Environmental Geology

James Reichard

Chapter 1
Humans and the Geologic Environment
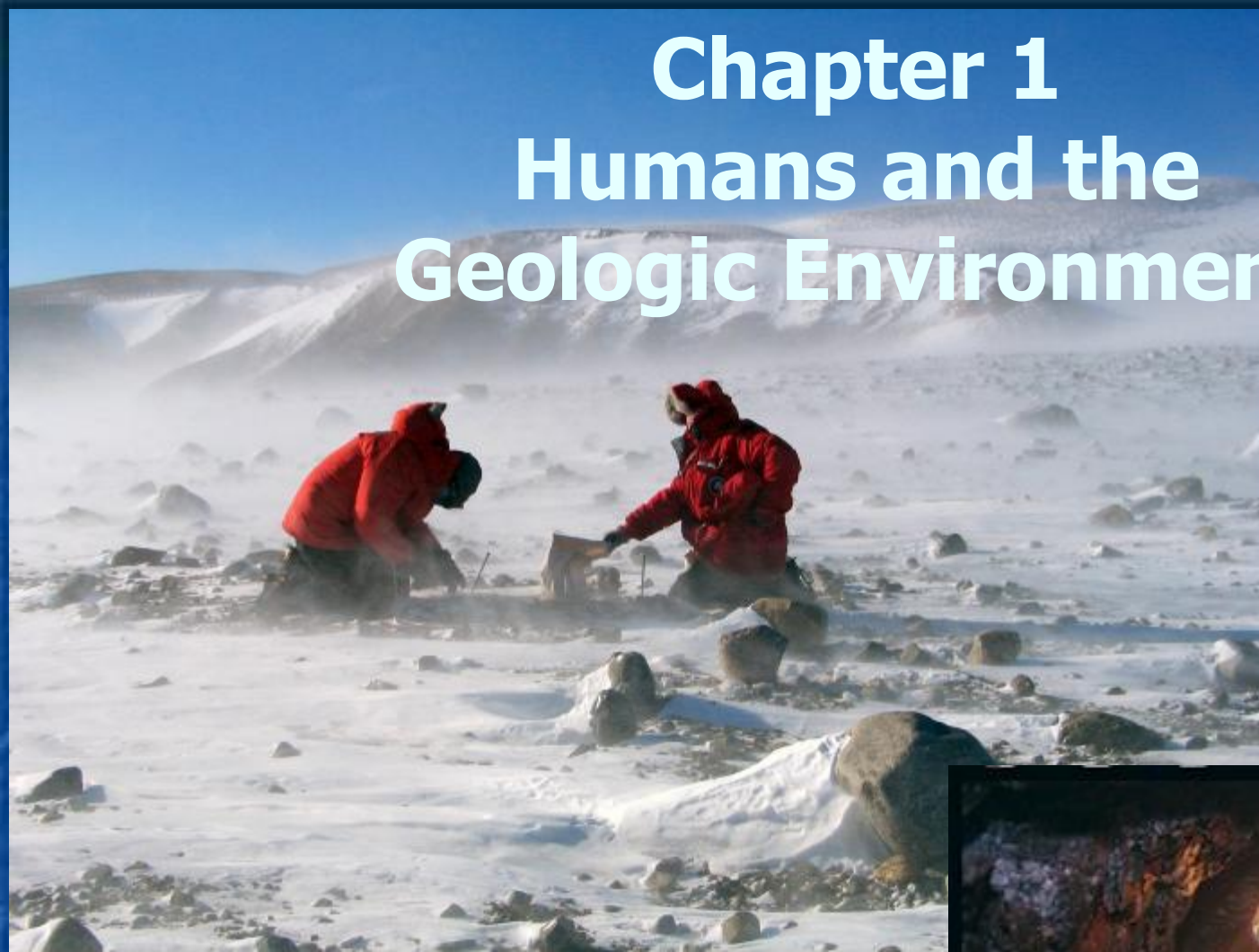
Earth

- 4.6 Billion Years Old
- Only planet in solar system with thriving life (or life at all)
- *Homo sapiens* only home

What Makes Earth Unique

- Right conditions for life
- Liquid, frozen and gas state water
- Earth can hold its atmosphere
- Natural processes for removing CO_2
- But, humans are using natural resources and interacting with geologic processes
- Geologic processes include volcanic eruptions, floods, landslides, earthquakes, etc

What Is Geology?

- The study of the solid Earth, its composition and how formed
- Both materials (metals, minerals, fossils fuels) and processes (floods, volcanic eruptions, landslides)
- Geologists study how mineral forms, locate fossil fuel deposits, study hazardous Earth processes

Two Main Branches of Geology

1. Physical Geology
   - Studies processes that shape and modify the Earth
2. Historical Geology
   - Interprets the geologic rock record – "geologic time"
   - New sub discipline: Environmental Geology
     - Uses geology to solve problems between humans and the environment

How Science Operates

The Scientific Method

1. Gather data from observations or experiments
2. Develop hypothesis to explain data
   - Can have more than one hypothesis – "multiple working hypotheses
3. Test hypothesis
   - Extensive testing yields supporting data, develop theory
4. Theory
   - After more supporting data, develop law
5. Law - Law of gravity for example

The Scientific Method
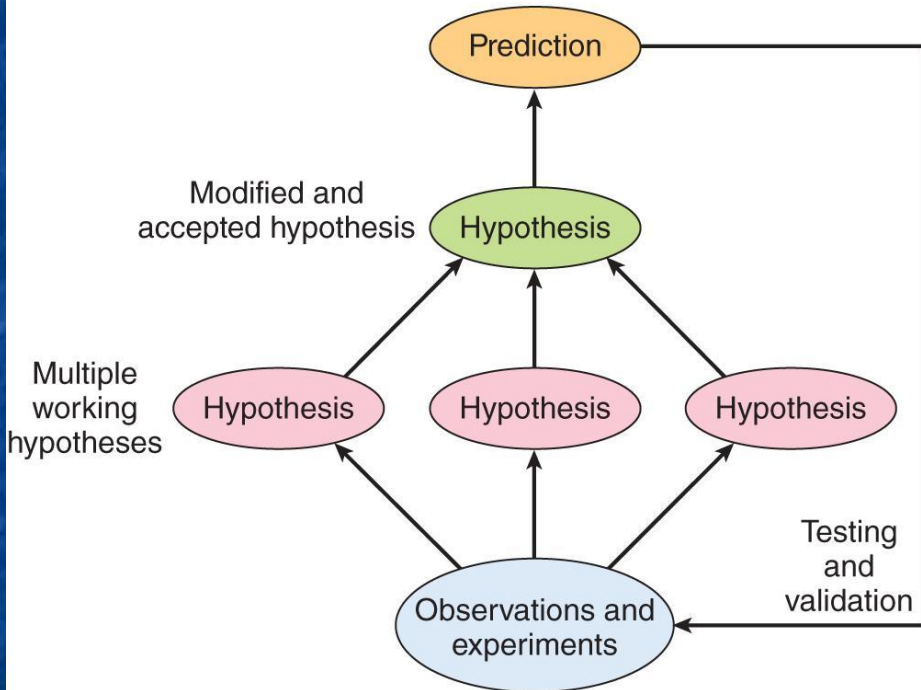
Fig 1.5 pg 8
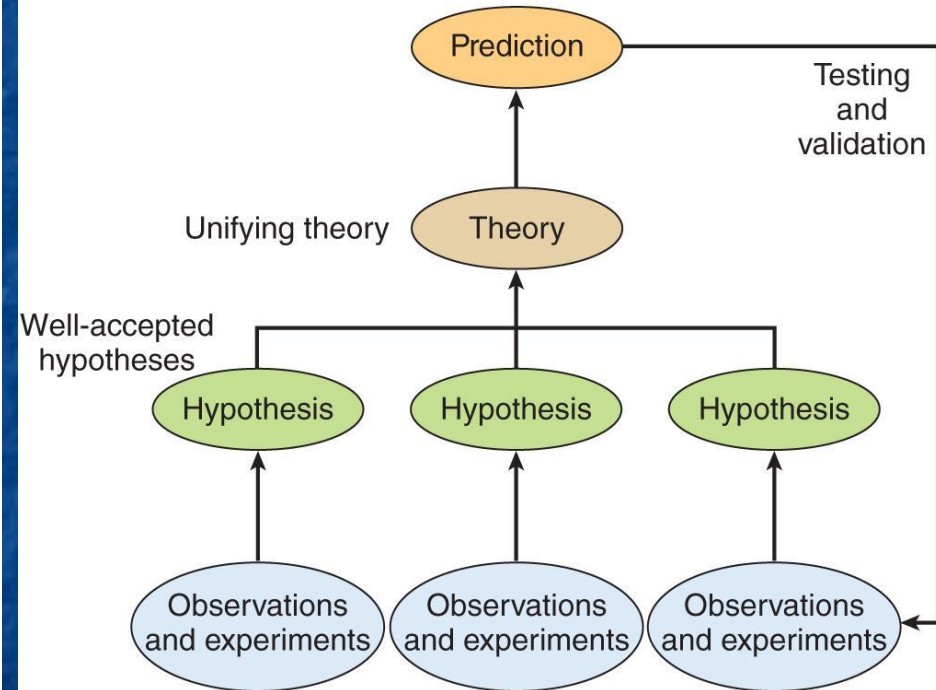
Fig 1.6 pg 9

Environmental Geology

- Solves problems between humans and the environment
- Two categories of environmental problems related to geology
    - Geologic hazards – any geologic condition that creates potential risk to human life or property, for ex. Earthquakes, volcanic eruptions, floods, pollution
    - Earth resources – water, soil, minerals and energy

Environmental Geology

Geologic hazards
1. Natural
   - Earthquakes, volcanic eruptions
2. Artificial
   - Pollution – impacts human health and ecosystems
   - Human interference

Environmental Geology

Earth's Resources – water, soil, mineral and energy resources.

1. Renewable
   - Soil and water
2. Nonrenewable
   - Minerals and rock
   - Energy – fossil fuels

Geologic Time

- Classifies all rocks by relative or chronological age
  - Law of Superposition- in horizontal sediments, the rocks at the bottom or deepest are the oldest, youngest are at the top

  - Geologic Time Scale- Chart of relative ages of all the rocks.

Geologic Time

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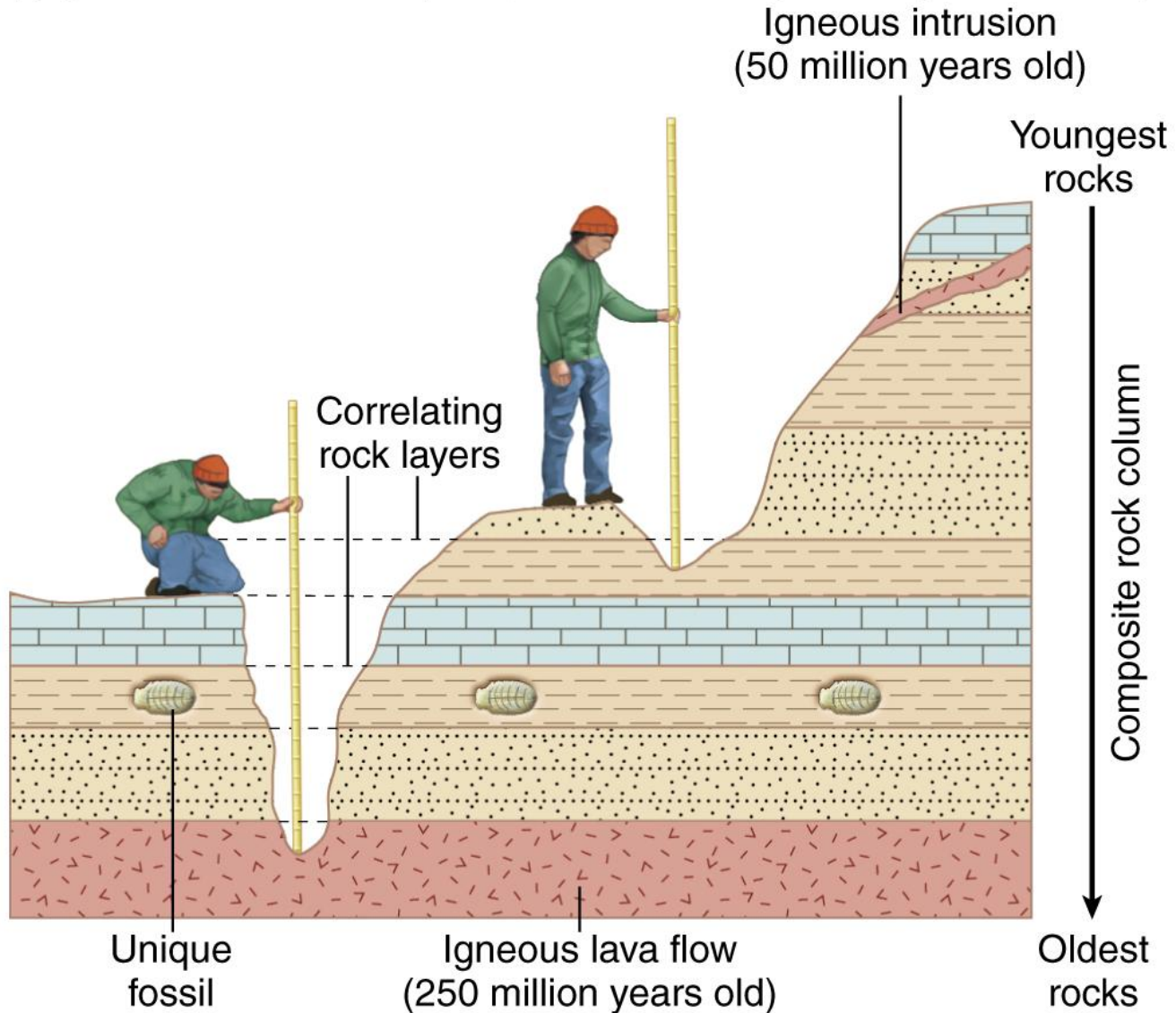
Igneous intrusion
(50 million years old)

Youngest rocks

Correlating rock layers

Composite rock column

Unique fossil

Igneous lava flow
(250 million years old)

Oldest rocks

Fig 1.10 pg 14

Geologic Time Scale
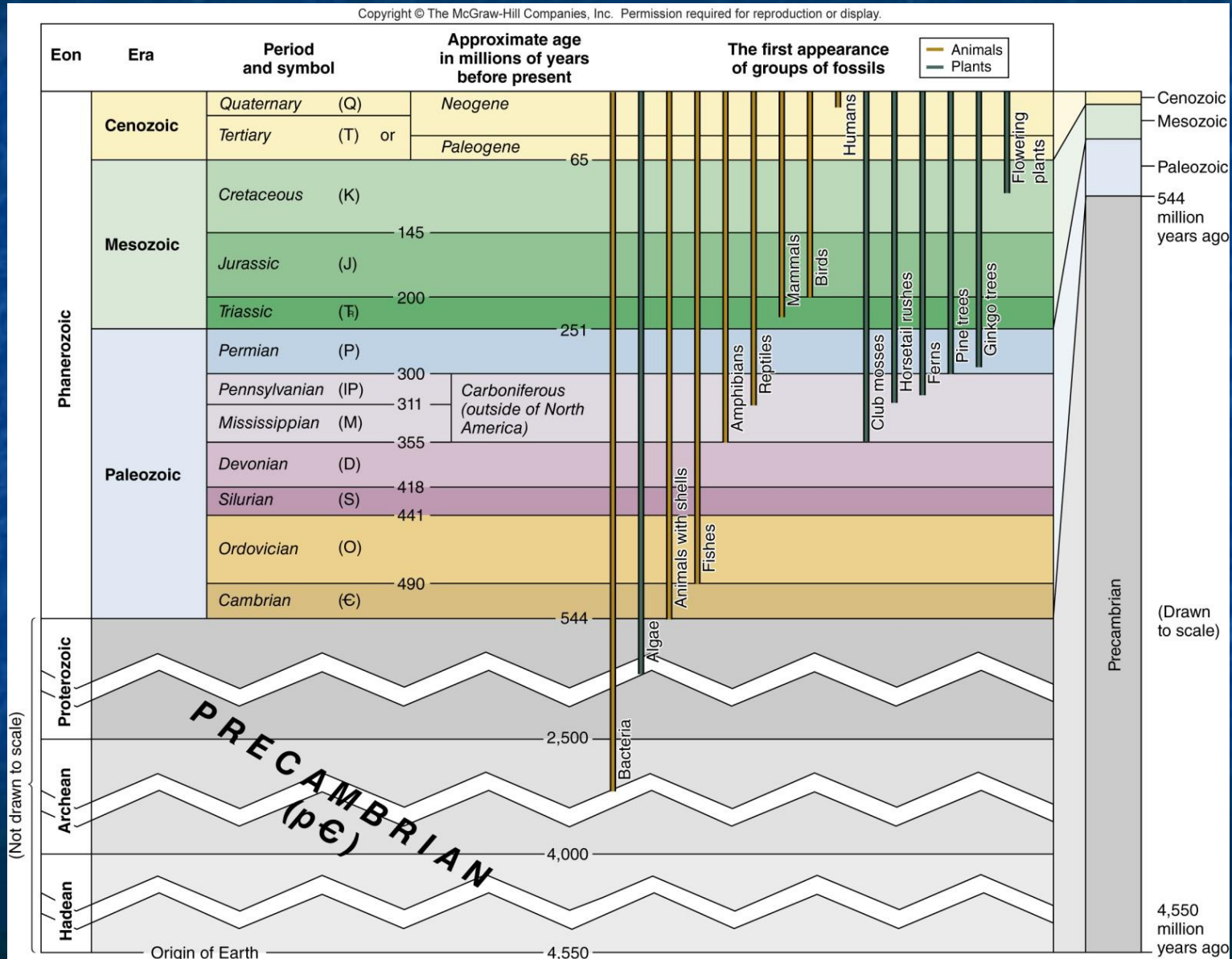
Fig 1.11
pg 15

Geologic Time

- Absolute age in years
    - Quantified date, actual number of years old
    - Uses radiometric dating – dating technique involving any type of radioactive element and its decay product
        - Radioactive decay of isotopes
        - Half life (decay rate) – time it takes half the parent isotope to decay into the daughter product
        - Example – Uranium atoms decay into lead atoms at a dependable rate; nearly all igneous rocks contain uranium

An Easier Look at Earth's History

TABLE 1.1   Milestones in Earth's 4.6-billion-year history as represented on a compressed calendar year consisting of 365, 24-hour days.

Beginning of Earth history	January 1
Oldest surviving rocks	Middle February
Oldest fossils—single-cell cyanobacteria	Early March
First fossils of animals with hard body parts	Middle October
First dinosaur fossils	December 11
Last dinosaur fossils	December 26
First modern human fossils	23 minutes before midnight, December 31
Egyptian civilization	35–14 seconds before midnight
Roman civilization	18–11 seconds before midnight
Columbus arrives in North America	3.5 seconds before midnight
Past 20 years	0.14 seconds before midnight

Environmental Risk and Human Reaction

Environmental Risk

- Chance that natural event will be negative for an individual or society
- Risk = (probability of event) x (expected consequences)

Environmental Risk and Human Reaction

- Natural geologic processes
  - Incremental
    - Slow but constant – for ex, uplifting of tectonic plates creating mountain, erosion of sedimentary rocks in Grand Canyon
  - Sporadic
    - Random discrete events – for ex, volcanic eruption, floods, earthquakes

Earth as a System

Four major systems that are interlinked:

1. Atmosphere
2. Hydrosphere
3. Biosphere
4. Lithosphere (solid Earth)

Earth as a System

Mixture of gases surrounding Earth

Atmosphere

Hydrosphere

Biosphere

All waters of Earth, including subsurface and atmospheric water

Living organisms of Earth, including those on the land and in the water, air, and subsurface

Geosphere

Solid portion of Earth composed of rocks and minerals
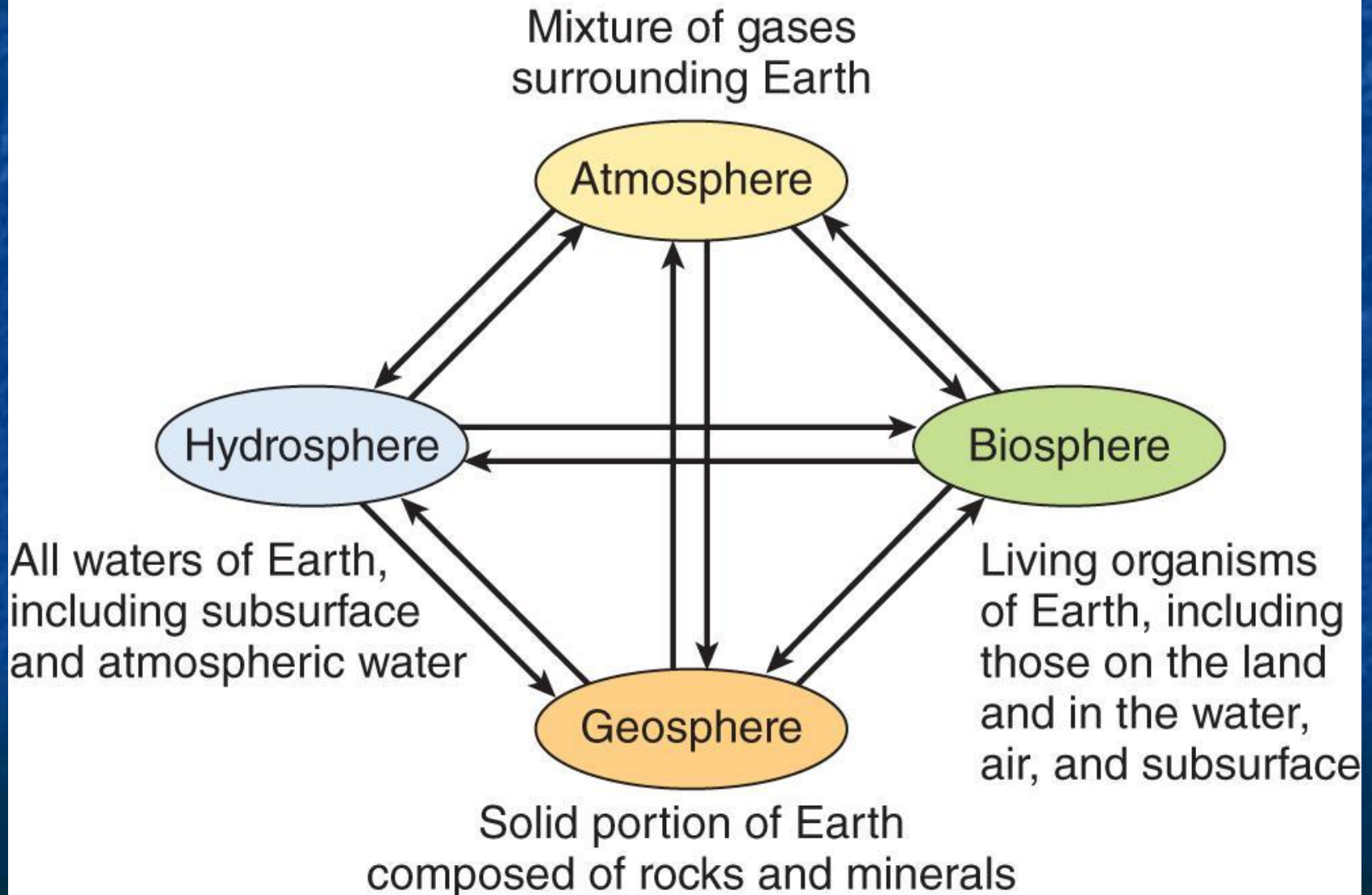
Earth and Human Population

- Humans are part of the biosphere

- We interact with the other three spheres

- Increasing population causes more interference with the other three spheres
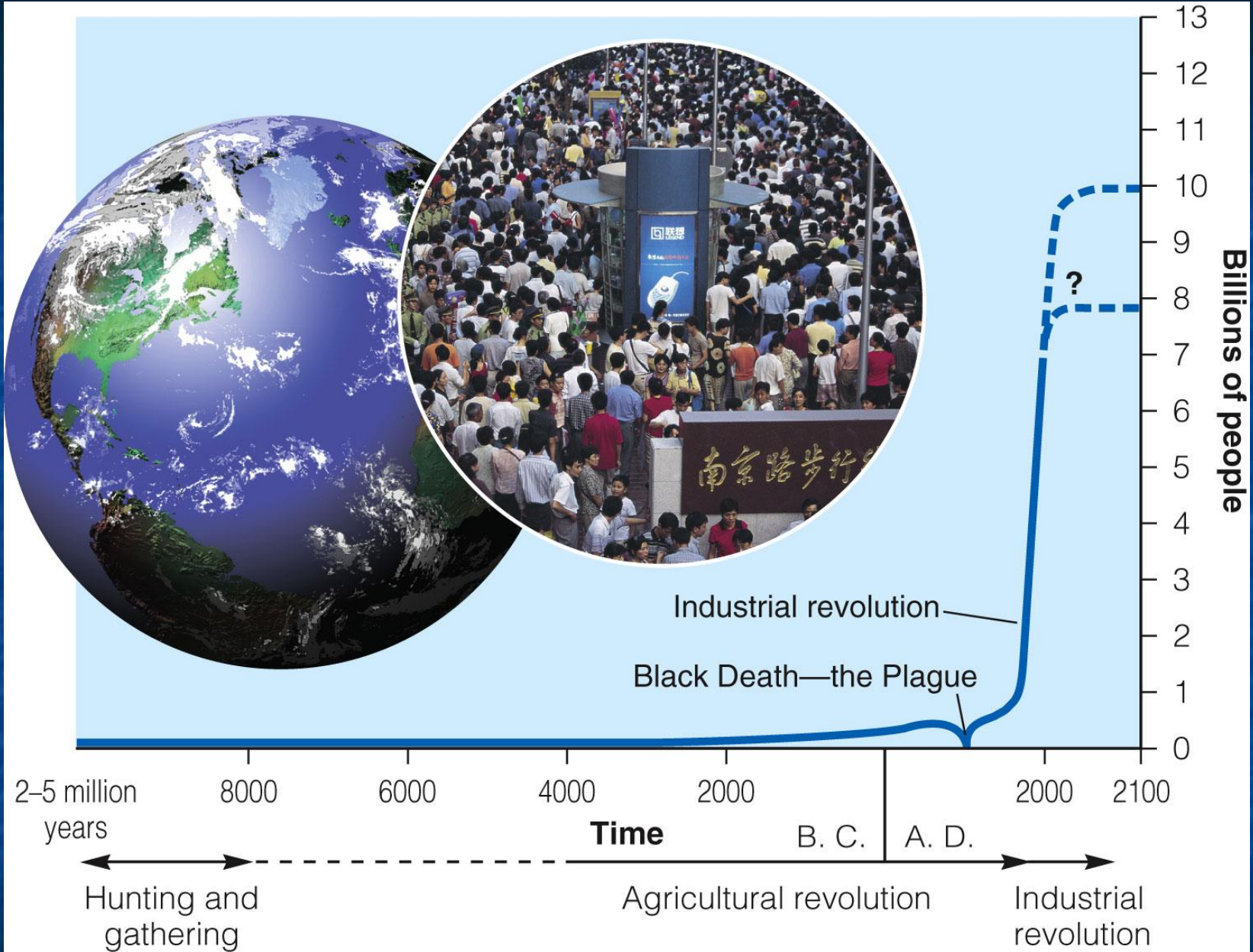
Population Growth

- Linear
  - Added, straight line
  - Slow and steady

- Exponential
  - Multiplied, nonlinear
  - Increases greatly over time

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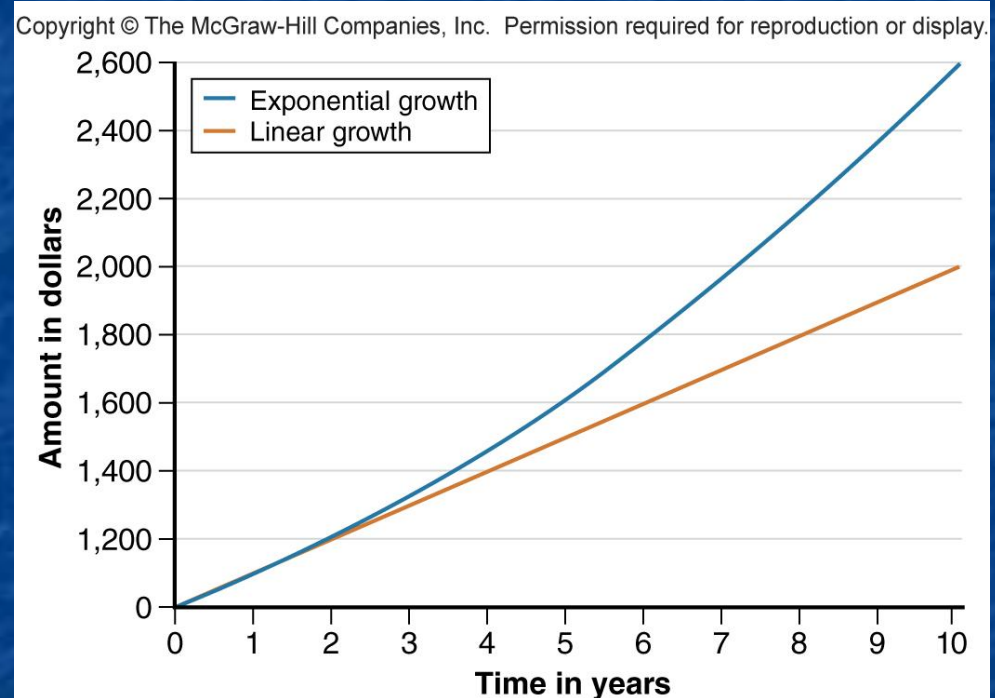
Limits to Growth

- Limit to how many people Earth can support first in 1687 by Antoni van Leeuwenhoek

- 1798 Thomas Malthus
  - Population growth exponential
  - Food production linear
  - Food production controls population
  - To date, food production has kept up with demand. . . But are we feeding everyone??

Industrial revolution

Black Death—the Plague

Billions of people

| 2–5 million years | 8000 | 6000 | 4000 | 2000 | | 2000 | 2100 |

Time   B. C. | A. D.

Hunting and gathering

Agricultural revolution

Industrial revolution

Sustainability

- Being able to maintain a system or process for an indefinite period of time

- Sustainable society
  - Lives within the Earth's capacity to provide resources for future generations
  - Natural systems operate this way

Population Growth Pyramids

- <u>Pop growth</u> affected by birth and death rates
- More births than deaths = growth
- More deaths than births = decline
- If births and deaths roughly equal = equilibrium
- Countries in <u>demographic transition</u> are changing from high birth rate, high death rate to lower birth and lower death rates

Demographic Transition

Transition has to do with industrialization, standard of living and empowerment of women to choose how many children to have, access to birth control.

Population growth of humans affects the environment and wildlife thus human population growth is a huge issue in biology and environmental science.

Age structure graphs allow countries to predict how they are growing so they can provide social services to changing populations — they are planning tools.

Demographic Transition

o For example, <u>booming levels of school age children</u> means you need more access to vaccines, day cares, schools, health care clinics.

o If you have an <u>aging population</u>, you might need more health care professionals and nursing homes but fewer schools.

o If there are <u>more young people/young adults</u>, you could put funding into providing education and job training for those people rather than services for the really young or elderly

Age Structure Pyramids

o <u>Rapid growth</u> =large numbers of children and teenagers creating a population boom, small numbers of old people due to early deaths, India, China, most of Africa, Afghanistan , Mexico (pyramid skinny of top)

o <u>Slow growth</u> = growing but more even numbers in age categories, many in reproductive age, more old people,

o <u>No Growth</u> = declining population numbers, not having children at a replacement rate, numbers even across all age categories, most of Europe

Age Structure Pyramids - Population Planning Tools
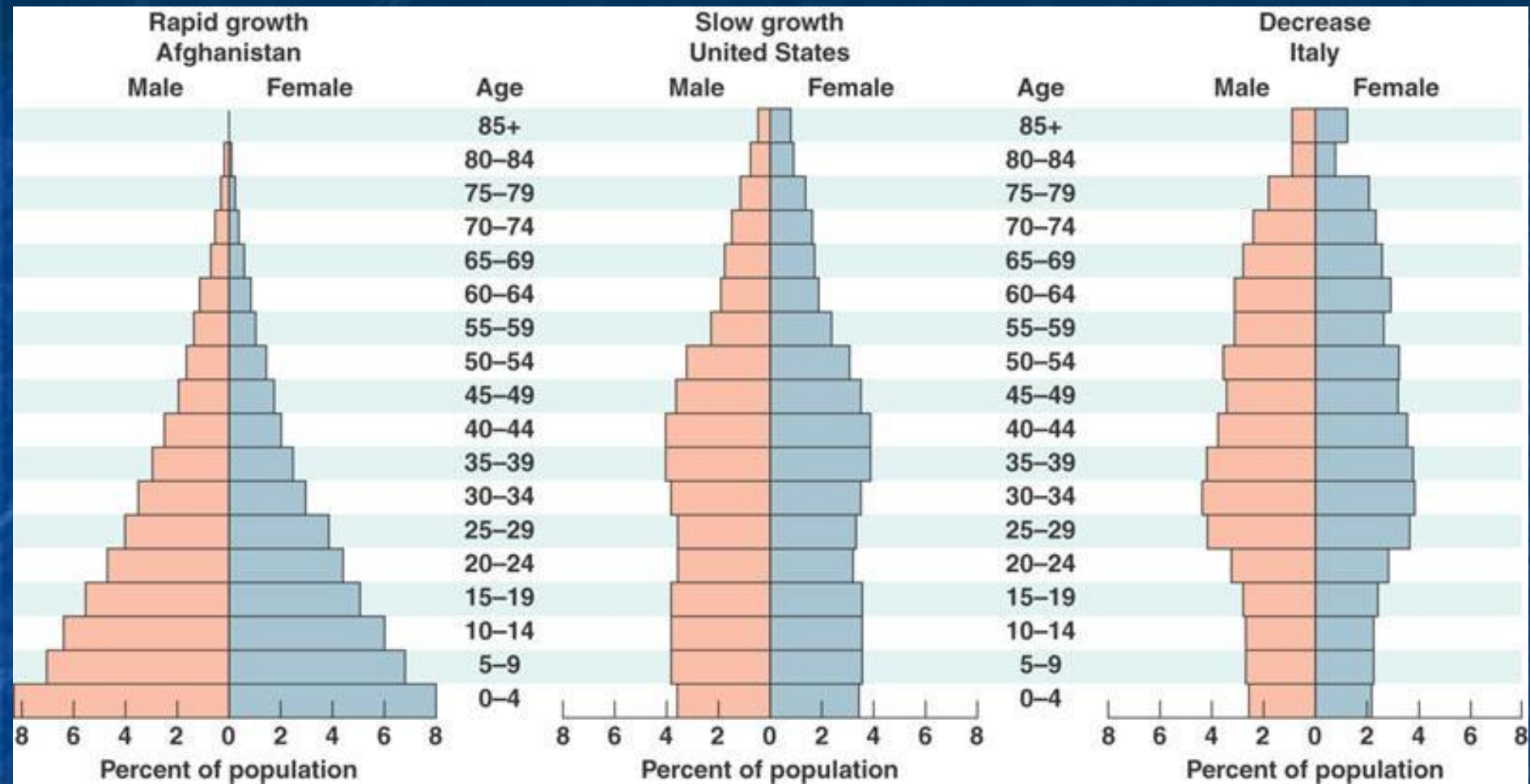
Notice overall shapes of each age structure pyramid, also notice that you can see how many males and females in each age category.

Ecological Footprint

- Biologically productive land/sea area needed to support lifestyle of humans

  - 6 acres per person global average
  - 10 for a Swiss
  - 4 for a Chinese
  - 24 for an American

Easter Island Case Study 1.1

- Dutch sailors first discovered it in 1722 and estimated there were 2,000 inhabitants

- By then no trees, canoes were leaky and made of planks and scraps

- Huge statues weighing several tons lined the island

Easter Island Case Study 1.1

- Archaeologists have learned that human activity began 400 – 700 AD
- Population may have been up to 20,000
- Pollen record shows shrubs, trees and wetlands had been present
- Diet had consisted of dolphins, birds and nuts
- After 1400 AD palm tree was extinct on the island
- By 1500, no more bird or dolphin bones

Environmentalism

- Awareness and environmental movements began in 1960s and 70s.
- 1962 Rachel Carson's book *Silent Spring*
- Pollution was having visible negative effects on water, beaches, recreational sites and air.
- Clean Air Act 1970
- Clean Water Act 1972

Chapter 1 Quiz

- On Bb in "Quizzes" folder.
- Can take 3 times, highest score recorded