1 **CHAPTER 1**

Introduction to Planet Earth

2 **"oceanography"? not just descriptive - should be: *oceanology*!**

a little oceanography haiku:

3 **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.

4 **Earth's Oceans**

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

5 **Earth's Oceans**

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9 **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

10 **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

11 **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

12 **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

13 **The Seven Seas**
- Before the 15th century, Europeans considered the seven seas to be the following:
  1. Red Sea
  2. Mediterranean Sea
  3. Persian Gulf
  4. Black Sea
  5. Adriatic Sea
  6. Caspian Sea
  7. Indian Ocean

14 **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)

15 **Early Exploration of the Oceans**
- Early "explorers" used boats to seek new fishing grounds for food.
- The ocean facilitated trade and interaction between cultures.

16 **Pacific Navigators**
- The peopling of the Pacific Islands required extensive travel in open boats and exceptional navigation skills.
- It was difficult because islands are widely scattered.

17 **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.
- Thor Heyerdahl sailed on a balsa raft – the *Kon Tiki* – to demonstrate migration of South Americans to Pacific Ocean islands.

18 **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

19 **European Navigators**
- Greek Pytheas
  - Sailed northward using a simple method to determine latitude in 325 B.C.
  - Navigated using the North Star

20 **European Navigators**
- *Eratosthenes* (276 – 195 B.C.) determined Earth's circumference fairly accurately.

21 **Europeans**
- Herodotus produced inaccurate world map around 450 B.C.

22 **Europeans**
- *Claudius Ptolemy* - fairly accurate world map around 150 A.D.
  - Erroneously updated Eratosthenes' original circumference estimation, later causing Christopher Columbus to believe he had reached Asia

23 **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

24 **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

25 **Viking Routes and Colonies**

26 **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.
    - Englishman John Cabot arrived in northeast North America in 1497.

27 **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.

28 **Voyages of Columbus and Magellan**

29 **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)
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30 **Cook's Voyages**

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32 **Oceanography**

- Further studies in the mid- to late-1800's:
  - U.S. Exploring Expedition (Maury)
    - First physical oceanographer?
  - Darwin (including HMS Beagle)
    - Corals, atolls, volcanic islands
  - H.M.S. Challenger
    - First cruise devoted to oceanography
    - Forbes' theory of "azoic" zone
    - 50 folio volumes, still used today
    - Ended in 1876, but no follow-up…

33 **Voyage of the Beagle**

34 **Oceanography Continues**

- More high-technology tools available today
  - Sonar
  - Robotics

- Computers
- Satellites

35 **Shore Stations**
- Stazione Zoologica, Naples
  - Established in 1872
- Scripps Institution of Oceanography
  - Ritter, Scripps meet in 1903
  - Property sold to U.C. in 1912 for $10
- Woods Hole Oceanographic Institute
  - Self-contained, not affiliated with another university
  - Incorporated in 1930

36 **Bathysphere**
- William Beebe, 1934
- Record depth: 923 meters

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38 **Alvin**
- Robert Ballard, 1964
- Discovered:
  - Hydrothermal vents (1977)
  - Wreck of the Titanic (1985)
- Mother ship: *Atlantis*
- Frequently visits San Diego

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40 **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
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41 **The Scientific Method**

42 **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.

43 **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

44 **Nebular Hypothesis**
- Gravity concentrates material at center of cloud (Sun).
- Protoplanets form from smaller concentrations of matter (eddies).
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45 **Nebular Hypothesis of Solar System Formation**

46 **Relative positions and orbits of the planets**
- Plus the newly-designated “dwarf planet”

47 **Relative actual sizes of the planets**
- Minus you-know-who...

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49 **Protoearth**
- Larger than Earth today

- Homogeneous composition
- Bombarded by meteorites
  - Moon formed from collision with large asteroid.

50 **Artist's Conception of Protoearth**

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

52 **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.

53 **Earth's Internal Structure**

Layers defined by

1. Chemical composition
2. Physical properties

54 **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)

55 **Layers by Physical Properties**

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

56 **Lithosphere**

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

57 **Continental vs. Oceanic Crust**

58 **Asthenosphere**

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

59 **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

60 **Isostatic Adjustment**

61 **Origin of Earth's Atmosphere**

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

62 **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.

63 **Development of Earth's Oceans**

64 **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.

65 **Oxygen**

- Humans require O_2.
- Ozone (O_3) protects from ultraviolet radiation.
- Early Earth had little free oxygen.
- The lack of ozone may have helped originate life.

66 **Stanley Miller's Experiment**

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

67 **Stanley Miller and His Experiment**

68 **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.

69 **Plants and Animals Evolve**

- Heterotrophs
  - Very earliest life
  - Require external food supply
- Autotrophs
  - Evolved later
  - Manufacture own food supply

70 **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

71 **Photosynthesis and Respiration**

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

- Cellular respiration

72 **Photosynthesis and Respiration**

73 **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.

74 **Changes to Earth's Atmosphere**

- Photosynthetic organisms are responsible for life as we know it today.
- Reduce CO_2, increase O_2 to 21%
- High oxygen = biodiversity increase
- Low oxygen associated with extinction events

75 **Plants and Earth's Environment**

76 **Age of Earth**

- Radiometric age dating
  - Spontaneous change/decay
  - Half-life
- Earth is about 4.6 billion years old.

77 **Radioactive Decay**

78 **Radioactive Decay**

79 **Geologic Time Scale**

80 **End of CHAPTER 1 –**
Introduction to Planet "Earth"