching and Learning Enhancement Fund 2012-2014

Oceans

Oceans I

Approximately how much of the earth's surface is covered with water?

A. ⅓

B. ½

C. ⅗

D. ¾

E. ⅞

Solution

Answer: D

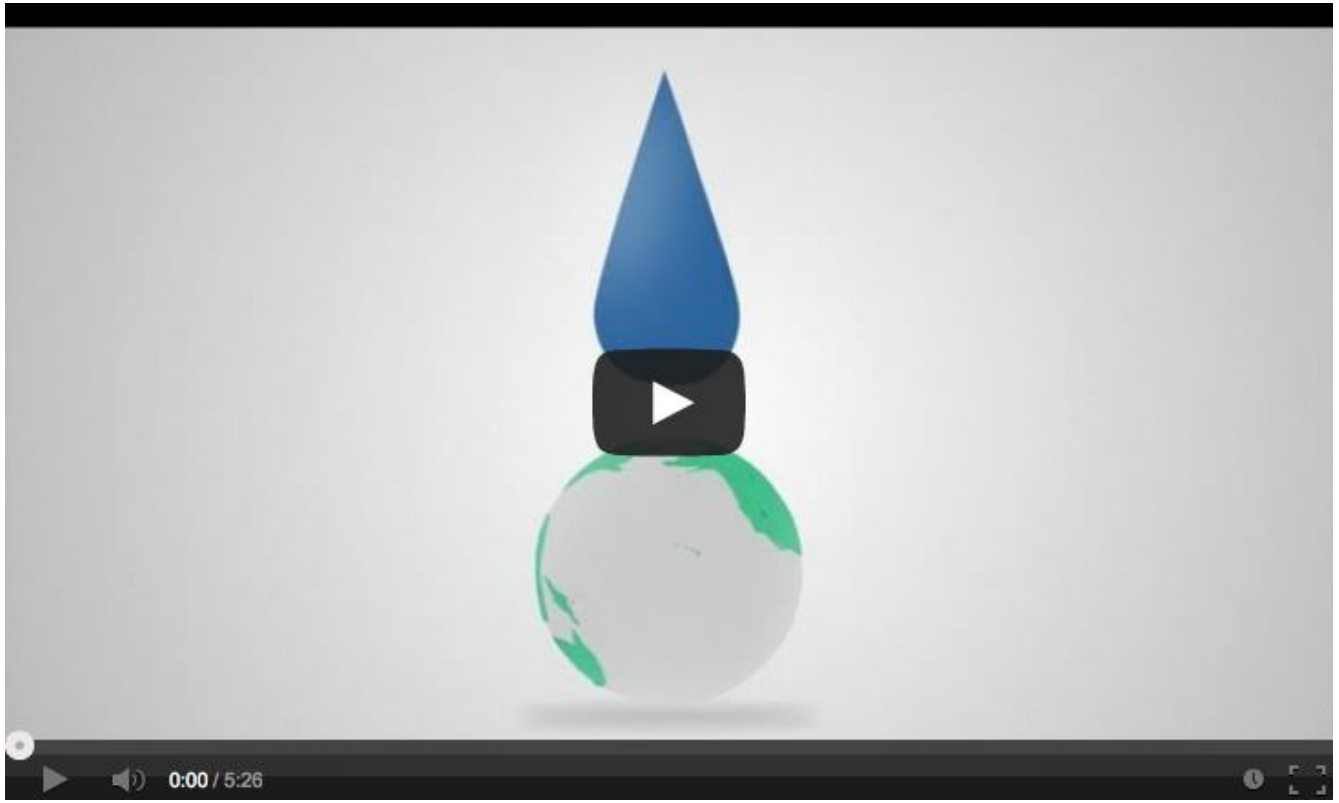
Justification: On Earth, there are five ocean basins: Pacific Ocean, Atlantic Ocean, Indian Ocean, Arctic Ocean and Southern Ocean. Together, these make up 71% of the earth's surface, or just under ¾, or 75% of the earth.

The ocean looks big when we look out at it, but just think that we don't only explore it's surface, we also explore the depth of the ocean. At some points this is deeper than the height of Mount Everest!

The ocean contains 97% of our world's water and an amazing 99% of the biodiversity on our earth. Similarly, our ocean basins hold the greatest geological features on our planet.

Extend Your Learning: Video

Title: How big is the ocean?



Oceans II

Which of the following is true about exploring the earth's oceans?

A. Exploration is difficult mainly because of the intense pressure as you travel deeper

B. Scientists don't need to explore the deep ocean because there are no living plants or animals in the deepest parts of the ocean

C. Scientists have successfully explored most of the ocean with ease

D. Exploring the ocean bottom is difficult with the human eye, so scientists use radar to map the landscape of the ocean floor

Solution

Answer: A

Justification: As you go deeper in the ocean, the amount of water above you increases, creating greater pressure on an object. Every 10 m you dive, the additional pressure you experience increases by 1 atmosphere (i.e. the pressure experienced at sea-level). This is an extremely large obstacle to overcome in order to safely explore the ocean.

While it ***IS*** important that scientists map the ocean floor in order to gain knowledge, they do this with sonar, not radar. Sonar (**So**und **N**avigation **A**nd **R**anging) sends out sound waves to the bottom of the ocean.

Solution Cont'd

Exploring the deep ocean is important because several specialized and adapted species of plants and animals live there. By studying these species, we can learn more about adapting to the crushing pressure of the ocean, extreme cold and lack of light. Scientist use this knowledge to not only understand adaptations of other species, but also to model new technologies along similar principles.

Humans have developed pressurized oxygen tanks allowing them to breathe underwater and explore parts of the ocean as they dive deeper and pressure increases. In addition, Remote Operating Vehicles (ROV's) such as *Alvin* are made with a thick titanium outer shell in order for scientists to withstand the tremendous pressure and study the ocean depths.

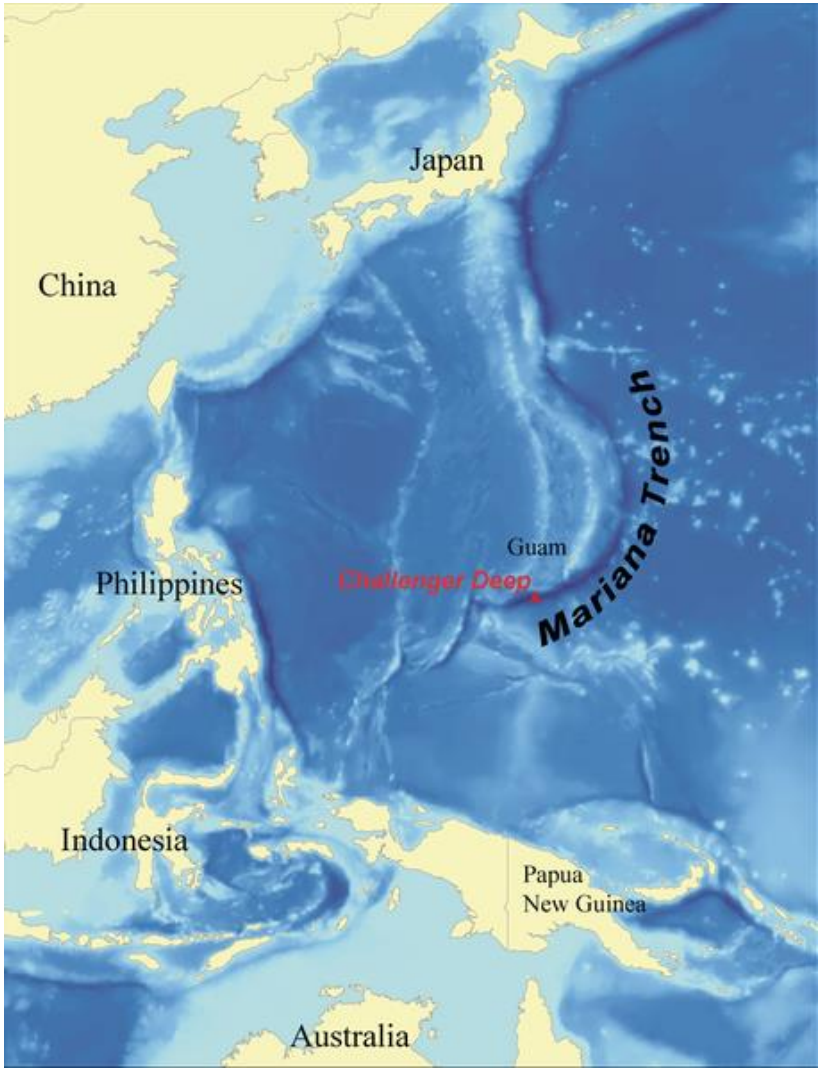
Extend Your Learning: Video

Title: Water Works: Pressure and Density

Oceans III

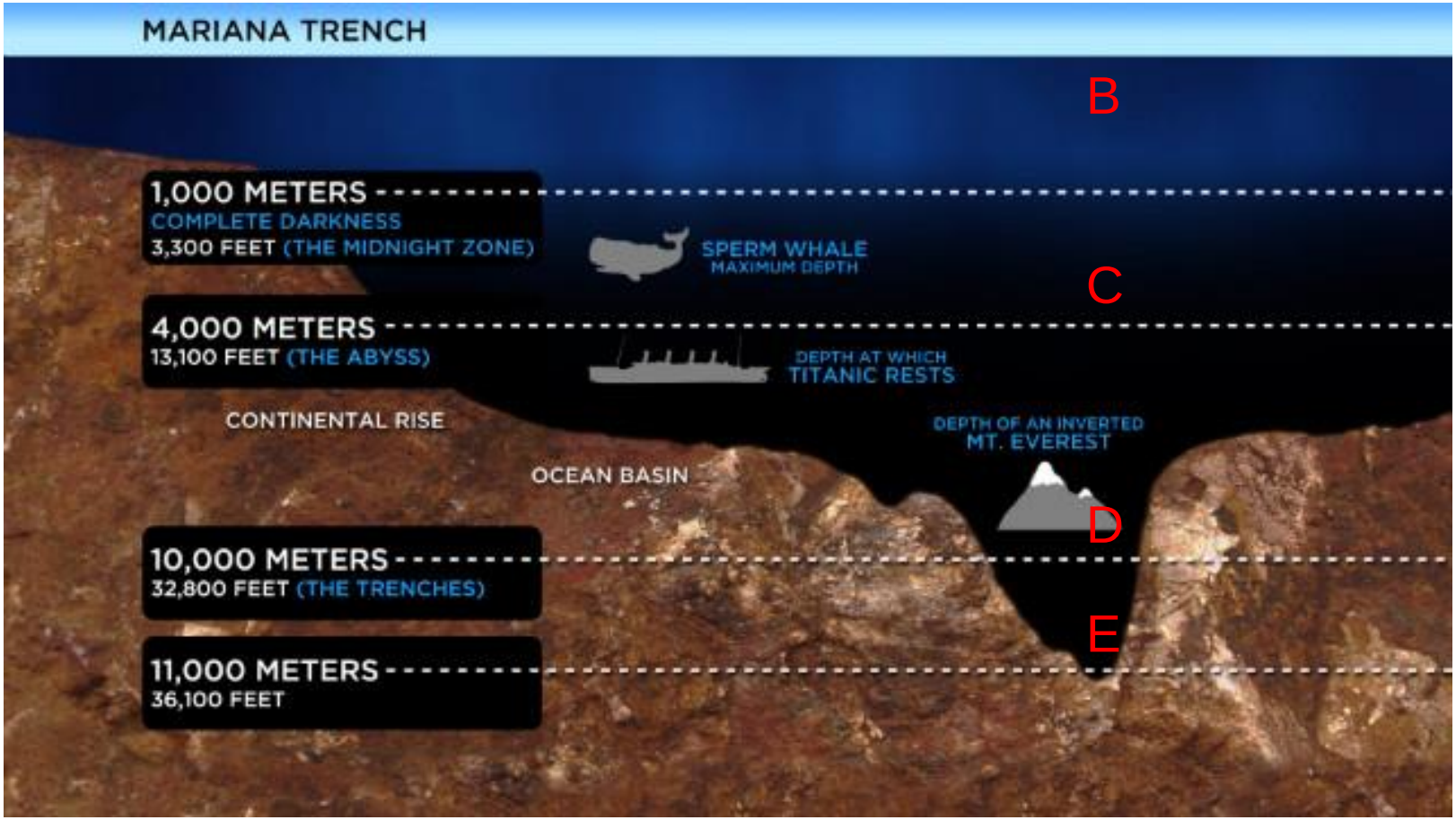
The Mariana Trench is located in the western Pacific Ocean, just east of the Mariana Islands. It is the deepest part of Earth's oceans, with its deepest point being the Challenger Deep (red point in picture to right). The Challenger Deep is a small valley in the Mariana Trench and is located roughly 11 kilometres below the surface of the ocean.

See the next slide to consider how depth affects pressure in the ocean.



Oceans III Cont'd

In this cross section of the ocean at the Mariana Trench, at what point would the pressure be the greatest?



Solution

Answer: E

Justification: As you travel farther down in the ocean, the pressure increases. This pressure increase is independent of the landscape of the bottom of the ocean.

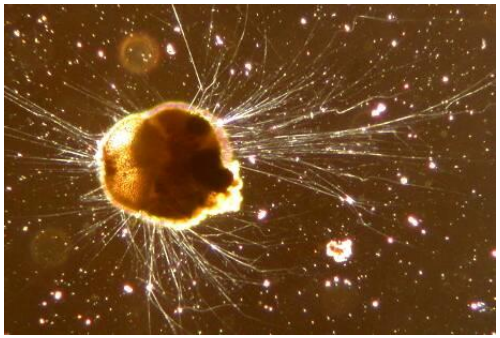
At point D, you may think that the pressure is greatest because the sides of the Mariana Trench are “pushing” in on an object. This is not the case because pressure is only based on the volume/mass of water above an object. Therefore, the greatest pressure is at the Challenger Deep, approximately 11 kilometres below the ocean’s surface.

Extend Your Learning: Points of Interest

Many organisms live and thrive in deep parts of the ocean, such as the Mariana Trench. Click on each organism to find out more information about what lives just over 11 kilometres below the surface of the ocean under crushing pressure and in total darkness.

sea pig

spoon worms



foraminifera

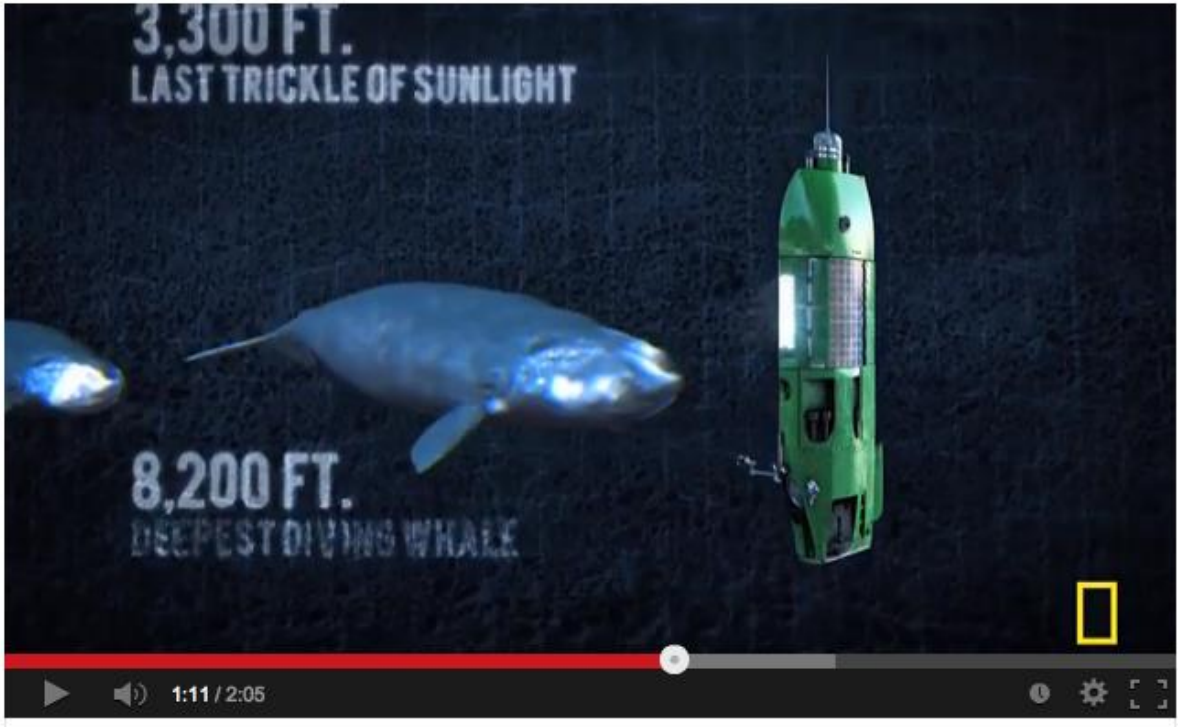
Extend Your Learning: Video

Consider the following questions as you watch the video linked in the picture on the following slide.

1. What is the purpose of this mission? How does it contribute to the advancement of ocean exploration?
2. How does the shape of the submarine contribute to the function of the mission?
3. What challenges do you think James Cameron would have faced while traveling down to the Challenger Deep?
4. Would you think this is something that you would want to do?

Extend Your Learning: Video Cont'd

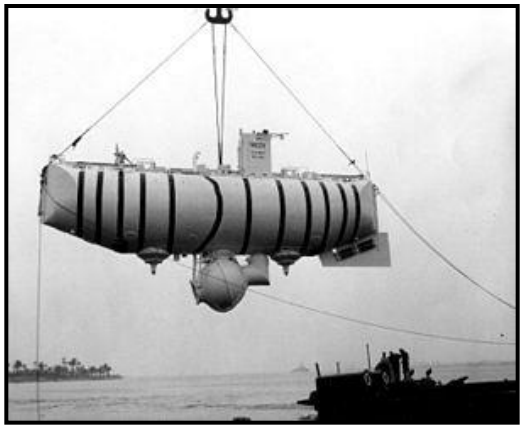
Title: Long Way Down: Mariana Trench



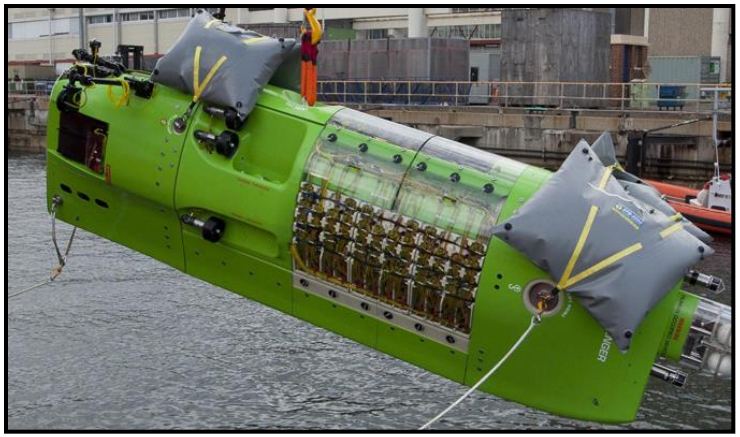
Extend Your Learning: Compare and Contrast

Explore the following websites and use the questions below to guide your discussion.

Trieste Mission



Deep Sea Challenge Mission



- What was the purpose of each of these missions?
- How did each mission help advance our exploration of the ocean?
- What major differences can you see in the design of the submarines? What does this tell you about technology?
- How do the outcomes of each of these missions differ?

Oceans IV

Black smokers (types of hydrothermal vents) often form in chimney-like shapes on the ocean floor.

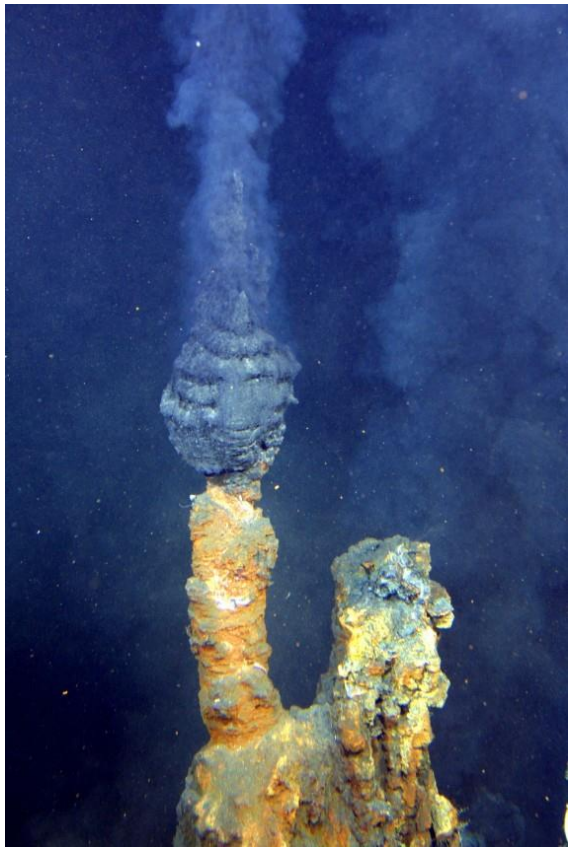
How are these shapes formed?

A. Intense pressure at the bottom of the ocean pushes the material back into the earth's core

B. Minerals are released from the earth's core and hardens into an ash-like substance

C. Magma from the Earth's core seeps out and solidifies

D. Rocks spew out of the black smokers and settle around the vents



Solution

Answer: B

Justification: The water deep in the ocean where hydrothermal vents are found averages at a temperature of 2 degrees Celsius. Hot, black mineral-rich water makes its way through the Earth's crust and solidifies (hardens) around this crack as soon as it hits the cold ocean water. These minerals build up on the sides, creating the chimney-like shape of black smokers.

Because of the intense heat in the earth's core, it's not possible for rocks to come out of these vents. All rocks would melt down to magma at high temperatures. If magma escaped and hit the cold water, it would form large rocks (igneous rocks).

Magma doesn't come out because the crack doesn't go deep enough to reach this layer in the earth.

Extend Your Learning: Video

Title: Underwater Vents and Volcanoes

Oceans V

Colourful tube worms live in and around black smokers because they thrive in cold environments at the bottom of the ocean. How do these tube worms thrive in such harsh environments?

A. They change the chemicals that are emitted from the black smokers into food

B. They eat other organisms that are attracted to the vents, such as clams and crabs

C. They use the process of photosynthesis to make their own food

D. They are constantly in a dormant state and can acquire the few nutrients needed from water

Solution

Answer: A

Justification: Although tube worms can survive in extremely cold environments, like any other living thing, they require nutrients to thrive. Hydrothermal vents spew out nutrient-rich water in an area of the ocean that doesn't have many naturally occurring nutrients.

After nutrients leave the vents, they settle to areas on the ocean floor that surround the vents.

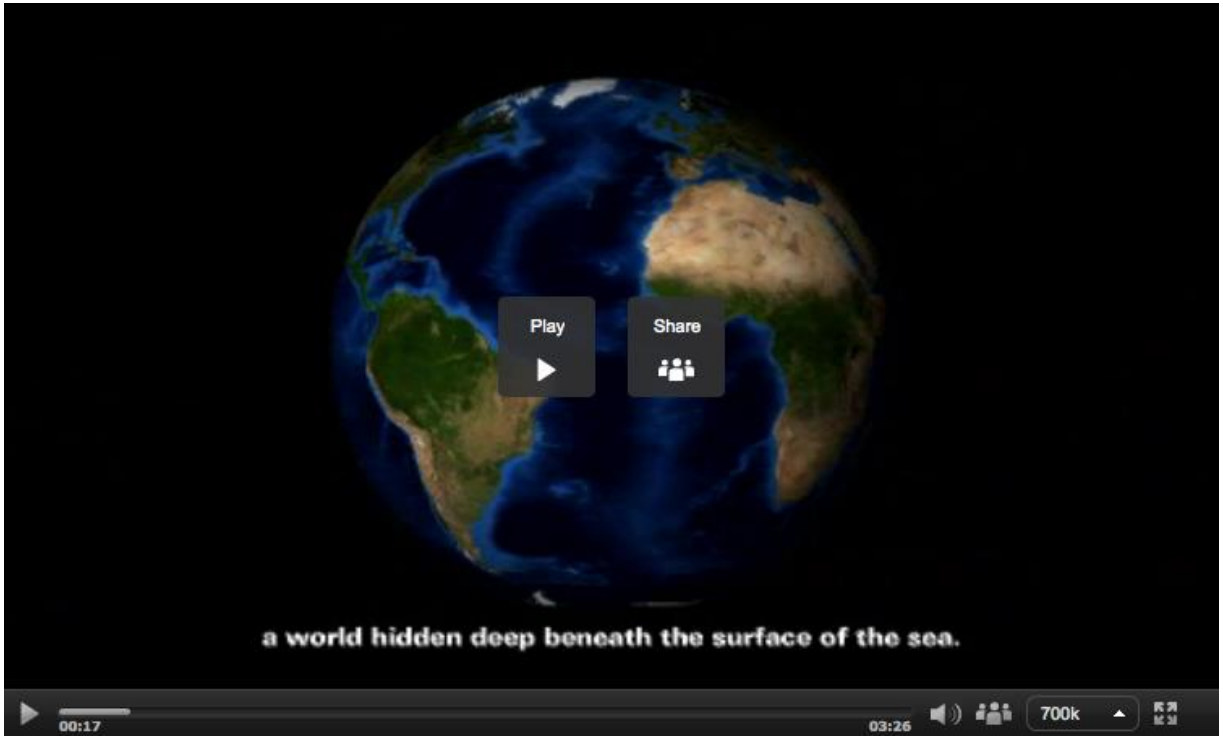
Tube worms do not have mouths or digestive systems to eat prey, so they absorb these nutrients and convert them to food through chemical processes.

Extend Your Learning: Video

Title: Deep Surprises

Extend Your Learning: Video

Title: Hydrothermal Vent Creatures



Oceans VI

The Newt Suit is a Canadian-made specialized diving suit used to explore ocean depths of up to 305 metres below sea level.

What advantage does the Newt Suit provide scientists over traditional scuba gear?

A. Scientists have more dexterity (ability to move) in order to collect samples of plants and animals

B. Scientists are able to travel faster and escape danger quickly in the Newt Suit

C. Scientists are able to better communicate with others when wearing the Newt Suit

D. Scientists are able to spend more time underwater when wearing the Newt Suit

Solution

Answer: D

Justification: When deep sea explorers wear the Newt Suit, they are able to remain underwater for over 8 hours. This is because the Newt Suit has a supply of breathable air much greater than the supply in a scuba tank.

While the Newt Suit allows scientists to remain underwater for long periods at one time, they don't have much dexterity or ability to move around at fast speeds. There is a motor on the back of the suit, allowing explorers to move from one location to another, as well as moving up and down in water, but it cannot travel faster than 5.5 km/hr.

Extend Your Learning: Fast Facts

Fast facts about Canada's latest contribution to deep sea exploration technology, the EXOSUIT:

Designer: Phil Nuytten & Nuytco Research

Place of Design: North Vancouver, British Columbia, Canada

Mass: 272 kilograms

Material: aluminum alloy metal

Features: communication device, high-definition camera, SONAR, lights, oxygen monitors and pincer-like claws for dexterous tasks

Use: For scientists to discover new species of plants and animals, oil rig maintenance

Oceans VII

Sonar (SOund Navigation And Ranging) is a technology used to navigate, communicate and detect objects underwater.

How does Sonar work to detect objects in the ocean?

A. It emits (sends out) a pulse of sound and measures the angle of reflection to determine distance of an object

B. It emits a pulse of sound that gets absorbed into an object, which determines distance

C. It emits a pulse of sound and determines distance by the time it takes the pulse to reflect back

D. It emits a pulse of sound waves that bounce back in larger or smaller quantities, which determines distance

Solution

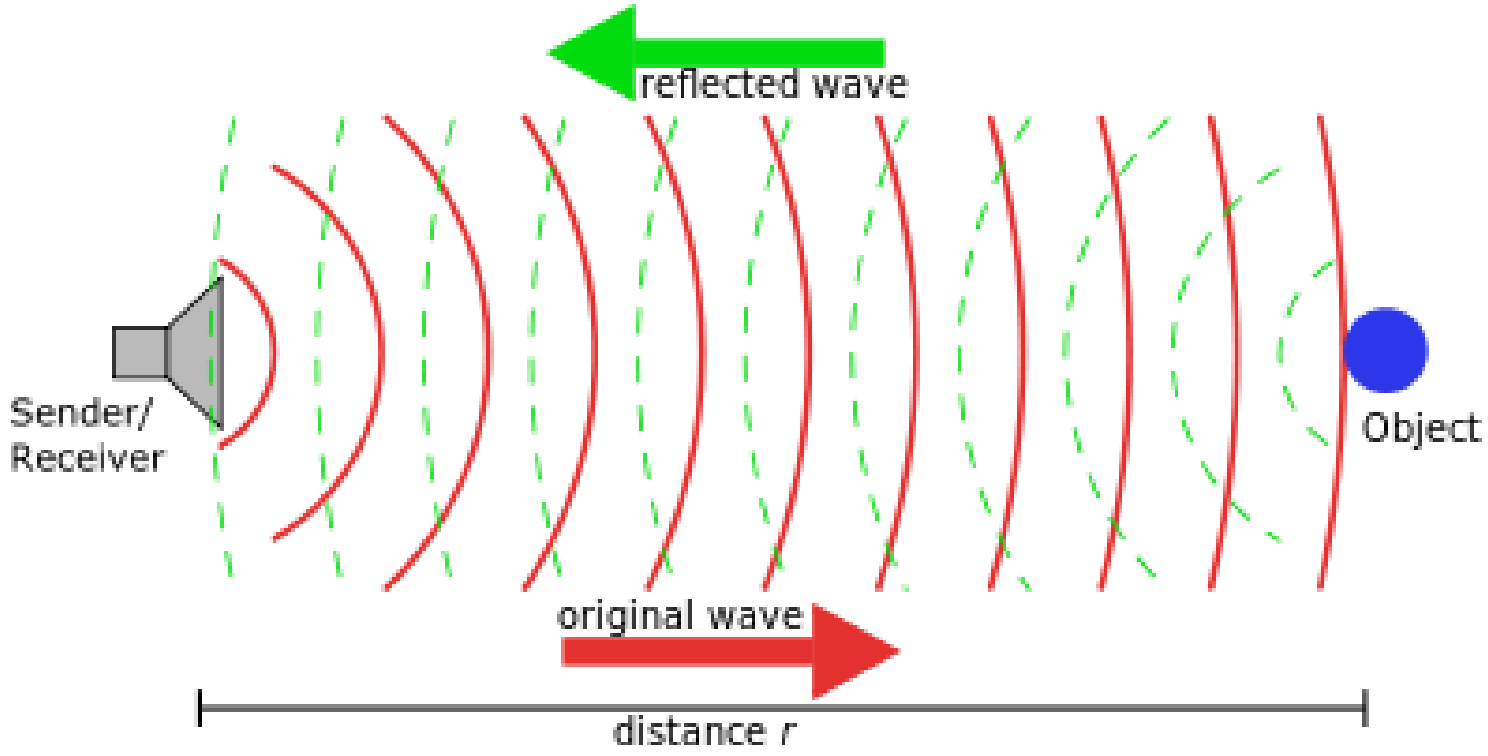
Answer: C

Justification: As the name indicates, Sonar uses the echoes of sound waves to determine the distance of objects underwater. This will also allow ships to navigate properly, by avoiding objects that may cause some danger. The pulses of sound that are emitted (sent out), often called “pings,” bounce back from an object. The time it takes a pulse to bounce back enables the receiver to determine the distance of an object underwater. For example, a ping that comes back quickly indicates something is closer than a ping that comes back slowly.

A small Sonar device that you may be familiar with is a “fishfinder.” This may be used to determine where schools of fish are located underwater.

Solution Cont'd

The diagram below is a basic representation of how sonar sends and receives sound waves underwater.



Extend Your Learning: Video

Title: Sounding the Deepest Spot on Earth

Extend Your Learning: Discussion

You may have already made this connection, but there are some animals that use something similar to Sonar called “echolocation.” These include bats, toothed whales, shrews and cave dwelling birds.

What do you know about these animals? What characteristics do they have in common?

Why might these animals require echolocation to survive?

What barriers might echolocation pose to these animals?