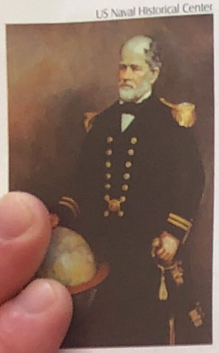


US Naval Historical Center

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 detailed 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?

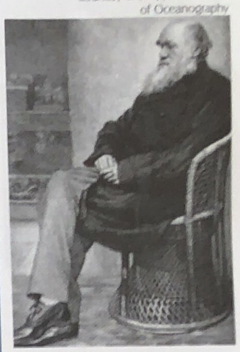
What theory did Darwin propose as a result of his observations during the H.M.S. Beagle expedition?

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.



Courtesy of Scripps Institution of Oceanography

Figure 2-29

Charles Darwin.

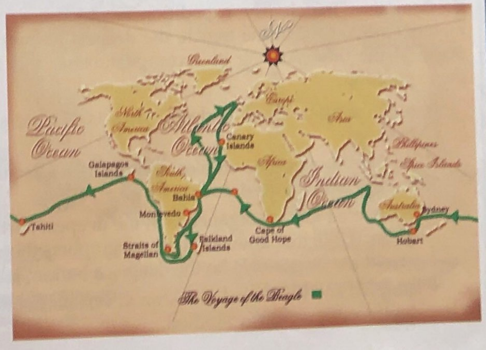


Figure 2-30

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.

NOAA/Oceanexplorer

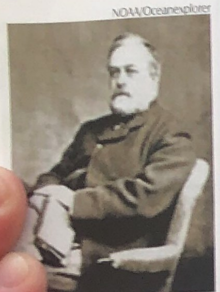


Figure 2-31

Charles Wyville Thomson.

The H.M.S. *Challenger*, a warship converted and equipped for general oceanographic research sailed under the direction of Scottish professor Charles Wyville Thompson and British naturalist Sir John Murray.

NOAA Ship Collection/Oceanographer

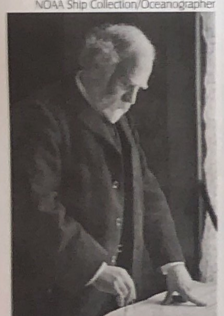


Figure 2-32

Sir John Murray.

British naturalist who sailed on the four-year research mission of the H.M.S. *Challenger*.

The Challenger Expedition

What expedition is commonly recognized as the first devoted entirely to marine science?

What accomplishments and discoveries did the H.M.S. Challenger *make?*

While several expeditions devoted to exploration and science had sailed by 1872, the *Challenger* expedition, which launched that year, is recognized as the first devoted entirely to marine science. The H.M.S. *Challenger*, a warship converted and equipped for general oceanographic research, sailed under the direction of Scottish professor Charles Wyville Thompson and British naturalist Sir John Murray. Its four-year mission was to gather detailed and consistent observations of various oceanographic phenomena across as much ocean as possible.

Using methodologies similar to those used by present-day oceanographers, the *Challenger* gathered physical, geological, chemical, and biological oceanography data at regular intervals across the sea. From 1872 to 1876, the expedition sailed almost 130,000 kilometers (80,778 miles) in the Atlantic, Pacific, and Antarctic oceans. They documented temperature, currents, water chemistry, marine organisms, and marine bottom sediments at 362 stations scattered over 36 million square kilometers (14 million square miles) of ocean floor.

The *Challenger* accomplishments were so extensive that the expedition report took more than 23 years to complete. It was 29,500 pages long, in 50 volumes, and included the first systematic plot of currents and temperatures, a map of bottom deposits (still considered accurate), outlines of the main contours of the ocean basins, and the discovery of the Mid-Atlantic Ridge and the Marianas Trench. The expedition recorded a depth of 8,200 meters (26,900 feet) in the trench, the deepest known spot in the ocean at the time. Among its accomplishments and discoveries, the expedition:

- took the first soundings deeper than 4,000 meters (13,123 feet).
- captured biological samples in midwater and along the bottom with a towed device.
- discovered marine organisms in the deepest parts of the ocean. (Until that time, most oceanographers thought life would not be possible on the deep-sea bottom.)
- sampled and illustrated plankton in various habitats and depths not previously studied.
- cataloged and identified 715 new genera and 4,717 new species. (The next closest achievement in terms of species discovery is probably the late 1970s discovery of deep-sea hydrothermal vent communities, which you'll read about in later chapters.)

The *Challenger* expedition contributions were so vast that much of its work remains the foundation for several oceanographic disciplines. Even the illustrations it produced of plankton remain in use today. Recognizing the ship and expedition's role in furthering science, NASA named the second space shuttle *Challenger* in its honor.

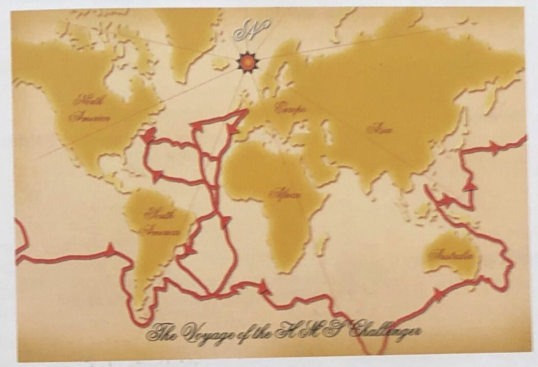


Figure 2-33

Voyage path of the *Challenger* expedition.

H.M.S. *Challenger* Volumes/NOAA

Figure 2-34a

Illustration plate of octopi from *Challenger* expedition report.

H.M.S. *Challenger* Volumes/NOAA

Figure 2-34b

Illustration plate of starfish from *Challenger* expedition report.

These plates are representative of the report's exquisite artistic detail.

Twentieth-Century Marine Science

The Oceanography Explosion

What change led to the growth and expansion of modern oceanography in the 20th century?

Oceanography in the modern sense really came into existence at the beginning of the 20th century. Ocean research accelerated from the early 1900s, so that by the 1950s, you could find marine science expeditions and projects in progress somewhere in the world at any given time. Especially in the latter half of the century, these became so numerous and frequent that it's impossible to list them all here. You'll touch on many of them as you go through *Life on an Ocean Planet*.

Although many factors contributed to the growth and expansion of marine sciences in the 20th century, most of these stem from a single, significant social change: the Industrial Revolution. The Industrial Revolution started around 1760 in England and it took time to spread to other countries. Although it was in progress, its most noticeable effects didn't appear until the last half of the 19th century, continuing into the 20th. During this period, science and technology began accelerating the pace of advancements that continues today.

One major change was the rise of steam engines and iron ships. As late as the 1870s, most vessels were wooden ships powered by sail. By 1900, these had largely given way to iron and steel steam ships. This improved trade and oceanography because sea travel was no longer at the mercy of wind and current.

As the Industrial Revolution progressed, so did technologies that applied to ocean research. During the early 1900s, scientists and engineers began designing and building elaborate research equipment. Building on the work of the *Challenger* in the previous century, oceanographers became truly interdisciplinary in collecting data. Research increasingly considered physical, geographic, chemical, and biological oceanography.

Although the dream of an underwater ship had been in the human mind for centuries, it was the invention of the diesel engine, electric motor, and the lead-acid battery that made the first useful submarines possible in the 20th century. This technology advanced rapidly. At the turn of the century there were few submarines and they were largely experimental. However, less

STUDY QUESTIONS

Find the answers as you read.

1. What change led to the growth and expansion of modern oceanography in the 20th century?
2. For what accomplishment do we recognize the German *Meteor* expedition?
3. What was the significance of the *Atlantis*?
4. What noted discovery did the second H.M.S. *Challenger* make?
5. How have submersibles and self-contained diving changed the study of the oceans?
6. What are the three types of submersible that have been used for underwater research?
7. What are the advantages and disadvantages of submersibles and scuba?
8. What other technology has opened underwater research?
9. How have Loran-C and GPS benefited seafaring and oceanography?
10. What are three types of sea surface observations that satellites can make to benefit oceanographers?

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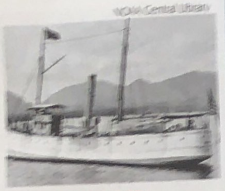

Figure 2-35a

Rise of steam engines and iron ships.

NURP

Figure 2-35b

Submersible.

OAR/NURP

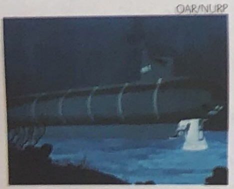

Figure 2-35c

Nuclear submarine.

Although many factors contributed to the growth and expansion of marine sciences in the 20th century, most of these stem from a single, significant social change: the Industrial Revolution. The rise of steam engines, iron ships, submersibles, nuclear submarines, and modern sampling equipment helped further marine science in the 20th century.

than 15 years later, submarine warfare played an important strategic role in World War I. The sinking of the *Lusitania* in May 1915 by a German submarine was a key motivator that propelled the US into the conflict.

As the pace of the Industrial Revolution picked up, the role and view of science took on new weight. More funding became available for research as Western societies became wealthier through industry. Applied research (science to create a specific product or solve a specific problem) grew. This research creates and meets demand for everything from new medicines to consumer goods. Pure research (no goal except science) also increased as government and industry recognized that pure research generates tangible economic benefits. It's worth the investment even when you don't know what the return will be.

Global conflict and the Cold War also drove science and technology in the 20th century. Countries invested in research to develop their military capabilities, but also to further their international stature. The 1960s and 1970s sea and space explorations by the United States and the Soviet Union were good examples. Both countries made great advances while competing for political prestige.

These trends continue today. The need for ocean resources has never been higher. The need for solutions to environmental problems concerning the sea has never been greater. Yet, as you learned in the last chapter, most of the ocean remains unexplored. This suggests need and opportunity. It may well be that the oceanography explosion of the 20th century will pale in comparison to that of the 21st century.

Three Expeditions

For what accomplishment do we recognize the German Meteor *expedition?*

What was the significance of the Atlantis?

What noted discovery did the second H.M.S. Challenger *make?*

Although there were hundreds of marine science expeditions and research vessels in the 20th century, three in particular stand out. These were the German *Meteor* expedition, the *Atlantis*, and the second H.M.S. *Challenger*.

The German *Meteor* expedition began in 1925 and is often cited as one of the first modern oceanographic research cruises. The *Meteor* crossed the Atlantic 14 times in just over two years, gathering physical, chemical, geological, and biological data. This included about 9,400 temperature, salinity, and chemical samples at varying depths. Analysis of these data established patterns for ocean water circulation, nutrient dispersal, and plankton growth.

NOAA/Ship Collection

Figure 2-36

***The Meteor* research vessel.**

The German *Meteor* expedition began in 1925 and is often cited as one of the first modern oceanographic research cruises. The *Meteor* crossed the Atlantic 14 times in just over two years, gathering physical, chemical, geological, and biological data. This included about 9,400 temperature, salinity, and chemical samples at varying depths. Analysis of these data established patterns for ocean water circulation, nutrient dispersal, and plankton growth.

The primary accomplishment for which we recognized this expedition, however, is mapping the Atlantic seafloor with echo-sounding technology. *Meteor* scientists used approximately 67,400 echo soundings to create the first detailed ocean floor map. They discovered a rugged, varied terrain instead of the long, flat bottom they expected. As you'll read in Chapter 11, this was an important step in developing theories that explain the creation and destruction of the seafloor over time.

In 1931, the United States launched the *Atlantis*. The significance of the *Atlantis* is that she was the first ship specifically designed and built for ocean studies. Among many accomplishments, *Atlantis* built on the work of the *Meteor*. During its voyages, it confirmed the existence of the Mid-Atlantic Ridge and mapped it. As with *Challenger*, NASA named one of the space shuttles in honor of *Atlantis*.

NOAA

Figure 2-37

***Meteor* research.**

Crew member handling plankton net for biological sampling.

In October 1951, a new H.M.S. *Challenger II* began a two-year voyage to measure the depths of the Atlantic, Pacific, and Indian oceans. This effort used echo-sounding technology to further the mapping efforts started by Meteor and continued by Atlantis and other vessels. The most noted discovery made by the second *Challenger* was finding the deepest known part of the ocean. Located in the Marianas Trench (discovered by the first *Challenger*), they named it the Challenger Deep in honor of the first *Challenger* expedition. At 10,838 meters (35,558 feet), this is still the deepest known place in the world.

NOAA/Ship Collection

Figure 2-38

Second *Challenger* expedition—1950s.

H.M.S. *Challenger II* seen here entering Suva, Fiji, in 1951, during her world voyage. The most noted discovery made by the second *Challenger* was finding the deepest known part of the ocean. Located in the Marianas Trench (discovered by the first *Challenger*), they named it the Challenger Deep in honor of the first *Challenger* expedition. At 10,838 meters (35,558 feet), this is still the deepest known place in the world.