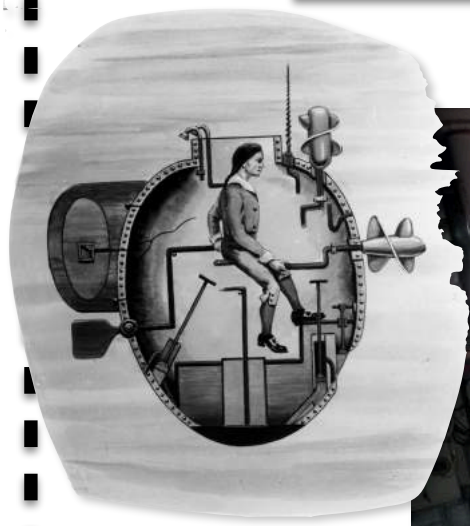
Submarines!



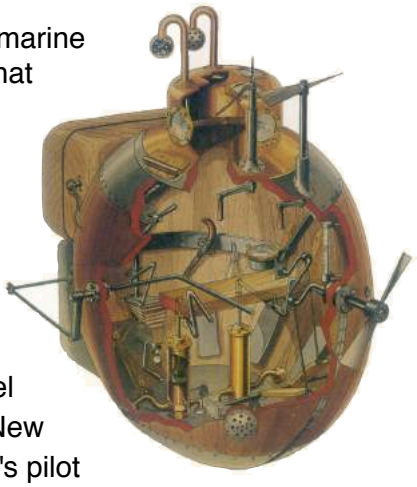
In this packet, we will learn about submarines, their history, how they work, and how the U.S. Navy utilizes them today! We are then going to learn about **buoyancy** and energy!

Contact the Albacore Museum for Field Trip and School Visit Opportunities!

***This packet is intended for elementary schools, to be used in groups of three or fewer and/oindividually.**

Special Thanks to National Museum of the United States Navy for writing content

History of Submarines in the United States



Underwater exploration has fascinated people for thousands of years, yet submarine travel did not become common until the mid-twentieth century. It was not until 1900, that the U.S. Navy commissioned its first submarine.

The first American submarine was designed before the Revolutionary War by David Bushnell, a young inventor from Connecticut. He designed and built a one-man submersible that he called *Turtle*. Bushnell's *Turtle* featured a hand-cranked screw-like paddle that moved the boat forward and back underwater, air pipes that brought fresh air into the boat, **ballast tanks** that took on water to dive and emptied to **ascend**, and a primitive torpedo to attack enemy ships. Bushnell adapted his vessel to use against the British during the American Revolutionary War. *Turtle* was sent to New York harbor in September 1776 to surprise the British ships blockading the city. *Turtle*'s pilot crept up on HMS *Asia* and attempted to attach explosives to the side of the wooden ship, but failed to do so before losing control of the boat. Lee escaped, but tried again to attack the British one month later without success. Despite *Turtle*'s failures, Bushnell proved that a boat could be used for underwater surprise attacks.

Between the American Revolution and the American Civil War many people experimented with submarine technology, including Robert Fulton, an innovator and promoter of the steam engine. In 1800, Fulton completed his version of a submarine, *Nautilus*. Fulton's design introduced elements that can be found in modern submarines, such as adjustable diving planes for easy vertical maneuvering underwater, a dual system of propulsion, and a compressed air system that allowed the crew about four hours of underwater travel. As naval ships continued to develop throughout the nineteenth century, submarines were still considered unsafe for the U.S. Navy. Despite concerns during the Civil War, both Union and Confederate forces experimented with submarines. One such experiment was the Confederate submersible *H.L. Hunley* named for its financier Horace L. Hunley. Powered by nine men working a hand-cranked propeller, *Hunley* set out underwater to attack USS *Housatonic* in Charleston Harbor. *Hunley*'s crew used its torpedo to attack and sink *Housatonic*. *Hunley* became the first submarine ever to sink an enemy ship, however, *Hunley* never **ascended,** losing her entire crew. The submarine's potential as a surprise attack vessel finally was realized, but the problem of working safely underwater remained unresolved.

Drawing of the inside of the *H.L. Hunley*

Check your reading!

What is the name of the U.S. Navy vessel sunk in the American Civil War, making it the first American ship sunk by a submarine?

_____

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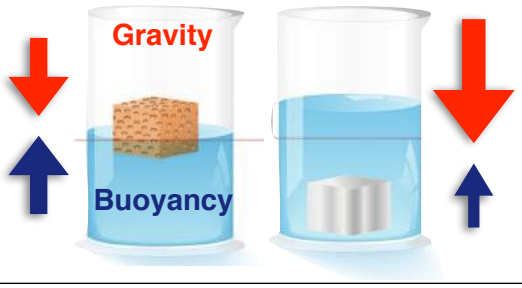
Buoyancy

Buoyancy: the ability to float in water or air or some other fluid.

The force of **buoyancy** explains why some objects sink in water while others float. This law is known as **Archimedes' principle**, after the ancient Greek scientist who discovered it. Through his experiments, Archimedes found that any object that is completely or partially submerged in a fluid (either liquid or gas) is acted on by an upward, or buoyant, force. The strength of the force equals the weight of the fluid displaced by the object. The weight of the object is reduced by the weight of the displaced fluid.



Let's test Buoyancy!

These two quick and easy experiments will show us how buoyancy works!

What you'll need:

- 2 oranges
- 1 Diet Soda
- 1 Regular Soda
- 1 bucket, filled with water

1. Peel one of the oranges.
2. To the left, write down your hypothesis, which orange will float? Will both float?
3. Place both the whole and peeled orange in the bucket of water. What happens?

4. Remove both oranges, and write your hypothesis about the soda. What do you think will happen with the Diet and Regular Sodas? Write your hypothesis to the left.
5. Place both sodas in the bucket of water. What happens?

Hypotheses:

Which orange do you think will float?

Peeled **Whole**

Which Soda do you think will float?

Diet **Regular**

Turn to the next page to learn why this happened!

Density

Every substance has its own unique value for density. **Density** is the amount of **mass** a substance is compared to its size. A one inch lead block has more mass than an aluminum block of the same size. Therefore, the density of lead is greater than the density of aluminum. Density also applies to liquids. To have the same **mass** of water and rubbing alcohol, a greater volume of alcohol is needed because it is less dense than water.

Soda Can Experiment

The cans of soda have exactly the same volume, or size. But their density differs due to what is dissolved in the soda. Regular soda contains sugar as a sweetener. If you look at the nutrition facts on a can of regular soda, you will notice that it contains sugar...a lot of sugar. Diet sodas, on the other hand, use artificial sweeteners. The difference in the amount of dissolved sweeteners leads to a difference in density. Cans of regular soda tend to be more dense than water, so they sink. Cans of diet soda are usually less dense than water, so they float.

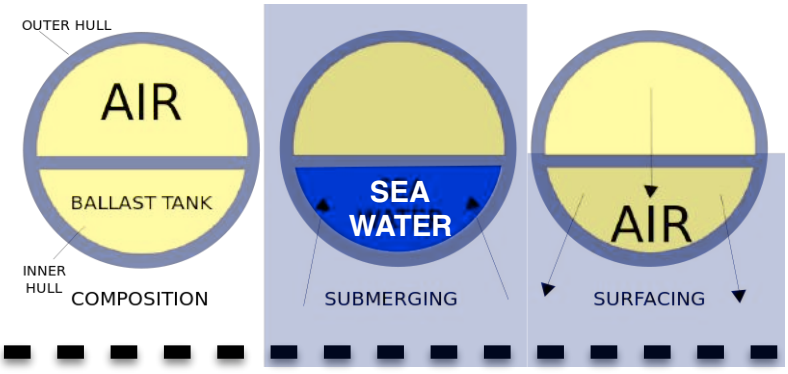
Orange Experiment

While making the orange weigh slightly more, the peel of an orange helps displace enough water to make the unpeeled orange buoyant. The peel is also full of tiny pockets of air that make the unpeeled orange less dense than water and the the orange floats. When you remove the peel the orange no longer displaces enough water to overcome gravitational force, the orange becomes more dense than water, and it sinks.

So, what about submarines?

To control its buoyancy, the submarine has **ballast tanks** and auxiliary, or trim tanks, that can be alternately filled with water or air (see animation below). When the submarine is on the surface, the ballast tanks are filled with air and the submarine's overall density is less than that of the surrounding water. As the submarine dives, the ballast tanks are flooded with water and the air in the ballast tanks is vented from the submarine until its overall density is greater than the surrounding water and the submarine begins to sink (negative buoyancy). A supply of compressed air is maintained aboard the submarine in air flasks for life support and for use with the ballast tanks.

howstuffworks.com

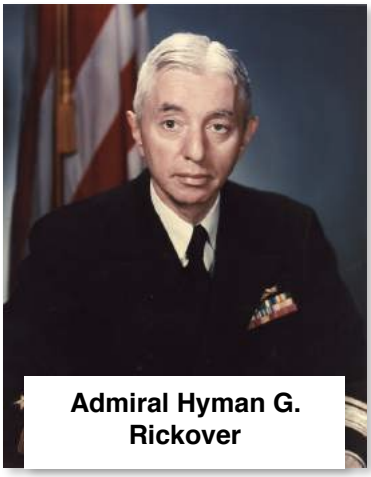


Submarine History Continued

Ten years after the end of the Civil War, immigrant John Holland began designing and building submarines in the United States. By 1888, the U.S. Navy recognized the potential for submarines in its fleet and held a design competition for a new underwater vessel. Holland introduced a new method of propulsion using a gasoline engine. Holland designed a small, lightweight gasoline engine that turned a propeller while the boat cruised on the surface. Holland's efforts proved successful and he was able to persuade the Navy in April of 1900 to purchase this submarine. It was added to the fleet as USS *Holland* (SS-1).

John Holland

Although the gasoline engine worked well on paper, the engine had flaws. Gasoline is flammable and unstable. Using this fuel in a confined environment, such as the submarine, endangered the crew.



Admiral Hyman G. Rickover

Another danger was the batteries that ran the electric motor during underwater travel. They were heavy, bulky, inefficient, and explosive. Finding a safer way of propulsion was needed if the submarine was ever to descend for long periods of time.

Around the same time Holland was creating his submarines, German scientist Rudolf Diesel developed an excellent substitute for the gasoline engine. Diesel's engine used a fuel that was more stable than gasoline and could be stored safely. These advantages granted submarines with Diesel engines longer and safer cruises on the surface. While underwater, batteries were still necessary to provide power. After 1909, Diesel engines would be used in American submarines for nearly 50 years.

Despite the success of diesel-powered submarines, the quest for a single power source continued. The concept of nuclear power was discovered by German scientists in the 1930's. Upon learning of this idea, American physicist Ross Gunn visualized the potential for nuclear-powered submarines and Phillip Abelson first sketched an image of one. The most recognized proponent of nuclear-powered submarines in the U.S. Navy was Admiral Hyman G. Rickover.

How did diesel gasoline get its name?

Nuclear Submarines

USS *Nautilus,* the first nuclear-powered submarine commissioned by the U.S. Navy

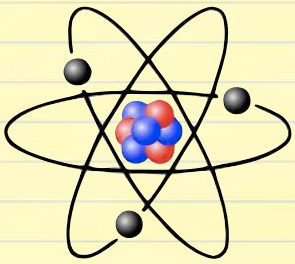
Rickover managed a research team that converted the concepts of nuclear power into working submarines. Nuclear power uses atoms, the smallest particles of an element, to produce an enormous amount of energy. That energy allows the power plants on submarines to super heat water and create steam. The steam then powers a giant turbine which turns the sub's propeller. Those small nuclear power plants on submarines could supply the necessary power for these boats to travel up to 500,000 miles and to stay underwater almost indefinitely without refueling.

Rickover convinced the Navy and the Atomic Energy Commission that nuclear power was the ideal propulsion method for submarines. On January 17, 1955, the first nuclear-powered submarine, USS *Nautilus* (SSN-571) went to sea. On her first voyage, *Nautilus* traveled completely submerged in the Atlantic for more than 1,300 miles. In 1958, she traveled under the polar ice cap and reached the North Pole.

Today's fleet of American nuclear submarines is able to spend up to six months on submerged patrol. Submarines have two complete crews. When a boat returns from a lengthy cruise, the crews rotate. Since the vessel is refueled only once or twice over its lifetime, there is no need to "stop for gas. " However, subs still need to stop to restock food and supplies.

Powering Submarines

Can you put these power sources in chronological order?



_____ _____ _____

Build Your Own Submarine!

What you'll need:

- empty 16 or 20 oz. plastic soda bottle with hole in cap (the hole should be big enough to pass a flexible straw through)
- three wide rubber bands
- 24 pennies
- aluminum foil
- adhesive tape
- flexible straw
- large tub of water

1. Cut three holes in side of the soda bottle.
2. Stack the pennies into three piles containing 4, 8, and 12 pennies.
3. Carefully wrap stacks of pennies with foil.
4. Place a rubber band around the plastic bottle and slide it next to the closest hole. Position the other rubber bands next to the two remaining holes.
5. Place the four-penny stack under the rubber band closest to the bottle's top.
6. Place the eight-penny stack under the middle rubber band, next to the middle hole.
7. Place the 12-penny stack under the last rubber band (NOTE: The weights should be next to the holes NOT over them.)
8. Push the shorter end of the straw (about 1 inch) through the hole in the bottle's cap. Reattach the bottle cap to the bottle. Keep the flex section outside and bent upwards. Tape straw securely into place in bottle cap.
9. Lower the "submarine" into the water. Do not let long end of straw take in water.
10. Observe the action of the "sub" and record your observations.
11. When the sub stops sinking, blow into the straw.
12. Observe the action of the sub and record your observations.

Questions to Consider

1. What makes your submarine sink?

_____

2. What makes it surface?

_____

3. You learned the basic properties that make submersibles dive and surface. What is your model missing that U.S. Navy submarines have to navigate underwater? Think of your sub as an underwater plane.

_____

_____

Vocabulary

1. **Archimedes' principle- s**tates that something totally or partially in a fluid will face an upward force equal to the weight of fluid it displaces.
2. **Ascend-** go up or climb
3. **Ballast Tank-** a compartment in a boat, ship, or submarine that can hold water. Filling or emptying the tank will determine its buoyancy.
4. **Buoyant-** the ability to float in water or air or some other fluid.
5. **Density-** degree of consistency measured by the quantity of mass by its size.
6. **Mass-** the quantity of matter which something contains

An object with very high _____ will not float as well, making it less _____. Much like gravity, _____ _____ states that there is a force pushing you upward when in water. Submarines can operate its buoyancy by filling or emptying its _____ _____. Should the tanks be empty, the submarine can ascend to the surface with ease.