

Magellan himself perished in the Philippines in a fight with islanders. Needless to say, the number of deaths and the stories of hardships discouraged anyone from trying to sail around the world again.

In 1577, Francis Drake left England on an expedition to the New World. His purpose was to raid Spanish ships and settlements for their treasure. His expedition rounded the southern tip of South America, then successfully raided Spanish territory along the west coast of South America. Loaded with treasure and knowing the Spanish would be waiting for him in the Atlantic, Drake decided to make for home by going westward. When he returned to London in 1580, Queen Elizabeth knighted him for his exploits. His cargo of treasure and spices was worth a fortune. This was the second successful circumnavigation of the world.

The Birth of Marine Science (1700-1900)

The beginning of the 18th century marked a distinct change in sea exploration. While previous exploration had been motivated by specific military, trade, or conquest objectives, at this time exploration for its own sake began to take place.

Several factors contributed to the change. By 1700, global colonialization had distributed European outposts widely. This made repairs and resupply more available and allowed seafarers to range farther without fear of being too far from food or the ability to make major repairs. Another important factor was the rise of Britain as a sea power.

As Britain began to compete with France and Spain for global conquest, they realized that the more they knew about the seas and the world, the more effective they would be. The Royal Navy launched voyages with the objectives of exploration, mapping, and projecting British presence around the world. The crew often included scientists and naturalists.

Cook's Expeditions

In what way did the voyages of James Cook differ from those of sea explorers before him?

What invention in 1735 was a major breakthrough for open-ocean navigation?

What geographical discoveries did the Cook expeditions make?

The voyages of Captain James Cook largely receive credit as the first sea expeditions devoted to methodical, scientific oceanography. They differed from those of sea explorers that came before in that they were the first major expeditions launched with science and exploration as their only goals. They also documented their findings with more detail and attention to the scientific method than any previous major expeditions.

A major contribution to Cook's voyages was the invention of the *chronometer*. The chronometer was a clock or watch that wasn't affected by the waves and motion of the sea. Introduced in 1735, the chronometer was a major breakthrough for open-ocean navigation because it made it possible to determine longitude in the open sea. This meant that sailors could determine their exact position out of sight of land—even in uncharted

STUDY QUESTIONS

Find the answers as you read.

1. In what way did the voyages of James Cook differ from those of sea explorers before him?
2. What invention in 1735 was a major breakthrough for open-ocean navigation?
3. What geographical discoveries did the Cook expeditions make?
4. Which continent did the United States Exploring Expedition prove exists?
5. Why do we remember Matthew Maury as the father of physical oceanography?
6. How did Darwin explain the formation of coral reefs?
7. What theory did Darwin propose as a result of his observations during the H.M.S. *Beagle* expedition?
8. What expedition is commonly recognized as the first devoted entirely to marine science?
9. What accomplishments and discoveries did the H.M.S. *Challenger* make?



Figure 2-22

Captain James Cook. The voyages of Captain James Cook largely receive credit as the first sea expeditions devoted to methodical scientific oceanography. They differed from those of sea explorers that came before in that they were the first major expeditions launched with science and exploration as their only goals.

Figure 2-23
The three voyages of Captain James Cook.



Cook headed from Tahiti to New Zealand, quickly concluding that it was not part of the southern continent. Next, he explored and documented the location of Australia. After exploring it for several months, Cook concluded it wasn't the fabled southern continent either and returned to England.

Life on an Ocean Planet

Cook's second voyage departed Plymouth, England, on July 13, 1772. Again with scientists included in his crew, his orders were to find the southern continent. To accomplish this, Cook planned to sail south and circumnavigate the globe as they searched.

After rounding the Cape of Good Hope, Cook crossed into the Antarctic circle in January 1773. Ice fields blocked his path, so he headed for warm waters to the east, landing in New Zealand and Tahiti. Leaving there, the expedition continued through the

LONGITUDE AND CHRONOMETERS

James Cook led one of the first major sea voyages with the ability to determine longitude. The technology that made it possible was the chronometer—a special clock invented specifically for use at sea.

By using stars, sailors had long been able to determine their latitude, which told them how far north or south they were. This was helpful, but without the ability to determine longitude, they could only guess how far east or west they'd traveled.

Sailors knew they would be able to determine longitude accurately by comparing Greenwich Mean time to the local time based on the sun's position on the

horizon. This is possible because the local time changes one hour for every 15° longitude you travel. Traveling eastward, the time moves ahead one hour, and traveling west it moves back one hour.

Figure 2-23a
Harrison's first marine chronometer—designated H1.



Chronical Marine—Mariner, London

Prior to 1735, however, docks didn't run accurately on ships. Waves and rocking affected the dock mechanisms so much that they were unusable at sea. In 1714, the British government offered, by Act of Parliament, 20,000 British pounds sterling (about \$12 million in today's US currency) to anyone who could solve the longitude problem to within half a degree accuracy. The government established a Board of Longitude to administer and judge applications for the award.

Years went by. Along with legitimate attempts at a solution, the board received many wild and absurd ones. The phrase "finding the longitude" became an idiom for "the pursuit of a fool." Many people believed the prob-

lem was beyond solution.

Eventually, a working class cabinet maker named John Harrison solved the problem in 1735 by inventing a clock that runs accurately at sea. Although lacking much formal education, Harrison turned the scientific and academic establishment through extraordinary mechanical talent and determination.

His innovations included springs made of two metals to overcome accuracy problems with temperature changes, and jeweled bearing movements to reduce friction. Many of these exist in mechanical docks and watches today.

Figure 2-23b

Harrison's H4 marine chronometer used by Captain James Cook.



Chronical Marine—Mariner, London

Although his intent was to create a sea-going timepiece, Harrison's work also made possible two other timepieces that we've taken for granted for centuries: the pocket watch and the wrist watch.

Figure 2-24
John Harrison (1693-1781)



Chronical Marine—Mariner, London

Life on an Ocean Planet

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south Pacific, discovering and documenting islands along the way. In November the expedition turned southward again, crossing back into the Antarctic circle in January 1774. Although Cook went farther south than any explorer to that time, he never found the elusive southern continent. Returning to warmer water, the expedition furthered its exploration of the Pacific, then headed home. They arrived in England on July 29, 1775.

Cook began his final voyage on July 12, 1776. Leaving two ships with crew that included scientists, his purpose was to find the fabled Northwest Passage. This was a hoped-for route past the Americas north of present-day Canada. Unlike previous attempts, Cook determined to explore from the Pacific side instead of the Atlantic. His expedition sailed south, rounded the Cape of Good Hope, then headed north east.

On January 18, 1779, Cook sighted the Hawaiian Islands. He named them the Sandwich Islands after his friend, the Earl of Sandwich (renumbered today for naming the sandwich). According to Cook's reports, the Hawaiian people rowed out to greet him and were friendly. They thought that Cook was a god and that his men were supernatural beings.

Cook departed Hawaii about two weeks later, reaching the coast of present-day Oregon on March 7. He followed the coastline north and passed through the Bering Strait. After searching until August, Cook concluded that the Northwest Passage didn't exist and headed south for warmer waters.

By January 17, 1779, Cook's ships arrived again in Hawaii. This time they weren't welcomed so warmly, and with rising tensions, they departed by February 4. As fate would have it, however, they ran into a storm that broke a foremast. This forced them back to Hawaii for repairs, and the Hawaiians weren't very welcoming.

Cook died on February 14, 1779, during hostilities with the aboriginal Hawaiians. Accounts about what happened vary. One story was that the Hawaiians took one of Cook's smaller boats. To get it back, Cook took a Hawaiian chief hostage and died in the fighting that ensued. With morale low, his crew returned home rather than continuing the voyage, reaching England in August 1780.

Despite his untimely end and his failure to find Antarctica, Cook's contributions were extraordinary. Because of his thoroughness and accuracy in documenting his finds, many considered him a naturalist, file discoverer, mapmaker, and reports changed the Western view of the world.

The United States Exploring Expedition

Which continent did the United States Exploring Expedition prove exists?

One of the first significant scientific expeditions launched by the US was the United States Exploring Expedition. This expedition, which is also referred to as the Wilkes Expedition, after its commander, Charles Wilkes, was authorized by an act of Congress in 1836. It's objective was to explore the southern Atlantic Ocean and the Pacific Ocean, which were areas becoming increasingly important to American traders and whalers.

The expedition of five ships left Norfolk, Virginia, in August 1838. The crew included scientists and illustrators charged with studying and documenting the expedition's discoveries.

The Exploring Expedition sailed through the southern oceans for almost four years. By the time it returned to New York in June 1842, it had explored Madeira, both coasts of South America, Terra del Fuego, many South Pacific islands, Australia, New Zealand, Hawaii, California, Oregon, the Philippines, Singapore, and St. Helena. The five ships had rounded the Cape of Good Hope and, perhaps most significant, visited and proved the existence of Antarctica—the elusive southern continent.

Besides mapping, the expedition gathered specimens of flora and fauna as it traveled. They shipped these back to the US when they visited established ports. These specimens went into the trust of the Smithsonian Institution in 1838. After its conclusion, the United States Exploring Expedition final report consisted of 19 volumes of maps, text, and illustrations documenting their discoveries.



Figure 2-26
Lt. Charles Wilkes—Commander of the US Exploring Expedition.



U.S. Naval Historical Center

Figure 2-27

US Exploring Expedition. One of the first significant scientific expeditions launched by the US was the United States Exploring Expedition. This expedition, which is also referred to as the Wilkes Expedition, after its commander, Charles Wilkes, was authorized by an act of Congress in 1836. It's objective was to explore the southern Atlantic Ocean and the Pacific Ocean, which were areas becoming increasingly important to American traders and whalers.



Figure 2-28

Matthew Maury. Often called the "father of physical oceanography," Matthew Maury became established as an authority on ocean exploration and science. His work began early in the century with three voyages that took him to Europe, around the world, and along the South American Pacific coast. From 1834 to 1841, Maury produced and published dedicated works about sea navigation and his journeys.

Matthew Maury—Father of Physical Oceanography

Why do we remember Matthew Maury as the father of physical oceanography?

During the same approximate period as the United States Exploring Expedition, a US naval officer named Matthew Maury became established as an authority on ocean exploration and science. His work began early in the century with three voyages that took him to Europe, around the world, and along the South American Pacific coast. From 1834 to 1841, Maury produced and published detailed works about sea navigation and his journeys.

In 1842, the navy appointed Maury superintendent of the Depot of Charts and Instruments of the Navy Department in Washington D.C. In this position, he began publishing his research on oceanography and meteorology, along with charts and sailing directions.

By 1853, Maury had earned global acclaim for his work. In that year, he represented the US at an international congress on ocean exploration in Brussels. As a result, Maury's systems for recording oceanographic data from naval and merchant vessels were adopted worldwide.

Through his experience with sailing and navigation, Maury was among the first to envision a worldwide pattern for surface winds and currents. Based on his analysis of these patterns, he produced instructions for making long-distance sailing more efficient by working with prevailing currents and winds. In 1855, he published *The Physical Geography of the Sea*, which is now considered the first textbook on modern oceanography. Thanks to his study of currents and other physical aspects of the sea, we remember Maury today as the father of physical oceanography.

Darwin and the H.M.S. Beagle

How did Darwin explain the formation of coral reefs?

What theory did Darwin propose as a result of his observations during the H.M.S. Beagle expedition?

Of all the 19th-century oceanographic expeditions, perhaps the best known is the five-year voyage of the H.M.S. *Beagle*. This voyage began on December 27, 1831. The *Beagle* sailed under the command of Robert Fitzroy, with the now-famous Charles Darwin aboard as the ship's naturalist. Departing from Plymouth, England, with a crew of 73, the *Beagle* ultimately circled the Earth

studying the southern oceans. In its travels, it voyaged along both coasts of South America.

The route along South America proved especially interesting to Darwin. He spent much of his time studying the geology and biology of the coastline, with a particular interest in the unique animals in the Galapagos Islands off today's Ecuador. Darwin also noted the changes in organism characteristics and habitats that corresponded with latitude.

As the *Beagle* sailed through the warm South Pacific, Darwin turned his attention to coral and coral reefs. Among other observations, he noted that coral only grows in the relatively shallow, warm, upper depths. However, coral reefs themselves extended far deeper than coral grows. Darwin hypothesized that the massive coral reefs they saw could only result when the seafloor slowly sinks. As the seafloor descends, Darwin proposed, the coral grows upward from its base to remain in the shallow water it needs to survive. This hypothesis became the basis for Darwin's first major published work, *Structure and Distribution of Coral Reefs*. Darwin's explanation that coral reefs form by growing upward as the seafloor recedes is the explanation accepted by most scientists today.

Having returned to England in 1836, Darwin spent the next 20 years examining the data they had gathered. Based on this, Darwin ultimately proposed what we today call the theories of natural selection and the evolution of species. He proposed that new species result from natural selection favoring or disfavoring specific characteristics over long periods. He published his arguments, observations, and conclusions in 1859 in the now famous *The Origin of Species*. We'll look more closely at the theory of evolution in Chapter 3.



Figure 2-29

Charles Darwin.



Figure 2-30
Map of voyage of the Beagle.

Departing from Plymouth, England, with a crew of 73, the *Beagle* ultimately circled the Earth studying the southern oceans. In its travels, it voyaged along both coasts of South America.