# Guided Tour

## Chapter Outline

Each chapter begins with an outline of the subsections and boxed readings within each chapter.

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Chapter Outline



Oceanography is a broad field in which many sciences are focused on the common goal of understanding the oceans. Geology, geography, geophysics, physics, chemistry, geochemistry, mathematics, meteorology, botany, and zoology have all played roles in expanding our knowledge of the oceans. Oceanography today is usually broken down into a number of subdisciplines because the field is extremely interdisciplinary.

Geological oceanography includes the study of Earth at the sea's edge and below its surface, and the history of the processes that formed the ocean basins. Physical oceanography investigates the causes and characteristics of water movements such as waves, currents, and tides and how they affect the marine environment. It also includes studies of the transmission of energy such as sound, light, and heat in seawater. Marine meteorology (the study of heat transfer, water cycles, and air-sea interactions) is often included in the discipline of physical oceanography. Chemical oceanography studies the composition and history of the water, its processes, and its interactions. Biological oceanography concerns marine organisms and the relationship between these organisms and the environment in the oceans. Ocean engineering is the discipline that designs and plans equipment and installations for use at sea.

Scientists make discoveries about the natural world, both

considered to be a valid hypothesis, recognizing that it may be replaced by a more complete hypothesis in the future.

If a hypothesis is consistently supported by repeated, different experiments, then it may be advanced to the level of a **theory**. The great value of a theory is its ability to predict the existence of phenomena or relationships that had not previously been recognized. Scientists use the word "theory" in a much more restrictive sense than the general public, who use the word in the same way the word "speculation" is used. A scientific theory is not an idle speculation, however. It is a tested, reliable, and precise statement of the relationships among reproducible observations.

A collection of hourly measurements of sea surface elevation at a specific point would comprise a set of scientific data or facts. An initial explanation of these data might be the hypothesis that sea surface elevation varies in response to tidal forces. This hypothesis could be expressed as a mathematical equation. If repeated measurements elsewhere in the oceans yielded reproducible data that continued to be accurately explained by the hypothesis, it would rise to the level of tidal theory (discussed in chapter 11).

Even when a hypothesis is elevated to the status of a theory, the scientific investigation will not necessarily stop. Scientists do not discard accepted theories

## Field Notes Boxes

The essays represented within these boxes are written by oceanographers in the field. These readings highlight relevant oceanographic topics and provide insights into engaging oceanographic careers.

Field Notes

**Modeling the December 26, 2004, Sumatra Tsunami**

*By Dr. Eddie Bernard*

Dr. Eddie Bernard is the Director of the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle, Washington. He directs a broad range of oceanographic research programs including ocean climate dynamics, fisheries oceanography, El Niño forecasts, tsunamis, and seafloor spreading. Dr. Bernard is an expert in the study of tsunamis.

At 07:59 Local Time (00.59 UTC) on December 26, 2004, a magnitude 9.3 megathrust earthquake occurred along 1300 km (800 mi) of the oceanic subduction zone located 100 km (62 mi) west of Sumatra and the Nicobar and Andaman Islands in the eastern Indian Ocean. Highly destructive tsunamis were generated by up to 10 m (33 ft) vertical displacements of the sea floor associated with massive (more than 20 m [65 ft] horizontally) sudden movements of adjacent plates during this event. Although the exact numbers will never be accurately known, it is estimated that 237,000 people died and over $13 billion in damage occurred. Some economists estimate that the tsunami devastation will place about 1 million people in poverty for the rest of their lives. The tsunami was in excess of 20 m (65 ft) as it assaulted the Sumatra coastline (box fig. 1) and was recorded around the world. This tsunami is the first for which there are high-quality worldwide tide gauge measurements and for which there are multiple-satellite altimetry passes that were able to measure the tsunami wave height in the open-ocean. These widespread coastal and open-ocean measurements of the tsunami height have been used to further refine a global tsunami numerical model, known as MOST (Method of Splitting Tsunami), used to predict the propagation and wave heights of tsunamis all over the world. The objective of tsunami modeling is to develop faster and more reliable forecasts of tsunamis striking coastal regions. A comparison of the actual measured tsunami heights with the predicted heights from the MOST model have revealed some factors that contributed to the propagation of the tsunami's energy thousands of kilometers throughout the world oceans.

The first instrumental tsunami measurements were available about three hours after the earthquake from the real-time reporting tide gauge at the Cocos Islands (box fig. 2) located approximately 1700 km (1056 mi) south of the earthquake source area. Data from this gauge revealed a 30 cm (11.8 in)-high first wave followed by a long train of water level oscillations with maximum peak-to-trough ranges of 53 cm (21 in). Gauge data and inundation measurements from sites in India and Sri Lanka at similar distances from the epicenter yielded amplitudes almost ten times greater than the Cocos Islands values. These significant wave height differences were consistent with numerical modeling results that clearly demonstrate the highly directional nature of the Sumatra tsunami (box fig. 2).

Satellite altimetry measurements of tsunami amplitude were obtained from the Jason-1 and Topex/Poseidon satellites (see chapter 1, section 1.10) as they transited the Indian Ocean about



**Box Figure 1** Tsunami inundation along the northern Sumatra coastline where flooding exceeded 30m (98 ft) and caused the most deaths and damage. The white staff in the center of the photograph is 5m (16.5 ft). Photo courtesy of Jose Borrero, University of Southern California.

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## Chapter Summary

Each chapter's summary provides a quick review of key concepts.

## Key Terms

Key Terms are boldfaced and defined within the text, and end-of-chapter key terms listings indicate the most important terms and their locations within each chapter.

## Study Questions and Problems

Study Questions and Study Problems serve not only as a concept review, but challenge students to think further about the lessons within each chapter.

## Online Links to Related Topics

Find Internet links to each chapter's content, boxed readings, and figures inside the Online Learning Center for this text at www.mhhe.com/sverdrup9e. This icon web link within text indicates that a web link is provided for further reading within the Online Learning Center.

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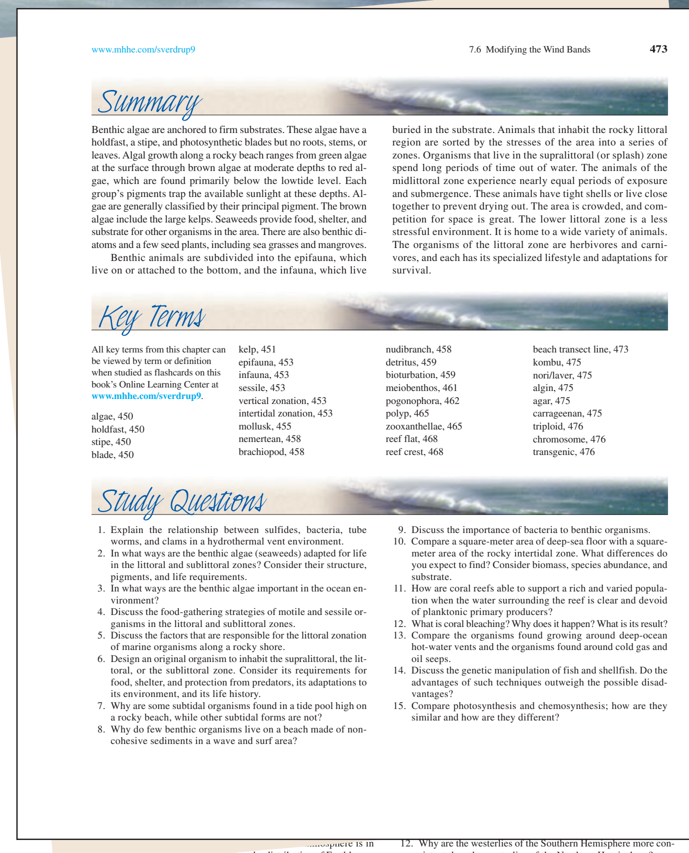

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Summary

Benthic algae are anchored to firm substrates. These algae have a holdfast, a stipe, and photosynthetic blades but no roots, stems, or leaves. Algal growth along a rocky beach ranges from green algae at the surface through brown algae at moderate depths to red algae, which are found primarily below the lowtide level. Each group's pigments trap the available sunlight at these depths. Algae are generally classified by their principal pigment. The brown algae include the large kelps. Seaweeds provide food, shelter, and substrate for other organisms in the area. There are also benthic diatoms and a few seed plants, including sea grasses and mangroves.

Benthic animals are subdivided into the epifauna, which live on or attached to the bottom, and the infauna, which live buried in the substrate. Animals that inhabit the rocky littoral region are sorted by the stresses of the area into a series of zones. Organisms that live in the supralittoral (or splash) zone spend long periods of time out of water. The animals of the midlittoral zone experience nearly equal periods of exposure and submergence. These animals have tight shells or live close together to prevent drying out. The area is crowded, and competition for space is great. The lower littoral zone is a less stressful environment. It is home to a wide variety of animals. The organisms of the littoral zone are herbivores and carnivores, and each has its specialized lifestyle and adaptations for survival.

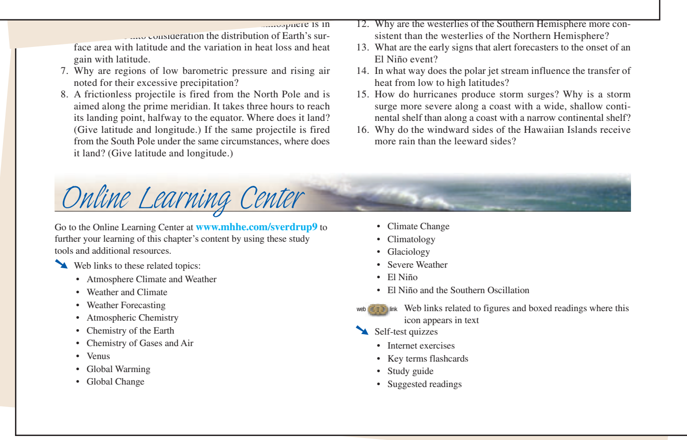
Key Terms

All key terms from this chapter can be viewed by term or definition when studied as flashcards on this book's Online Learning Center at www.mhhe.com/sverdrup9.

algae, 450
holdfast, 450
stipe, 450
blade, 450
kelp, 451
epifauna, 453
infauna, 453
sessile, 453
vertical zonation, 453
intertidal zonation, 453
mollusk, 455
nemertean, 458
brachiopod, 458
nudibranch, 458
detritus, 459
bioturbation, 459
meiobenthos, 461
pogonophora, 462
polyp, 465
zooxanthellae, 465
reef flat, 468
reef crest, 468
beach transect line, 473
kombu, 475
nori/laver, 475
algin, 475
agar, 475
carrageenan, 475
triploid, 476
chromosome, 476
transgenic, 476

Study Questions

1. Explain the relationship between sulfides, bacteria, tube worms, and clams in a hydrothermal vent environment.
2. In what ways are the benthic algae (seaweeds) adapted for life in the littoral and sublittoral zones? Consider their structure, pigments, and life requirements.
3. In what ways are the benthic algae important in the ocean environment?
4. Discuss the food-gathering strategies of motile and sessile organisms in the littoral and sublittoral zones.
5. Discuss the factors that are responsible for the littoral zonation of marine organisms along a rocky shore.
6. Design an original organism to inhabit the supralittoral, the littoral, or the sublittoral zone. Consider its requirements for food, shelter, and protection from predators, its adaptations to its environment, and its life history.
7. Why are some subtidal organisms found in a tide pool high on a rocky beach, while other subtidal forms are not?
8. Why do few benthic organisms live on a beach made of noncohesive sediments in a wave and surf area?
9. Discuss the importance of bacteria to benthic organisms.
10. Compare a square-meter area of deep-sea floor with a square-meter area of the rocky intertidal zone. What differences do you expect to find? Consider biomass, species abundance, and substrate.
11. How are coral reefs able to support a rich and varied population when the water surrounding the reef is clear and devoid of planktonic primary producers?
12. What is coral bleaching? Why does it happen? What is its result?
13. Compare the organisms found growing around deep-ocean hot-water vents and the organisms found around cold gas and oil seeps.
14. Discuss the genetic manipulation of fish and shellfish. Do the advantages of such techniques outweigh the possible disadvantages?
15. Compare photosynthesis and chemosynthesis; how are they similar and how are they different?



...consideration the distribution of Earth's surface area with latitude and the variation in heat loss and heat gain with latitude.

7. Why are regions of low barometric pressure and rising air noted for their excessive precipitation?
8. A frictionless projectile is fired from the North Pole and is aimed along the prime meridian. It takes three hours to reach its landing point, halfway to the equator. Where does it land? (Give latitude and longitude.) If the same projectile is fired from the South Pole under the same circumstances, where does it land? (Give latitude and longitude.)
12. Why are the westerlies of the Southern Hemisphere more consistent than the westerlies of the Northern Hemisphere?
13. What are the early signs that alert forecasters to the onset of an El Niño event?
14. In what way does the polar jet stream influence the transfer of heat from low to high latitudes?
15. How do hurricanes produce storm surges? Why is a storm surge more severe along a coast with a wide, shallow continental shelf than along a coast with a narrow continental shelf?
16. Why do the windward sides of the Hawaiian Islands receive more rain than the leeward sides?

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- Glaciology
- Severe Weather
- El Niño
- El Niño and the Southern Oscillation

web link Web links related to figures and boxed readings where this icon appears in text

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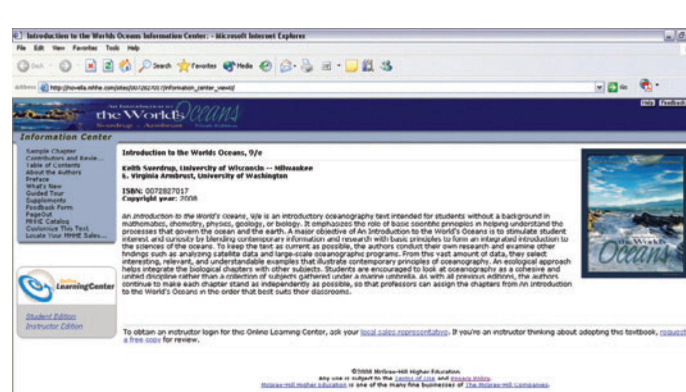

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