Oceanography is an interdisciplinary science

Many specialties, including:

- Marine geology ("jack of all geologic trades")
- Marine geophysics
- Marine biology
- Chemical oceanography
- Coastal engineering
- Limnology (study of fresh water lakes)
Earth, the water planet

• The planet Aqua: Earth is the only planet in the solar system with an abundance of liquid water on the surface.

• Earth has a fortuitous “Goldilocks” orbital distance from the Sun, allowing the fairly narrow temperature range (0 to 100°C. or 32 to 212°F.) of liquid water to exist.

• Early Earth was bone dry; water arrived from extraterrestrial sources; first oceans within 100 million years of its birth.

• Meteorites, asteroids, and comets containing vast quantities of water ice, violently bombarded earth from the outskirts of the solar system from 4.5 to 3.8 billion years ago.

• Water is also found on some moons of Jupiter and Saturn, with the possibility of liquid water being under the ice.
Earth – The Water Planet v2.0

The “Blue Marble”

Image: NASA
But, Earth’s oceans are a thin film

Drop on the planet: visualizing the Earth’s water

Water in, on, and above the Earth

- Liquid fresh water
- Freshwater lakes and rivers

Howard Perlman, USGS
Jack Cook, Adam Nieman
Data: Igor Shiklomanov, 1993
4 billion year old oceans?

- 4.4 billion year old zircon crystals found during 2005 in Australia are over half a billion years older than Earth’s oldest crust, and indicate oceans formed much earlier than once believed.
Oceans: The last frontier

- We know more about parts of the moon than about the deep oceans
- Only about 5% of the oceans have been explored and charted
- Manned deep ocean exploration is dangerous, due to physical, environmental, and technological barriers
- The deep ocean is dark, cold, and under high pressure
- Pressure of overlying water column on the ocean floor is 600 atmospheres; at the bottom of Mariana Trench is over 1000 atmospheres (15,000 lbs./inch^2)
- Due to salinity and pressure, deep ocean is as cold as 28°F.
- Manned mini-sub (submersibles), and robotic subs and probes with video cameras have done recent exploration.
• The oceans serve a number of important functions in regulating earth processes:
  
  ◆ Interaction with the atmosphere creates and influences weather patterns

  • A. **Waves** in water bodies are generated by winds that blow across the surface.

  • B. Oceans provide **humidity and moisture** to the air, greatly influencing weather. The most extreme example of this interaction is found in hurricanes, which are born over warm, tropical oceans. (The great lakes sometimes cause "lake effect" snow that is localized.)

  • C. Water "**smoothes outs**" drastic changes in **air temperature** because of its large heat absorbing capacity. This explains why Lake Michigan is cooler than the surrounding land during summer and warmer during winter.
The Importance of the Oceans

- Oceans are an **oasis of life on earth**, and they were the first cradle of life. The oceans provide an ideal environment suitable for a great diversity of living things.

- Oceans are a **carbon dioxide "sink"**- they regulate the amount of carbon dioxide in the atmosphere by dissolving large amounts of the gas in the water. The dissolved carbon dioxide, in turn, provides the raw material for sea creatures to build shell material (calcium carbonate), which also acts as a carbon dioxide sink. The oceans have played a key role in climate change through geologic time.
Mariana Trench: 36,201’ below sea level

- Located on western Pacific Ocean floor, east of the Philippines.
- Deeper than Mt. Everest is tall, by 7000 feet.
- Only two subs ever reached the Mariana Trench:
  1. In 1960, the Trieste, U.S. navy submarine, with two scientists aboard.
Wreck of HMS Titanic found by marine geologist Robert Ballard in 1986
Mid-Ocean Ridge Hydrothermal Vents (1977)

• Deep sea exploration by the submersible Alvin found deep-sea hydrothermal vents and surrounding biology communities based on chemosynthesis.

• Robert Ballard was a participating diver.
Earth Science, 11e

The Ocean Floor

Chapter 13
The vast world ocean

- Earth is often referred to as the blue planet
  - Seventy-one percent of Earth’s surface is represented by oceans and marginal seas
  - Continents and islands comprise the remaining 29%

- Northern Hemisphere is called the land hemisphere, and the Southern Hemisphere the water hemisphere
Views of the Northern and Southern hemispheres

Figure 13.1
The vast world ocean

Four main ocean basins

• Pacific Ocean - the largest and has the greatest depth
• Atlantic Ocean – about half the size of the Pacific and not quite as deep
• Indian Ocean – slightly smaller than the Atlantic, largely a southern Hemisphere body
• Arctic Ocean – about 7 percent the size of the Pacific
The oceans of Earth

Figure 13.2 B
Mapping the ocean floor

- **Bathymetry** – measurement of ocean depths and the charting of the shape or topography of the ocean floor

- **Echo sounder** (also referred to as *sonar*)
  - Invented in the 1920s
  - Primary instrument for measuring depth
  - Reflects sound from ocean floor
Echo sounder and multibeam sonar

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Figure 13.4 A
Mapping the ocean floor

- Multibeam sonar
  - Employs an array of sound sources and listening devices
  - Obtains a profile of a narrow strip of seafloor
- Measuring the shape of the ocean surface from space
Mapping the ocean floor

- Three major topographic units of the ocean floor
  - Continental margins
  - Ocean basin floor
  - Mid-ocean ridge
Major topographic divisions of the North Atlantic Ocean

Figure 13.8
Continental margins

- Passive continental margins
  - Found along most coastal areas that surround the Atlantic Ocean
  - Not associated with plate boundaries
    - Experience little volcanism and
    - Few earthquakes
Continental margins

- Passive continental margins
  - Features comprising a passive continental margin
    - Continental shelf
      - Flooded extension of the continent
      - Varies greatly in width
      - Gently sloping
      - Contains oil and important mineral deposits
**Continental margins**

- **Passive continental margins**
  - Features comprising a passive continental margin
    - Continental shelf
      - Some areas are mantled by extensive glacial deposits
      - Most consist of thick accumulations of shallow-water sediments
Continental margins

- Passive continental margins
  - Features comprising a passive continental margin
    - Continental slope
      - Marks the seaward edge of the continental shelf
      - Relatively steep structure
      - Boundary between continental crust and oceanic crust
Continental margins

- Passive continental margins
  - Features comprising a passive continental margin
    - Submarine canyons and turbidity currents
      - Submarine canyons
        - Deep, steep-sided valleys cut into the continental slope
        - Some are seaward extensions of river valleys
        - Most appear to have been eroded by turbidity currents
Continental margins

- Passive continental margins
  - Features comprising a passive continental margin
    - Submarine canyons and turbidity currents
      - Turbidity currents
        - Downslope movements of dense, sediment-laden water
        - Deposits are called turbidites
Turbidity currents

Figure 13.10
Continental margins

- Passive continental margins
  - Features comprising a passive continental margin
    - Continental rise
      - Found in regions where trenches are absent
      - Continental slope merges into a more gradual incline – the continental rise
    - Thick accumulation of sediment
    - At the base of the continental slope turbidity currents that follow submarine canyons deposit sediment that forms deep-sea fans
Features of a passive continental margin

Figure 13.9
Continental margins

- **Active continental margins**
  - Continental slope descends abruptly into a deep-ocean trench
  - Located primarily around the Pacific Ocean
  - Accumulations of deformed sediment and scraps of ocean crust form **accretionary wedges**
  - Some subduction zones have little or no accumulation of sediments
**Ocean basin floor**

- **Deep-ocean trenches**
  - Long, relatively narrow features
  - Deepest parts of ocean
  - Most are located in the Pacific Ocean
  - Sites where moving lithospheric plates plunge into the mantle
  - Associated with volcanic activity
    - Volcanic islands arcs
    - Continental volcanic arcs
An active continental margin

Figure 13.11
Ocean basin floor

- **Abyssal plains**
  - Likely the most level places on Earth
  - Sites of thick accumulations of sediment
  - Found in all oceans

- **Seamounts and guyots**
  - Isolated volcanic peaks
  - Many form near oceanic ridges
Ocean basin floor

- Seamounts and guyots
  - May emerge as an island
  - May sink and form flat-topped seamounts called guyots or tablemounts

- Mid-ocean ridge
  - Characterized by
    - An elevated position
    - Extensive faulting
    - Numerous volcanic structures that have developed on newly formed crust
Ocean basin floor

- Mid-ocean ridge
  - Interconnected ridge system is the longest topographic feature on Earth’s surface
    - Over 70,000 kilometers (43,000 miles) in length
    - Twenty-three percent of Earth’s surface
    - Winds through all major oceans
  - Along the axis of some segments are deep downfaulted structures called rift valleys
Ocean basin floor

- Mid-ocean ridge
  - Consist of layer upon layer of basaltic rocks that have been faulted and uplifted
  - Mid-Atlantic Ridge has been studied more thoroughly than any other ridge system
Seafloor sediments

- Ocean floor is mantled with sediment
- Sources
  - Turbidity currents
  - Sediment that slowly settles to the bottom from above
- Thickness varies
  - Thickest in trenches – accumulations may approach 10 kilometers
Seafloor sediments

- Thickness varies
  - Pacific Ocean – about 600 meters or less
  - Atlantic Ocean – from 500 to 1000 meters thick
- Mud is the most common sediment on the deep-ocean floor
Seafloor sediments

Types of seafloor sediments

- Terrigenous sediment
  - Material weathered from continental rocks
  - Virtually every part of the ocean receives some
  - Fine particles remain suspended for a long time
  - Oxidation often produces red and brown colored sediments
Seafloor sediments

Types of seafloor sediments

- Biogenous sediment
  - Shells and skeletons of marine animals and plants
  - Most common are calcareous oozes produced from microscopic organisms that inhabit warm surface waters
  - Siliceous oozes composed of skeletons of diatoms and radiolarians
  - Phosphate rich materials derived from the bones, teeth, and scales of fish and other marine organisms
Seafloor sediments

Types of seafloor sediments

- Hydrogenous sediment
  - Minerals that crystallize directly from seawater
  - Most common types include
    - Manganese nodules
    - Calcium carbonates
    - Metal sulfides
    - Evaporites
Distribution of marine sediments

Figure 13.17
Seafloor sediments

Distribution

- Coarse terrigenous deposits dominate continental margin areas
- Fine-grained terrigenous material is common in deeper areas of the ocean basin
- Hydrogenous sediment comprises only a small portion of deposits in the ocean
- There are a few places where very little sediment accumulates (Mid-ocean ridges)
Resources from the seafloor

- Energy resources
  - Oil and gas
  - Gas hydrates

- Other resources
  - Sand and gravel
  - Evaporative salts
  - Manganese nodules
Offshore oil drilling platform
Frozen methane hydrates
Seaside evaporative salt mining
Diatomaceous earth: fossilized diatoms
Manganese nodules on ocean floor