CHAPTER 1 HISTORY OF OCEANOGRAPHY

Key Concepts

Major Concept (I) *Scientists who study the oceans have many different scientific backgrounds. Essentially any scientific discipline can be applied to some field of oceanography.*

Related or supporting concepts:

- Many different areas of science can be used to study the oceans.
- Marine geologists study the sediments and rocks found on the sea floor and along coastlines. They also investigate the effects of volcanism associated with the formation of new oceanic crust at spreading centers, the destruction of old oceanic crust along trenches, and in areas such as the Hawaiian Islands.
- Physical geographers may study the formation and modification of landforms as a result of marine influence. Cultural geographers may study the role the oceans have had and continue to have in interactions between nations.
- Geophysicists investigate the occurrence of earthquakes in the oceans. They also measure the gravity and magnetic properties of marine rocks to determine such things as the rate of seafloor spreading, the frequency of the reversal of Earth's magnetic field, and the distribution of mass in ocean basins.
- Physical oceanography relies heavily on physics and mathematics to study the propagation of waves, the transmission of sound in water, and the nature of the tides, among other things.
- Chemists can apply their expertise to the analysis of seawater, the measurement of rates and effects of chemical reactions in the water, and the study of the composition of marine sediments and rocks.
- We now understand that the oceans interact with the atmosphere in complex ways to influence global weather patterns. Conversely, circulation in the atmosphere plays a major role in driving surface currents and can trigger events such as El Niño that impact life in the sea and weather on land. Hence, atmospheric scientists can immerse themselves in the oceans too.
- One of the most fundamental characteristics of the oceans is their role as a habitat for a tremendous variety of plants and animals. Consequently, marine biology is a major field of oceanographic study for reasons including pure scientific curiosity, investigation of possible applications to medical research, and for harvesting food reserves to feed the planet's ever increasing population.

Major Concept (II) *Oceanographic study has historically concentrated on different areas, driven by the needs and interests of different groups of people, or nations,*

at different periods of time.

Related or supporting concepts:

- The earliest interaction with the sea probably involved gathering marine organisms for food.
- Civilizations soon began venturing to sea to extend existing, and create new, trade routes.
- Eventually explorers and scientists went to sea for the purpose of increasing our knowledge of geography and the natural sciences.
- The seas have also served throughout time as political barriers and frequently battlegrounds in times of war.

Major Concept (III) *Most of the interaction that early civilizations had with the oceans was the result of a desire to discover new lands and improve trade routes rather than to gain any general scientific knowledge.*

Related or supporting concepts:

- Some historians believe that seagoing ships of all kinds are derived from early Egyptian vessels.
- The first recorded voyage by sea was led by Pharoah Snefru about 3200 B.C.
- The Phoenician civilization (1200 B.C. to 146 B.C.) were excellent sailors and navigators. They are known to have established trade routes throughout the Mediterranean Sea to trade with people in North Africa, Italy, Greece, France, and Spain. They also sailed northward into the Atlantic as far as Great Britain. There is also evidence that they were the first people to circumnavigate Africa at about 590 B.C.
- During this same period of time, from 1500 - 500 B.C., the boundaries of the Indian Ocean were being explored by Arab traders.
- Extensive migration throughout the Southwestern Pacific Ocean may have begun by 2500 B.C. These voyages were relatively easy because of the proximity of islands.
- Perhaps the most accomplished open ocean sailors of this time, again between about 1500 - 500 B.C., were the Polynesians, who managed to travel over vast expanses of the Pacific Ocean basin to populate numerous island chains. Unfortunately there is little written record of these great voyages.
- The Polynesians colonized the Hawaiian Islands between A.D. 450 and 600.
- Without the ability to determine latitude and longitude, and hence actual position on the globe, early explorers observed a variety of natural phenomena to help them in their travel when they were out of site of land. These included wind and wave patterns, their sense of smell, the location and pattern of clouds that would characteristically form over islands, and the sighting of birds that wouldn't stray too far from land.
- Greek civilization produced a number of great scientists interested in global geography

and the oceans including:

a. Aristotle (384 - 322 B.C.) who:
   i. believed the oceans filled the lowest spots on Earth,
   ii. knew that the sun evaporated water from the ocean which returned as rain, and
   iii. collected and described marine organisms.

b. Eratosthenes (c. 265 - 194 B.C.) who:
   i. mapped the known world, and
   ii. calculated Earth's circumference to be about 40,250 km, or 25,000 mi (incredibly close to modern measurements of about 40,067 km, or 24,881 mi).

c. Posidonius (c. 135 - 50 B.C.) who reportedly obtained a depth measurement in the Mediterranean of 1800 m (6,000 ft).

d. Pliny the Elder (A.D. 23 - 79) who:
   i. noted the relationship between the tides and phases of the moon, and
   ii. studied the currents flowing through the Straits of Gibraltar.

e. Ptolemy (A.D. 127 - 151) who produced the first world atlas (fig. 1.2). Ptolemy's work contained a major error in estimating the circumference of the earth at only 29,000 km (18,000 mi). This error led Columbus to believe he had reached the eastern shore of Asia when he made landfall in the Americas over 1000 years later.

Major Concept (IV) *During the Middle Ages, relatively little new knowledge was added to our understanding of the oceans. Despite this, advances continued to be made in shipbuilding, navigation, and piloting.*

Related or supporting concepts:

- Following the academic achievements of the Greeks and Romans, the Middle Ages were a period of roughly 1000 years of intellectual inactivity in the west.
- Practical problems related to the sea continued to be addressed during this time and there were significant improvements in:
  a. ship design and building,
  b. navigation, and
  c. cartography (the design and making of maps).
- The Vikings are credited with extensive voyages throughout the North Atlantic during the time from A.D. 793 - 1066 (fig. 1.4). These voyages:
  a. were aided by a period of global warming that reduced the hazards of drifting ice in the North Atlantic,
  b. resulted in the colonization of Iceland in A.D. 871,
  c. the discovery of Greenland in A.D. 982, and
  d. the exploration of North America, or Vineland, in A.D. 1002 roughly 500 years before Christopher Columbus' voyage.

- At about this same time, Arab civilization was building on the knowledge of the Greeks and Romans to pioneer and improve trade routes throughout the Indian Ocean.
- The Arab El-Mas´údé first described the relationship between surface currents and monsoon winds in the Indian Ocean allowing the Arabs to establish trade routes across the Indian Ocean.
- In the 1200s the Chinese sailed the same trade routes taken by the Arabs between China and the Persian Gulf.
- Charts during this time still lacked accurate lines of latitude and longitude. Consequently, they were not useful for navigation across large expanses of seawater and absolute location.
- Most charts were of near coastal waters, locating ports and noting distances between them. These charts were called "portolanos."
- In the 13th century:
    a. magnetic compass directions were added to maps (see fig. 1.5), and
    b. Greek knowledge in the hands of the Arabs was translated into Latin and re-discovered by northern Europeans.

Major Concept (V) *The 15th and 16th centuries were a period of time of great global voyages of discovery made by northern Europeans.*

Related or supporting concepts:

- Early in the 15th century the Chinese sailed throughout the Pacific and Indian Oceans on seven separate voyages using over 300 ships. This episode of explorations ended in 1433 when the Chinese concluded that there was little to learn from other societies.
- These voyages were the result of a desire to increase trade with known lands and discover new regions that might also prove to be financially rewarding.
- The person most responsible for the great age of European discovery was Prince Henry the Navigator (1394-1460) of Portugal. He founded a school of navigation, astronomy, and cartography about 1450.
- Bartholomeu Dias:
    a. lived from about 1450 - 1500,
    b. circumnavigated Africa, sailing around the Cape of Good Hope into the Indian Ocean in 1487, and
    c. was driven by his desire to find faster trade routes to the Far East.
- Christopher Columbus:
    a. lived from 1451 - 1506,
    b. made four voyages across the Atlantic, intent on reaching the Far East, and
    c. is credited with being the first European to see the "New World."
- Vasco da Gama:
    a. lived from about 1469 - 1524,
    b. sailed around the Cape of Good Hope and went on to India in 1498 (during this

voyage he was challenged by Arab ships in the Indian Ocean), and
c. returned to the Indian Ocean in 1502 with a large fleet of ships and defeated the Arabs.

- Amerigo Vespucci:
  a. lived from 1454 - 1512,
  b. was an Italian explorer,
  c. sailed several times to the New World between 1499 - 1502 on behalf of Spain and Portugal, and
  d. believed South America was a distinct continent not attached to Asia.
- Martin Waldseemuller was a German cartographer who christened what we now call South America "America" in honor of Vespucci in 1507.
- Vasco Nuñez de Balboa:
  a. lived from 1475 - 1519, and
  b. is credited with first sighting the Pacific Ocean in 1513.
- Ferdinand Magellan:
  a. lived from 1480 - 1521,
  b. sailed across the Atlantic and around the tip of South America into the Pacific where he was killed in the Philippines in 1521, however
  c. one of his three ships, the *Victoria*, continued around Africa and across the Indian Ocean to return home in 1522, completing the first circumnavigation of the globe (see fig. 1.7).
  d. Magellan is also credited with determining the length of a degree of latitude and calculating the circumference of the earth.
- In the last half of the 16th century explorers sought new knowledge of, and trade routes across, northern routes.
- Sir Martin Frobisher:
  a. lived from about 1535 - 94, and
  b. led three voyages in search of a northwest passage across North America in the 1570s.
- Henry Hudson followed Frobisher and sailed on four trips from 1607 - 1610.
- William Baffin
  a. lived from 1584 - 1622, and
  b. sought a northwest passage during two trips in 1615 and 1616.
- Sir Francis Drake:
  a. lived from 1540 - 96,
  b. sailed on the *Golden Hind* to circumnavigate the globe in a voyage that lasted from 1577 - 80 (see fig. 1.7), and
  c. returned with Spanish gold for Queen Elizabeth I.

Major Concept (VI) *The successful exploitation of the oceans for transportation and economical trade required the development of accurate navigational methods and detailed charts of landmasses, prevailing winds, and surface*

currents.

Related or supporting concepts:

- Following the great voyages of discovery new trade routes and distant colonies were established. This required the construction of accurate charts and the improvement of navigation techniques.
- Accurate charts and navigation require determinations of both latitude and longitude. Astronomical methods of determining latitude were developed by the Greeks. Accurate determination of longitude was much slower in developing because it required the invention of a timepiece that could accurately keep time during long voyages at sea.
- John Harrison constructed the first timepiece sufficiently accurate to use for calculating longitude during long sea voyages in 1761. This timepiece (see fig. 1.8) was tested by James Cook during his second voyage in the south Pacific.
- The science of the mapping of oceans and other large bodies of water for the purpose of improving navigation is called "hydrography."
- The first hydrographic office was established in France as early as 1720.
- In 1795 Great Britain appointed an official hydrographer for the British navy.
- Some of the earliest extensive mapping of the oceans was carried out by James Cook in his three voyages throughout the Pacific Ocean basin from 1768 - 79 (see fig. 1.9). Cook compiled data covering such things as:
    a. ocean depths,
    b. prevailing wind directions,
    c. characteristics of surface currents, and
    d. water temperatures.
- James Cook died in the Hawaiian Islands during his third voyage.
- The first chart of the Gulf Stream was made by Benjamin Franklin with help from his cousin Timothy Folger in 1769. Figure 1.10 in the text shows the detail of the current along the coast of the United States as well as the general clockwise circulation in the North Atlantic.
- The United States established a naval hydrographic office in 1830. This office was called the U.S. Hydrographic Office and it still exists, although its name has been changed to the U.S. Naval Oceanographic Office.
- Matthew Maury was placed in charge of the U.S. Naval Hydrographic Office and began a career compiling data on the seas. Among his accomplishments are:
    a. the founding of the Naval Depot of Charts,
    b. publication of the first wind and currents charts of the North Atlantic in 1847,
    c. construction of the first bathymetric chart of the North Atlantic with contours at 6000 ft intervals, and
    d. the publication in 1855 of a comprehensive book called **The Physical Geography of the Sea** (this book is sometimes considered to be the first oceanography textbook).

- Maury's careful compilation of current and wind directions, along with recommended sailing routes, are credited with reducing travel times between some ports by as much as a month.

Major Concept (VII) *In the 19 th century scientists began exploring the oceans in earnest. Scientific exploration was facilitated by accurate charts and ship's crews skilled in navigation.*

Related or supporting concepts:

- One of the earliest scientific voyages was aboard the HMS *Beagle* with Charles Darwin as the ship naturalist.
- The Beagle expedition sailed from 1831 - 36.
- Darwin collected a variety of marine organisms for study and proposed an explanation for the progressive evolution of coral reefs into atolls.
- One of the leading marine biologists of the 19 th century was Edward Forbes. Forbes believed the oceans could be divided vertically into zones, each of which was home to a characteristic group of organisms. He suggested that there was no life below about 550 m (1800 ft), and hence the waters beneath this were called the "azoic" (no life) zone. We now know that organisms can be found at all depths.
- Forbes' suggestion of an azoic zone is surprising because 20 years earlier another British scientist Sir John Ross had recovered a variety of marine organisms from the bottom of Baffin Bay at a depth of over 1800 m (6000 ft).
- Sir James Clark Ross recovered marine organisms, similar to those discovered by his uncle Sir John Ross, at even greater depths in the Antarctic.
- The similarity of the species recovered by the Rosses in the Arctic and the Antarctic led them to conclude that the deep water of the oceans must be uniformly cold.
- The extremely small plants and animals that drift freely in shallow water were first studied intensely by Johannes Muller. Muller was followed in this work by Victor Hensen who named these organisms "plankton" in 1887.

Major Concept (VIII) *It was also in the 19 th century that one of the greatest scientific oceanographic expeditions was mounted, the Challenger expedition.*

Related or supporting concepts:

- The Challenger expedition was organized by the British Royal Society and the British Admiralty and sailed under the direction of Wyville Thompson.
- The charge given to Thompson was to travel throughout the ocean basins collecting all of the scientific information possible about the seas (fig. 1.14e).
- The expedition lasted from December 21, 1872 until May 24, 1876; nearly 3½ years.
- During the voyage:

a. ocean depth measurements were taken at 361 locations,
b. a maximum depth of 8180 m (26,850 ft) was discovered in the Mariana Trench in the western Pacific Ocean,
c. water samples were taken at various depths and analyzed for temperature and chemistry,
d. it was shown that the relative abundance of the major component ions of seawater remains constant regardless of where the sample is taken,
e. 4717 new species of marine organisms were discovered, and
f. deep water currents were investigated.

- Scientists worked for 20 years after the conclusion of the expedition cataloging and analyzing all of the information that was collected.

Major Concept (IX) *Late in the 19 th century Fridtjof Nansen led a voyage to the Arctic to test his theories about surface circulation in Arctic waters. This was the beginning of the exploration of Polar seas that continued into the early 20 th century.*

Related or supporting concepts:

- Nansen was a Norwegian scientist who lived from 1861 to 1930. He was a zoologist by training but he had a particular interest in Arctic waters.
- Nansen designed a ship that could be frozen into the ice during winter months so that it would drift with the ice pack under the influence of surface circulation.
- The ship had a rounded bottom, rather than the traditional V-shape, so that the ice would lift it out of the water rather than crush it as it froze. The name of the ship was the *Fram* and it is shown in figure 1.15.
- The *Fram* was frozen into the ice for 35 months from 1893 - 96 and drifted with the ice pack around the pole.
- During this time measurements were taken of:
    a. water depth, demonstrating that the Arctic was very deep rather than a shallow sea,
    b. weather conditions,
    c. water temperature and chemistry, and
    d. characteristics of the periodic changes in numbers of plankton in the water.
- When it became apparent that the ship would not be carried over the Pole, Nansen left the ship on dog sled with one companion, F.H. Johansen, to attempt a 300 mile trip to reach it. The ship was left under the command of its captain Otto Sverdrup.
- Nansen was unable to reach the Pole due to inadequate supplies and fatigue. He and Johansen were forced to turn back and spend the winter of 1895 - 96 living off seals and walrus before being found in the early summer by a British expedition that brought them home.
- After breaking free from the ice, the *Fram* also returned to Norway in 1896.

- Nansen designed an instrument to collect deep water samples that is still used today. It is called a Nansen bottle in his honor.
- Roald Amundsen took the *Fram* to the Antarctic in 1911.
- Amundsen is also credited with the first traverse of a northwest passage entirely by water in a three year voyage from 1903 to 1906 by sailing from Norway to Nome, Alaska.

Major Concept (X) *The late 19 th and early 20 th centuries saw increased interest in the scientific study of the oceans to solve practical problems. This work often necessitated the design and construction of new instruments to make the needed measurements.*

Related or supporting concepts:

- As early as 1870 it was recognized that we needed to know more about the chemical and physical characteristics of the oceans to effectively deal with problems related to commercial fisheries.
- A tide-predicting machine was developed by Lord Kelvin, a British scientist, in 1872. This allowed the compilation of tide tables for different regions.
- Deep water circulation couldn't be studied until about 1910 when it became possible to identify individual water masses on the basis of their temperature and salinity characteristics. This could be accomplished with the addition of specially designed thermometers to Nansen bottles and an improved technique for measuring salinity devised by Martin Knudsen.
- Water depth and seafloor bathymetry were not easily measured until the successful testing and use of an echo sounder during the Meteor expedition in 1925 - 27. The echo sounder emitted a pulse of sound and then timed how long it took for the sound to reflect from the sea floor and return to the ship. Knowing the velocity of sound in water, it was simple to determine depth from this two-way travel time.

Major Concept (XI) *In the early 20 th century there was a great deal of interest in oceanography in the private sector that led to the creation of private institutions that would eventually become incorporated into universities. Government interest in oceanography blossomed at the federal level in the middle of the 20 th century in response to World War II.*

Related or supporting concepts:

- Following the Civil War, there was less interest in gaining more information about physical oceanography (directions of winds, waves, and currents) because steam driven engines replaced sails and ships could easily choose their own course.
- Alexander Agassiz (1835-1910), marine scientist and Harvard Professor, financed a

series of marine biological expeditions.

- The earliest oceanographic institution in the United States began shortly after the turn of the century. This was funded privately by Ellen B. Scripps and is now known as the Scripps Institution of Oceanography, located in La Jolla, California (fig. 1.17a). It is presently affiliated with the University of California, San Diego.
- The Woods Hole Oceanographic Institution was founded on the East Coast in 1930 (fig. 1.17b).
- The Carnegie Institution funded a series of cruises in the early 20th century directed toward investigating Earth's magnetic field. It also supported a marine biological station.
- By 1930 more marine programs were appearing at universities, and the Rockefeller Foundation was funding research programs and the construction of laboratories.
- World War II brought ocean science to the forefront of federal concern for military reasons. A variety of research endeavors were supported including:
    a. prediction of wave and tide conditions for amphibious landings,
    b. how explosives act in seawater,
    c. accurate charting of coastlines, and
    d. the propagation of sound in water in order to locate submarines.
- Following the war, oceanography became an important area for research that was well funded by a number of different government agencies including the:
    a. National Science Foundation (NSF),
    b. Office of Naval Research (ONR), and
    c. Atomic Energy Commission (AEC).
- The federal government operates a number of research vessels through the National Oceanic and Atmospheric Administration (NOAA) and owns many other ships that are "on loan" to universities that operate them.

Major Concept (XII) *Oceanography has grown into a major area of research in the last few decades with the development of new instrumentation and the construction of research vessels to conduct extensive expeditions in all of the world's ocean basins.*

Related or supporting concepts:

- Several international ventures were undertaken from the 1950s through the 1970s. These included:
    a. The Coast and Geodetic Survey established its tsunami warning system in the 1950s.
    b. The International Geophysical Year was observed in 1957 - 58. During this time marine geology and geophysics studies were carried out by sixty-seven different countries.
    c. An international program to explore the Indian Ocean took place in 1963 - 64.
    d. The 1970s were declared the International Decade of Ocean Exploration

(IDOE).

- The 1960s were a period of time where there was a lot of development of new equipment and application of technology to oceanography. In this time:
    a. research ships and submersibles were built for use by the federal government and universities,
    b. the Deep Sea Drilling Program was created in 1968 to core and retrieve seafloor sediment and rock, and
    c. there was widespread use of electronics technology from the space program and computers on board research vessels.
- In the 1970s there was a decline in the funds available for basic research. Despite this, instruments continued to be improved and the use of satellite technology to obtain basic data on the oceans began.
- Extremely interesting discoveries made in the 1970s include the existence of deep-sea hot water vents creating mineral-rich environments populated by a wide variety of unique marine organisms.
- The oceans are so vast that it is simply not possible to explore them adequately using ships alone. Satellites allow us to study characteristics of whole oceans simultaneously. This vast amount of data can only be analyzed with powerful computers.
- The first satellite launched to study the oceans was placed in orbit in 1978 and was called SEASAT (see fig. 1.17a). It had an operational lifetime of only a few months. It could measure wave heights to an accuracy of 5 cm (2 in).
- During the 1970s and 80s we began to see the first clear signs of global environmental degradation.

Major Concept (XIII) *In the next decade there will continue to be an increased emphasis on the study of the planet as a whole system. Now, and in the future, we must recognize that oceanographic studies need to be interdisciplinary in their nature due to the complexity of the problems we wish to investigate.*

Related or supporting concepts:

- There are a number of complex, large scale problems that researchers are interested in, including:
    a. the interaction of ocean and atmospheric circulation to influence weather patterns,
    b. the best ways to recover mineral resources from the seas,
    c. how we can increase our harvesting of food from the oceans while insuring that we do not over-harvest the organisms and destroy the supply,
    d. the erosion of rocks from land and transfer of that material to the oceans,
    e. the chemical reactions that take place in the sea on the seafloor,
    f. the occurrence of earthquakes and volcanism along active continental margins,
    g. the transfer of gases, including O_2 and CO_2, between the water and the air, and

h. improving the design of vessels to decrease the cost of transportation across the oceans.

- It used to be popular for scientists in different disciplines to research problems only from their narrow perspective. We know now that Earth is essentially a self-contained, complex environment where different processes interact and influence each other.
- Large scale cooperative studies of global problems have increased in importance as:
  a. scientists have realized that they need cooperation from people in other disciplines to study Earth processes in ever greater detail,
  b. the development of satellite technology has made it possible for the first time in history to gather very large scale data sets over short time periods, and
  c. society as a whole has recognized the potential for human actions to radically alter global environmental conditions.
- In 1992 the joint U.S.-French TOPEX/Poseidon program began a three year study of global sea level, ocean circulation, tides, and ocean-atmosphere interaction. TOPEX/Poseidon ended in 1995 but a follow-up mission is scheduled to begin in 2001.
- A meeting of representatives from 24 nations recommended the development of a Global Ocean Observing System (GOOS) in include satellites, buoy networks, and research vessels. Data obtained by the system may one day make it possible to predict phenomena such as El Niño more accurately.

Test Your Understanding With The Following Questions:

FILL IN THE BLANK

1. The North Atlantic was crossed by the _____ during the Middle Ages.
2. Early information about the oceans was acquired primarily by _____ and _____.
3. The first extensive maps of ocean regions and surrounding continents were produced by the _____.
4. A _____ was an early chart used during the Middle Ages to find harbors along trade routes.
5. The first European to sight the Pacific Ocean was _____.
6. The great Voyages of Discovery occurred in the _____ and _____ centuries.
7. The *Golden Hind* was the name of _____ _____ ship.
8. The Naval Depot of Charts was founded by _____.
9. The Meteor expedition concentrated on the _____ Ocean.
10. Nansen sailed on board the _____.

TRUE - FALSE

1. Scientific exploration of the oceans began with the Phoenicians.
2. The Polynesians are known to have navigated with the aid of charts made from sticks and shells.
3. Magellan sailed around the globe and returned to Spain in 1521.
4. The search for a northwest passage was driven by a desire to shorten the voyage to China from England and Europe.
5. Benjamin Franklin became interested in the Gulf Stream because of its effect on mail ships.
6. The Challenger expedition sailed under the leadership of Wyville Thompson.
7. The *Fram* was built with a specially deep, pointed keel for survival in the ice.
8. The scientific study of the oceans blossomed following WWII.
9. Following the Challenger expedition, it took another five years to analyze all of the data.
10. The Meteor expedition was a biological cruise.

MULTIPLE CHOICE

1. Early voyagers used a variety of observations to help guide them including:
    a. their sense of smell
    b. cloud formations
    c. the appearance of birds
    d. the direction of waves
    e. all of the above
2. This individual first calculated the circumference of the earth:
    a. Pliny
    b. Eratosthenes
    c. Franklin
    d. Ptolemy
    e. Elvis
3. During the Middle Ages:
    a. scientific investigation of the seas increased
    b. the great depths of the oceans were first discovered
    c. shipbuilding technology improved
    d. the first circumnavigation of Africa was completed
    e. accurate maps with latitude and longitude appeared
4. The explorer who first believed South America was a distinct continent was:
    a. Amerigo Vespucci
    b. Franco Americas
    c. Vasco d'Americ
    d. Bartholomeu Dias
    e. none of the above
5. The Challenger expedition is credited with:
    a. discovering over 4700 new species of marine organisms

b. measuring ocean depths greater than any previously found
c. discovering that major component ions have a constant relative abundance
d. sailing into and investigating all of the world's oceans
e. all of the above

6. Which of the following explorers used the *Fram*?
    a. William Baffin
    b. Fridtjof Nansen
    c. Roald Amundsen
    d. b and c
    e. all of the above
7. While on the HMS Beagle, Charles Darwin studied:
    a. the variability of seawater salinity
    b. the vertical zonation of life in the seas
    c. the formation of atolls
    d. the westward intensification of surface currents
    e. the Gulf Stream
8. The first serious study of the small animals and plants that populate surface waters was undertaken by:
    a. Edward Forbes
    b. Johannes Muller
    c. Aristotle
    d. Wyville Thompson
    e. Charles Darwin
9. The first European credited with sighting the Pacific Ocean is:
    a. Vasco Nuñez de Balboa
    b. Bartholomeu Dias
    c. Christopher Columbus
    d. Martin Waldseemuller
    e. Ferdinand Magellan
10. Oceanography in the 1970s:
    a. suffered from a decline in funding for basic research and the construction of ships
    b. was galvanized by the discovery of seafloor hydrothermal vents
    c. saw the development of more sophisticated submersibles
    d. benefitted tremendously from the acquisition of satellite data
    e. all of the above

Answer Key for 'Key Terms' and 'Test Your Understanding'

FILL IN THE BLANK

1. Vikings
2. explorers, traders
3. Greeks
4. portolanos
5. Balboa
6. 15^{th}, 16^{th}
7. Francis Drake's
8. Maury
9. Atlantic
10. *Fram*

TRUE - FALSE
1.F 2.T 3.F 4.T 5.T 6.T 7.F 8.T 9.F 10.F

MULTIPLE CHOICE
1.e 2.b 3.c 4.a 5.e 6.d 7.c 8.b 9.a 10.e