Chapter 1 Introduction to Planet "Earth"

Overview

- The world ocean is the most prominent feature on Earth.
- Oceans cover 70.8% of Earth's surface.
- The origin and development of life on Earth are connected to the ocean.
- · The oceans have a long history on Earth.

Earth's Oceans

- Oceans dominate Earth's surface
- Earth's largest habitat
- 97.2% of Earth's surface water



Earth's Oceans

- Earth has one ocean.
- Divided into four principal oceans and one other.
 - Pacific Ocean
 - Atlantic Ocean
 - Indian Ocean
 - Arctic Ocean
 - Southern, or Antarctic, Ocean





Earth's Oceans

Pacific Ocean

- World's largest ocean
 - · Accounts for more than half of Earth's ocean space
- World's deepest ocean
- Earth's largest geographic feature
- Named in 1520 by Ferdinand Magellan

Earth's Oceans

Atlantic Ocean

- Half the size of the Pacific Ocean
- Shallower than the Pacific Ocean
- Separates the Old World from the New World

Indian Ocean

- Smaller than the Atlantic Ocean
- Similar depth as the Atlantic Ocean
- Primarily in the Southern Hemisphere

Earth's Oceans

Arctic Ocean

- Seven percent the size of the Pacific Ocean
- Shallowest world ocean
- Permanent layer of sea ice a few meters thick

Southern Ocean or Antarctic Ocean

- Circumnavigates Antarctica
- Is really the parts of the Pacific, Atlantic, and Indian Oceans that lie south of 50°S latitude

The Seven Seas

- Smaller and shallower than oceans
- · Salt water
- · Usually enclosed by land
 - Sargasso Sea defined by surrounding ocean currents
- · Directly connected to the ocean

The Seven Seas

- Before the 15th century, Europeans considered the seven seas to be the following:
 - Red Sea
 - Mediterranean Sea
 - Persian Gulf
 - Black Sea
 - Adriatic Sea
 - Caspian Sea
 - Indian Ocean

Ancient Seven Seas Map



Comparing Oceans to Continents

- Average ocean depth is 3682 meters (12, 080 feet)
- Average continental elevation is 840 meters (2756 feet)
- Deepest ocean trench is the Mariana Trench at 11,022 meters (36,161 feet)
- Highest continental mountain is Mt. Everest at 8850 meters (29,035 feet)

Early Exploration of the Oceans

From here to slide #30 (Oceanography Continues) Section 1.2 of your textbook is summarized but not discussed in class – Please read it and Review questions 1 – 3 in the Concept Check of page 15

- Early explorers used boats to seek new fishing grounds for food.
- The ocean facilitated trade and interaction between cultures.

Pacific Navigators



Pacific People

- No written records exist of Pacific human history before the 16th century.
- Archeological evidence suggests island occupation by people from New Guinea as early as 4000–5000 B.C.

Pacific People

• **Thor Heyerdahl** sailed on a balsa raft - the **Kon** *Tiki* - to demonstrate migration of South Americans to Pacific Ocean islands.



European Navigators

- **Phoenecians** first from Western Hemisphere to develop navigation arts
 - Navigated circa 2000 B.C.
 - Explored Mediterranean Sea, Red Sea, and Indian Ocean
 - First circumnavigation of Africa
 - Reached the British Isles

European Navigators

- Greek Pytheas
 - Sailed northward using a simple method to determine latitude in 325 B.C.
 - Navigated using the North Star
- **Eratosthenes** determined Earth's circumference fairly accurately.

Europeans

- Herodotus produced inaccurate world map around 450 B.C.
- Claudius Ptolemy produced fairly accurate world map around 150 A.D.
 - Erroneously updated Eratosthenes' original circumference estimation, later causing Christopher Columbus to believe he had reached Asia



The Middle Ages

- Arabs dominant navigators in the Mediterranean Sea
- Traded extensively with East Africa, India, and Southeast Asia
- Learned to use Indian Ocean monsoon winds for travel

The Middle Ages

- Vikings explored North Atlantic Ocean
 - Settled Iceland and Greenland in 9th and 10th centuries A.D.
 - Leif Eriksson designated part of eastern Canada Vinland (now Newfoundland) in 995 A.D.
 - Greenland, Vinland settlements abandoned by 1450 A.D. due to climatic cooling

The Middle Ages

- Other Viking explorers
 - Erik "the Red" Thorvaldson discovered Greenland
 - Bjarni Herjólfsson first to find Newfoundland



The Age of Discovery in Europe 1492–1522

- Search for new Eastern trade routes by sea
 - Prince Henry the Navigator of Portugal sought trade routes around Africa.
 - Europeans explore North and South America.
 - Christopher Columbus was financed by the Spanish to find new trade routes to Asia.

The Age of Discovery in Europe 1492–1522

- Spaniard Ferdinand Magellan circumnavigated the globe.
 - Was killed on a Pacific Island in 1521
- Juan Sebastian del Caño completed the circumnavigation in 1522.
- Voyages paved the way for the Spanish to take gold from the Incas and Mayas.
- Spain's maritime dominance ended when England defeated the **Spanish Armada** in 1588.



Voyages of Columbus and Magellan

The Age of Discovery in Europe 1492–1522

- Italian Giovanni Caboto, also known as John Cabot - landed on northeastern coast of North America.
- Vasco Nuñez de Balboa attempted land crossing at Isthmus of Panama.

Voyaging for Science

- The English wanted to retain maritime superiority.
- Captain James Cook (1728–1779) undertook three scientific voyages.
 - Ships HMS Endeavour, Resolution, Adventure
 - Mapped many islands in Pacific
 - Systematically measured ocean characteristics
 - Marine chronograph (longitude)



Oceanography Continues

- · More high-technology tools available today
 - Sonar
 - Robotics
 - Computers
 - Satellites
- NOAA National Oceanographic and Atmospheric Administration





Nature of Scientific Inquiry

- Natural phenomena governed by physical processes
- Physical processes similar today as in the past
- Scientists discover these processes and make predictions.
- Called the scientific method



Theories and Truth

- · Science never reaches absolute truth.
- Truth is *probable* and based on available observations.
- · New observations yield scientific progress.
- · In reality, scientists have no formal method.
- **Theory** well-substantiated explanation of some aspect of the natural world.

Formation of Earth and the Solar System

- Nebular hypothesis all bodies in the solar system formed from nebula
 - Nebula = cloud of gases and space dust
 - Mainly hydrogen and helium



Nebular Hypothesis

- Gravity concentrates material at center of cloud (Sun).
- Protoplanets form from smaller concentrations of matter (eddies).



Protoearth

- · Larger than Earth today
- Homogeneous composition
- · Bombarded by meteorites
 - Moon formed from collision with large asteroid.



Protoearth

- Radioactive heat
 - Spontaneous disintegration of atoms
 - Fusion reactions
- Heat from contraction (protoplanet shrinks due to gravity)
- · Protoearth partially melts
- Density stratification (layered Earth)

Solar System Today



Density Stratification

- High density = heavy for its size
- Early Earth experienced gravitational separation.
 - High-density materials (iron and nickel) settled in core.
 - Less dense materials formed concentric spheres around core.

Earth's Internal Structure

- · Layers defined by
 - Chemical composition
 - Physical properties

Layers by Chemical Composition

- Crust
 - Low-density, mainly silicate minerals
- Mantle
 - Mainly iron (Fe) and magnesium (Mg) silicate minerals
- Core
 - High-density, mainly iron (Fe) and nickel (Ni)

Layers by Physical Properties

- Lithosphere
- Asthenosphere
- Mesosphere
- Outer core
- Inner core



Lithosphere

- Cool, rigid shell
- · Includes crust and upper mantle
- About 100 km (60 miles) thick

Asthenosphere

- · Relatively hot, plastic
- · Flows with high viscosity
 - Important for movement of lithospheric plates
- Base of lithosphere to about 700 km (430 miles) deep

Internal Structure of Earth



Continental vs. Oceanic Crust

SmartTable 1.1 comparing oceanic and continental crust		
	Oceanic crust	Continental crust
Main rock type	Basalt (dark-colored igneous rock)	Granite (light-colored igneous rock)
Density (grams per cubic centimeter)	3.0	2.7
werage thickness	8 kilometers (5 miles)	35 kilometers (22 miles)

Isostatic Adjustment

- Vertical movement of Earth's crust
- · Buoyancy of lithosphere on asthenosphere
 - Less dense continental crust floats higher than denser oceanic crust.
- **Isostatic rebound** rising of crust formerly weighed down by glacier ice

Isostatic Adjustment



Origin of Earth's Atmosphere

- Outgassing occurred during density stratification
 - Water vapor
 - Carbon dioxide
 - Hydrogen
 - Other gases
- · Earth's early atmosphere different from today

Origin of Earth's Oceans

- Outgassed water vapor fell as rain.
- The first permanent oceans formed 4 billion years ago.
- Salinity developed from dissolved rock elements.
 - Early acidic rain dissolved more crustal minerals than today.

Development of Earth's Oceans



Life's Possible Ocean Origins

- Earth's earliest known life forms are 3.5-billion-year-old bacteria fossilized in ocean rocks.
- These are the building blocks for life on early Earth.
- There is no direct evidence of early Earth's environment.

Oxygen

- Humans require O₂.
- Ozone (O₃) protects from ultraviolet radiation.
- · Early Earth had little free oxygen.
- The lack of ozone may have helped originate life.

Stanley Miller's Experiment

• Organic molecules formed by ultraviolet light, electrical spark (lightning), and a mixture of water, carbon dioxide, hydrogen, methane, and ammonia

Evolution and Natural Selection

- · Organisms adapt and change through time.
- · Advantageous traits are naturally selected.
- Traits are passed to the next generation.
- · Organisms adapt to environments.
- Organisms can modify environments.

Plants and Animals Evolve

Heterotrophs

- Very earliest life
- Require external food supply

Autotrophs

- Evolved later
- Manufacture own food supply

First Autotrophs

- Probably similar to modern anaerobic bacteria
 Survive without oxygen
- Chemosynthesis from chemicals at deep hydrothermal vents
- Supports idea of life's origins on deep ocean floor in absence of light

Photosynthesis and Respiration

- · Complex autotrophs developed chlorophyll.
- This allowed the use of the Sun for photosynthesis.
- Cellular respiration

Photosynthesis and Respiration



Great Oxidation Event

- 2.45 billion years ago
- Increased oxygen and ozone eliminated the anaerobe food supply.
- · Light and oxygen kill anaerobes.
- · Cyanobacteria adapted and thrived.

Plants and Earth's Environment



Changes to Earth's Atmosphere

- Photosynthetic organisms are responsible for life as we know it today.
- Reduce CO₂, increase O₂ to 21%
- High oxygen = biodiversity increase
- Low oxygen associated with extinction events



Geologic Time Scale

