# Chapter 1

# Introduction to Physical Geology

# Geology Is:

- the study of planet Earth,
- the materials of which it is made,
- the physical and chemical processes that act on these materials, and
- the history of the Earth and its inhabitants

# I. Who Needs Geology?

- Avoiding Geologic Hazards
- Supplying Things We Need
- Protecting the Environment
- Understanding Our Surroundings

# Practical Aspects

- *Natural Resources*
  - All manufactured objects depend on Earth's resources
  - Local concentrations of resources
    - mined or extracted
  - If it can't be grown, it must be mined
  - Most resources
    - limited in quantity
    - *non-renewable*

# Geology occupations

- Economic geologist – oil, coal, metals, industrial minerals
- Environmental geologist – prevention and cleanup of pollutants
- Engineering geologist – evaluation and prevention of geologic hazards, construction
- Mining engineer – developing mines

# Avoiding Geologic Hazards

- Geology can have a direct application to ensuring your safety:

  Earthquakes

  Volcanoes (pyroclastic flows vs. mudflows)

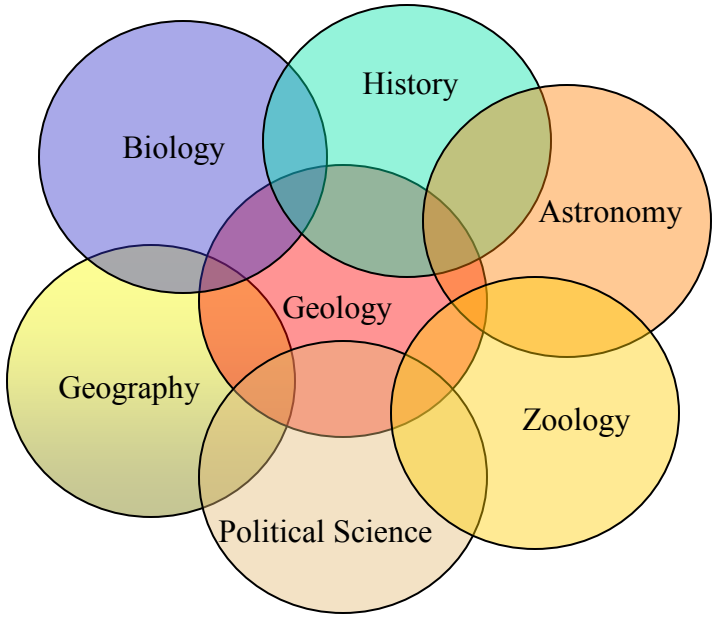
  Floods *

  Landslides *

  Wave erosion on coastlines

  Collapsing ground surfaces

# What does Geology entail?




A **Venn Diagram** Depiction of the Overlap of the various sciences that are a part of the study of ***Geology***……

Eruption of Mt. Pinatubo



Photo by Robert Lapointe, U.S. Air Force

# Volcanic Eruptions

- Nevado del Ruiz, Columbia (1985)
  - Mudflow overwhelmed town of Armero
  - Killed 23,000 people
  - Relatively small eruption, one of the worst volcanic disasters
- Mount Pinatubo, Philippines (1991)
  - 2nd largest eruption of 20th century
  - Tens of thousands of lives saved from flows

# Supplying Things We Need

- US economy geared to petroleum as a cheap energy source.  In a few decades, Americans have used up most of this country's known petroleum reserves, which took nature hundreds of millions of years to store in the Earth
- We face similar problems with diminishing resources of other materials, notably metals such as iron, aluminum, copper, and tin.
- For every living person in the US, we annually mine 40K pounds of resources (excluding energy = >17K)

# Protecting the Environment

- In the past, our need for raw materials led us to extract them w/o much regard for effects to the natural balance within the Earth, and on us
- Understanding geology can help us lessen or prevent damage to the environment
- Finally, the environment is further threatened b/c these are nonrenewable resources

# Understanding Our Surroundings

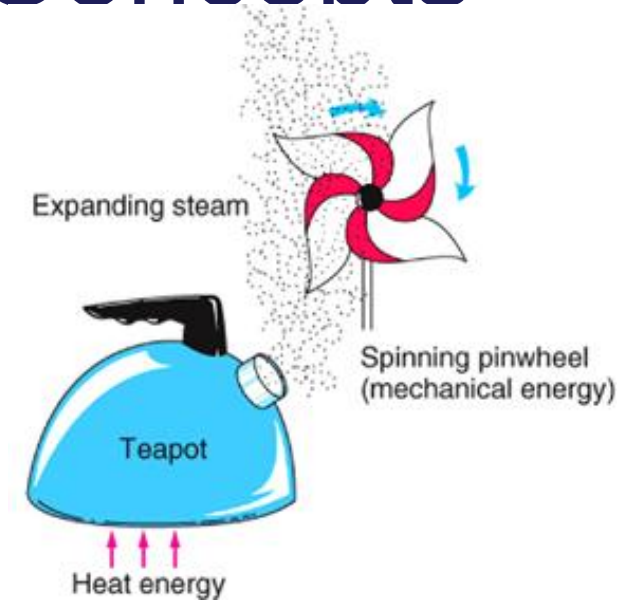
- Your next road trip, airplane ride, family vacation, beach excursion, hike, etc.!

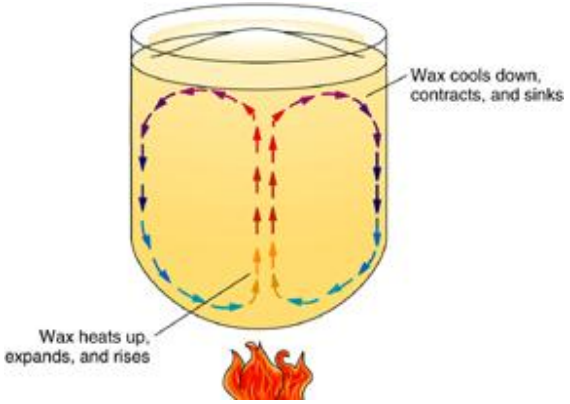
# Physical Geology

- Earth's Systems
  - ***Atmo****sphere*
    - gases that surround the Earth
  - ***Hydro****sphere*
    - water on or near Earth's surface
  - ***Bio****sphere*
    - all living or once-living materials
  - ***Geo****sphere*
    - solid, rocky Earth

# Physical Geology Concepts

- *Earth's* ***Heat Engines***
  - **External**
    - ***Energy from the Sun***
    - **Primary driver** of
      - **atmo**spheric weather
      - **hydro**spheric circulation
    - Controls ***weathering of rocks*** at Earth's surface
  - **Internal**
    - ***Heat moves*** from **hot interior** to **cooler exterior**
    - **Primary driver** of
      - most **geo**spheric phenomena
        - Volcanism
        - Magmatism
        - *Tectonics*



# Scientific Method

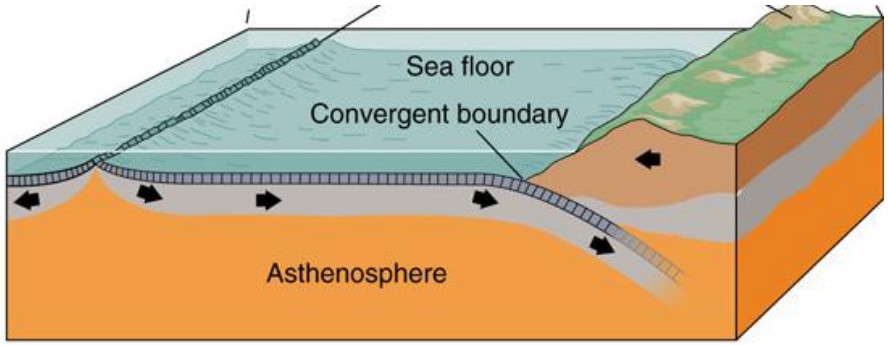
- Questions
- Collection of observations or data
- Development of explanations or hypothesis
- Predictions
- Testing/Observing if predictions were correct
- Further observations, testing, and approval/disapproval by other scientists
- Ex. Plate Tectonics

# Plate Tectonics –scientific method

- 1 – questions – submarine ridge? Deformation in mountains? Earthquakes? Ring of Fire? Continents fit?
- 2 – observe/gather data – new data from exploration of seafloor (magnetics)
- 3 – propose hypothesis – continental drift, seafloor spreading
- 4 – prediction – age of ocean floor, distance between NA & Eur. increase/year
- 5 - test predictions – drill ocean floor, age date rocks
- 6 – hypothesis becomes a theory

# The Theory of Plate Tectonics

- A theory in science is a concept that has been highly tested and in all likelihood is true
- The theory of plate tectonics is as important to geology as the theory of relativity is to physics, the atomic theory to chemistry, or evolution is to biology




B

# Theory - meaning

- General reading, theory = idea or possibility
- Science, theory = hypothesis so thoroughly tested and verified that they come as close as possible to what scientists accept as being indisputable facts = “proven”

# II. An Overview of Physical Geology—Important Concepts

- Internal Processes: How the Earth's Internal Heat Engine Works
- The Earth's Interior
- The Theory of Plate Tectonics
- Surficial Processes: The Earth's External Heat Engine
- Hydrologic Cycle
- Rock Cycle

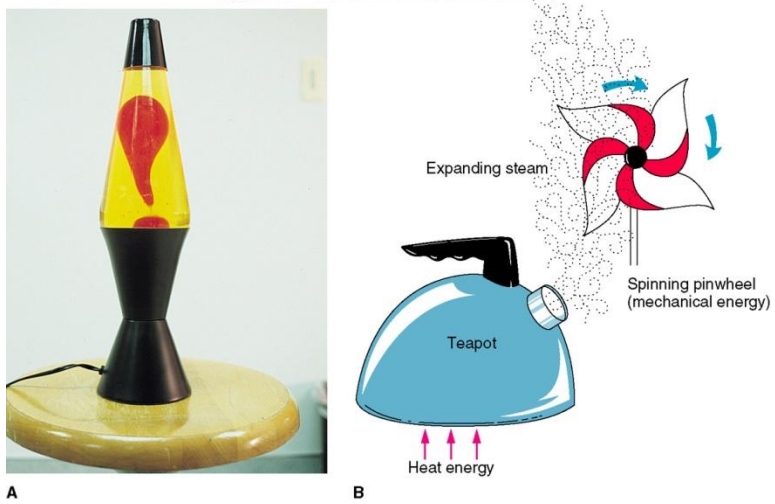
# Internal Processes:

- How the Earth's Internal Heat Engine Works (like a convection oven)

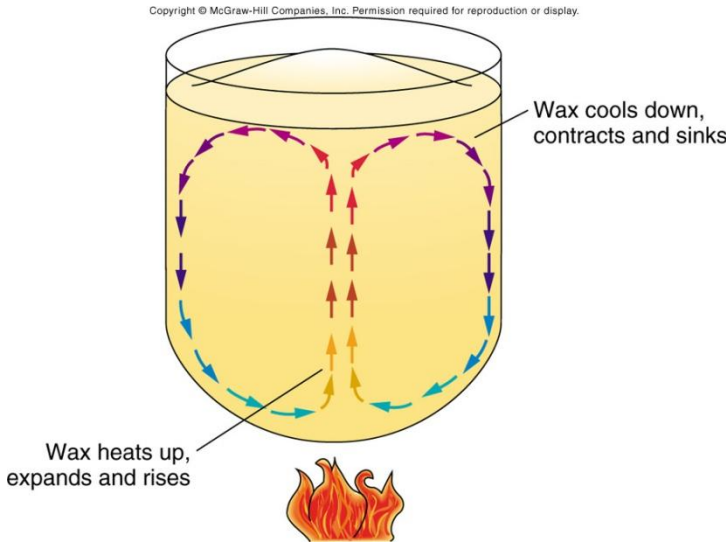
  Hot, buoyant material deep within the Earth moves slowly upward toward the cool surface

  Cold, denser material moves downward



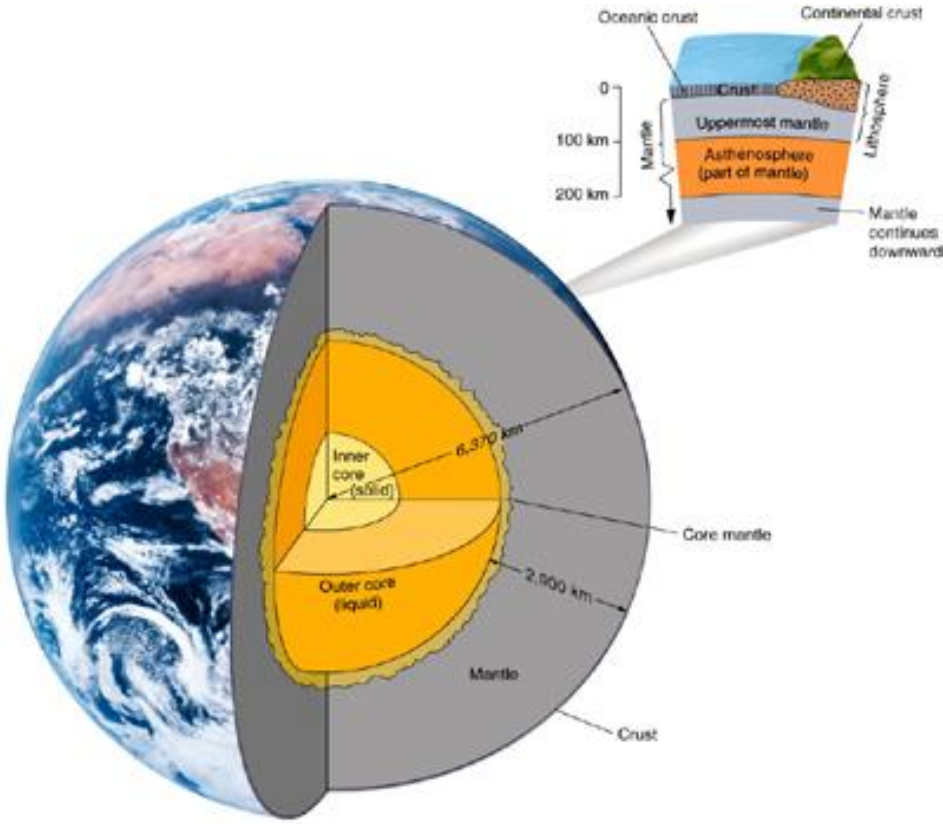




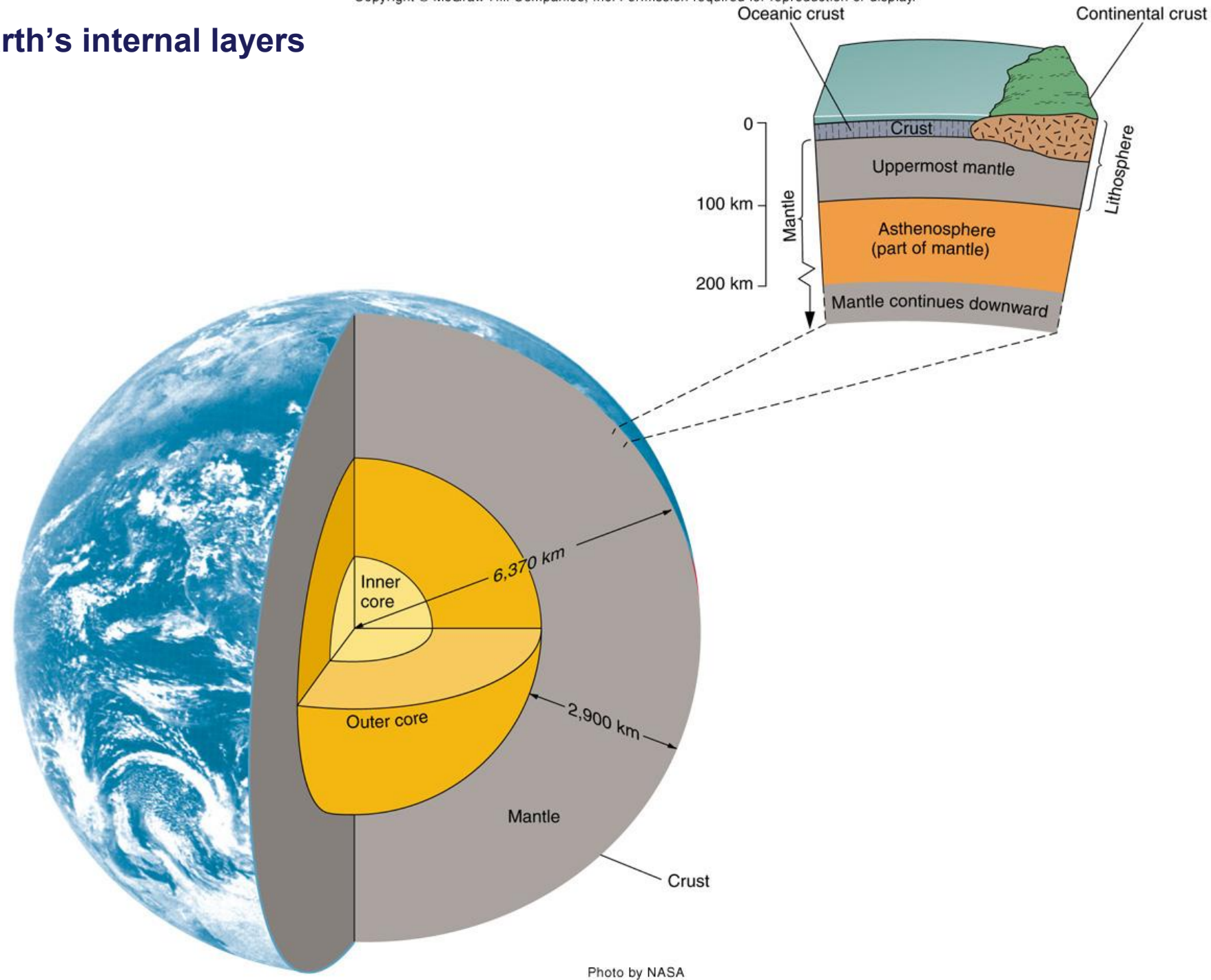



# Earth's Interior

- Compositional Layers
  - ***Crust***
    - Very thin outer rocky shell of Earth
    - Variable thickness
  - ***Mantle***
    - Hot solid
    - Special "plastic" zone
    - Fe-, Mg-, Si-rich minerals
  - ***Core***
    - **Outer** core
      - liquid
      - mostly iron
    - **Inner** core
      - solid
      - mostly iron



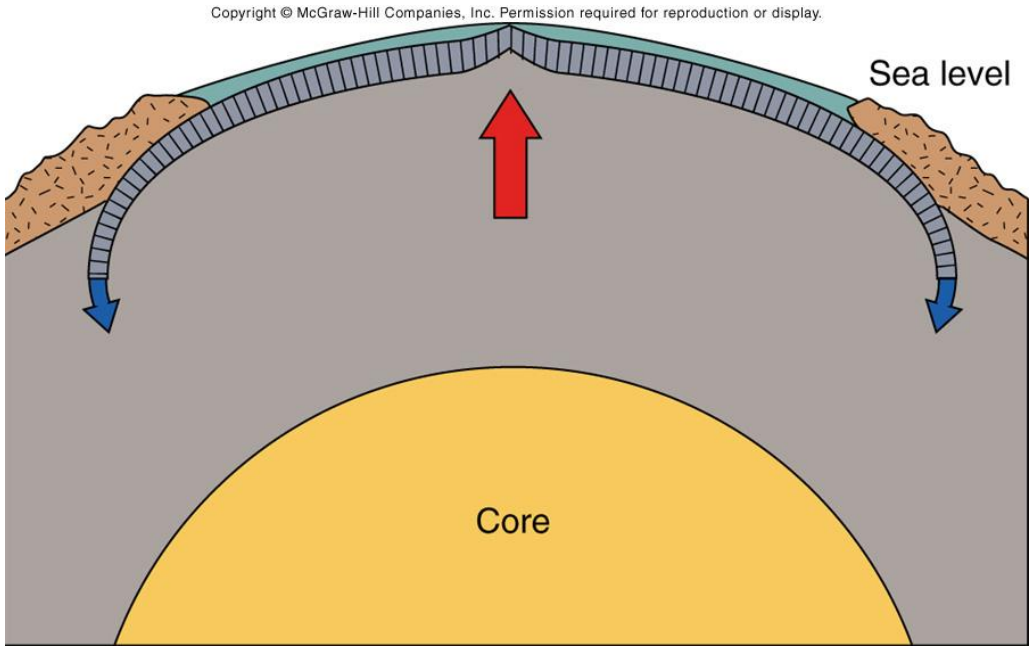
# Earth's internal layers

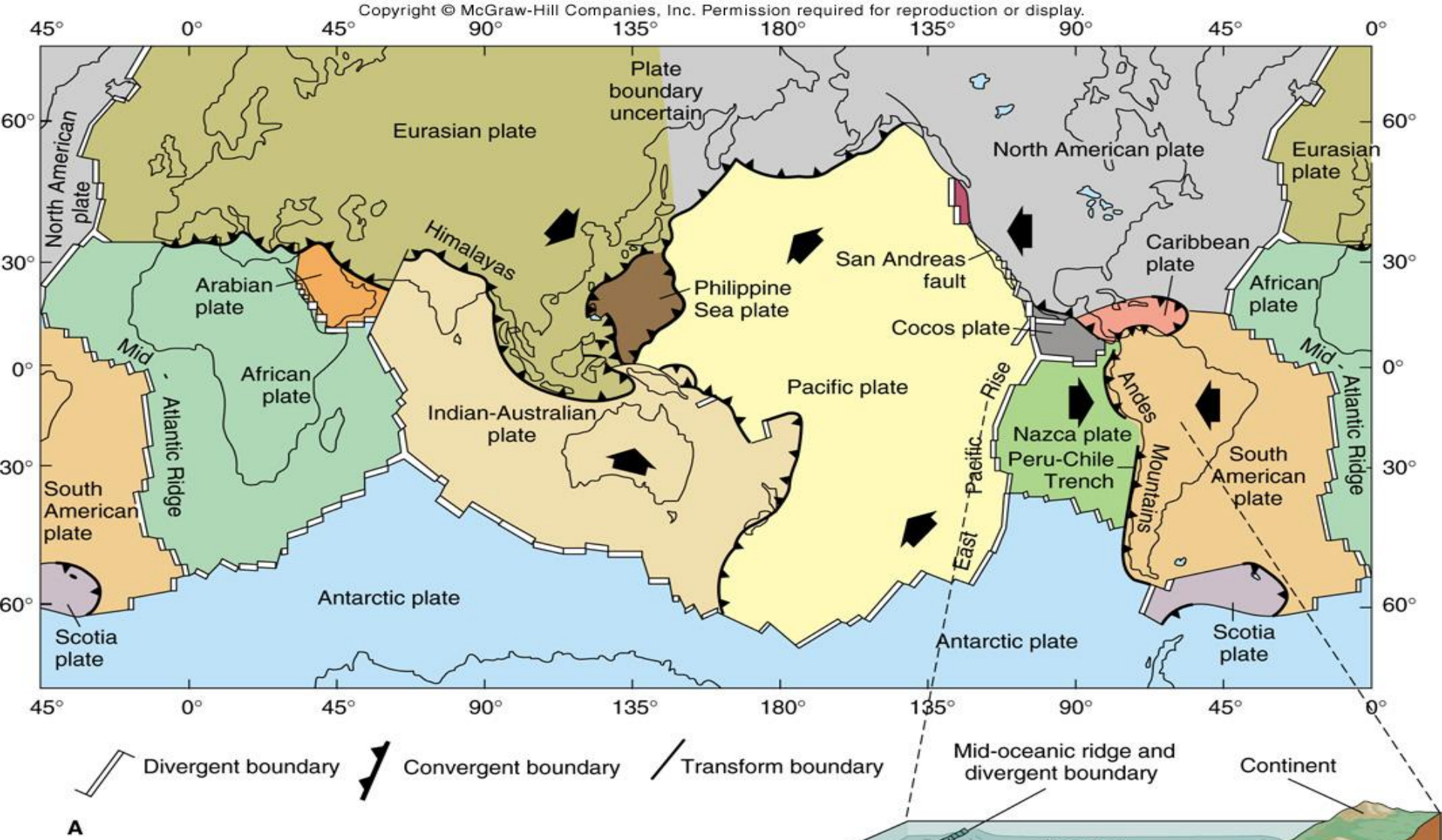


# The Earth's Interior, cont.

- Tectonic forces

Where hot mantle material wells upward, it will uplift the lithosphere. Where the lithosphere is coldest and densest, it will sink down through the asthenosphere and into deeper mantle.





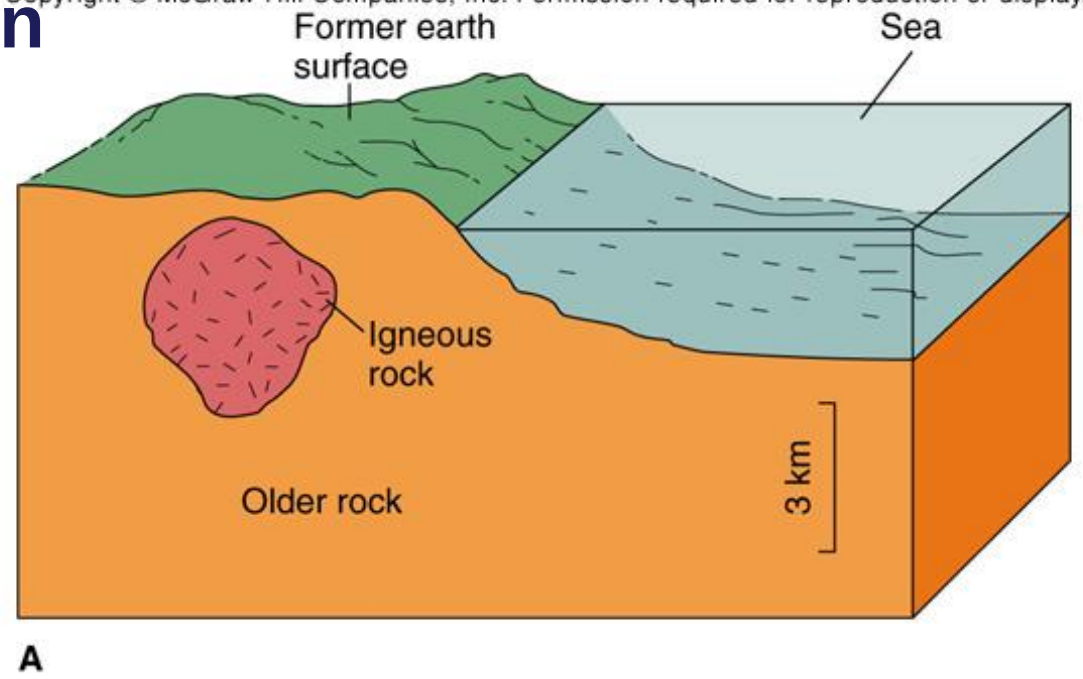

- The theory regards the lithosphere as broken into *plates* that are in motion

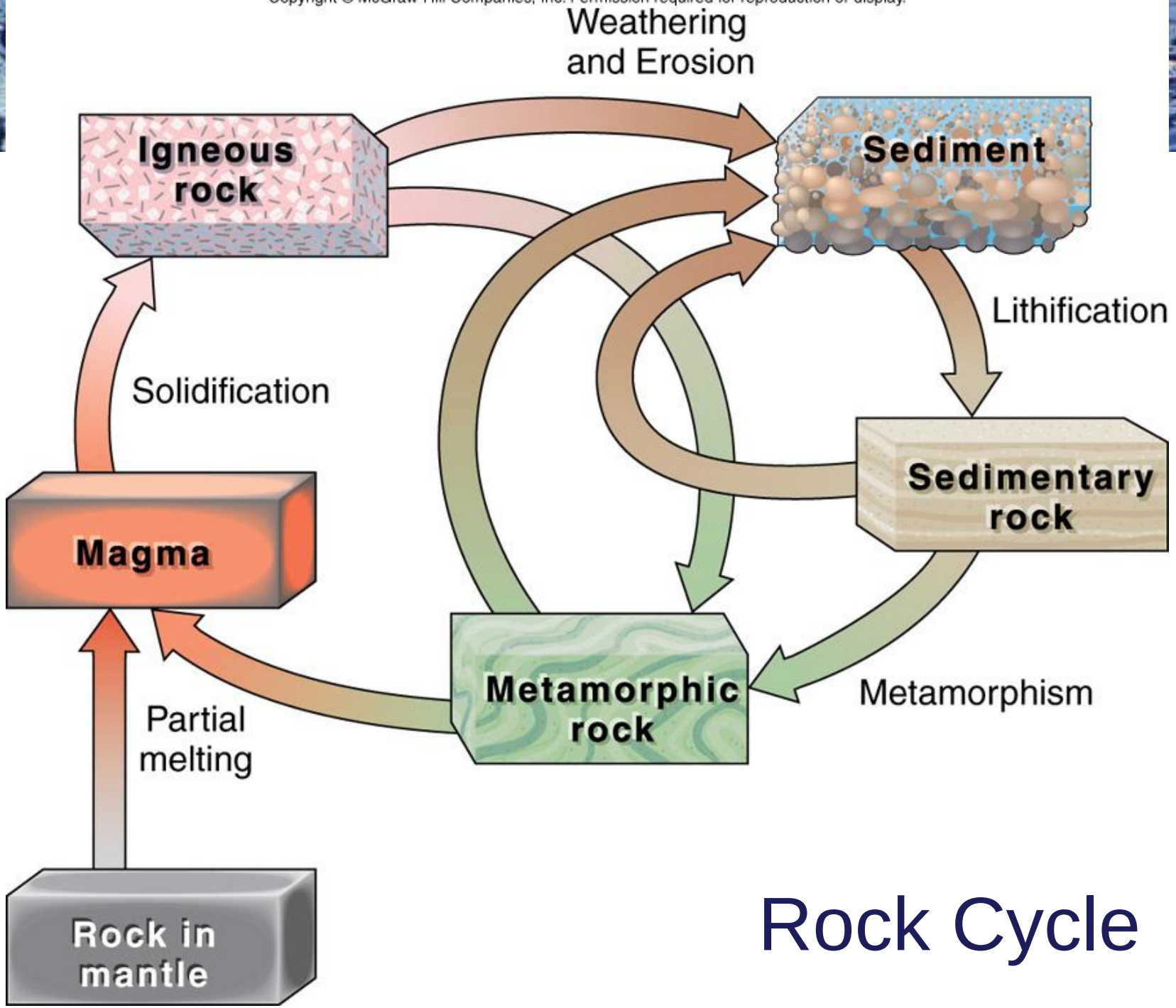
# Surficial Processes:

- The Earth's External Heat Engine
  - **Isostatic adjustment** (allows exposure of crust)
  - Weather patterns influenced by solar forces
  - Solar heating of air creates wind; wind creates ocean waves; moist air cools allowing rain and snow; rain flows downhill in streams, lakes, rivers, seas; glaciers accumulate and move downhill due to gravity
  - **Erosion** takes place where moving water, ice, or wind loosens and removes material
  - This loose material is called **Sediment**, it is the product of the breakdown of rock

# Uplift and erosion

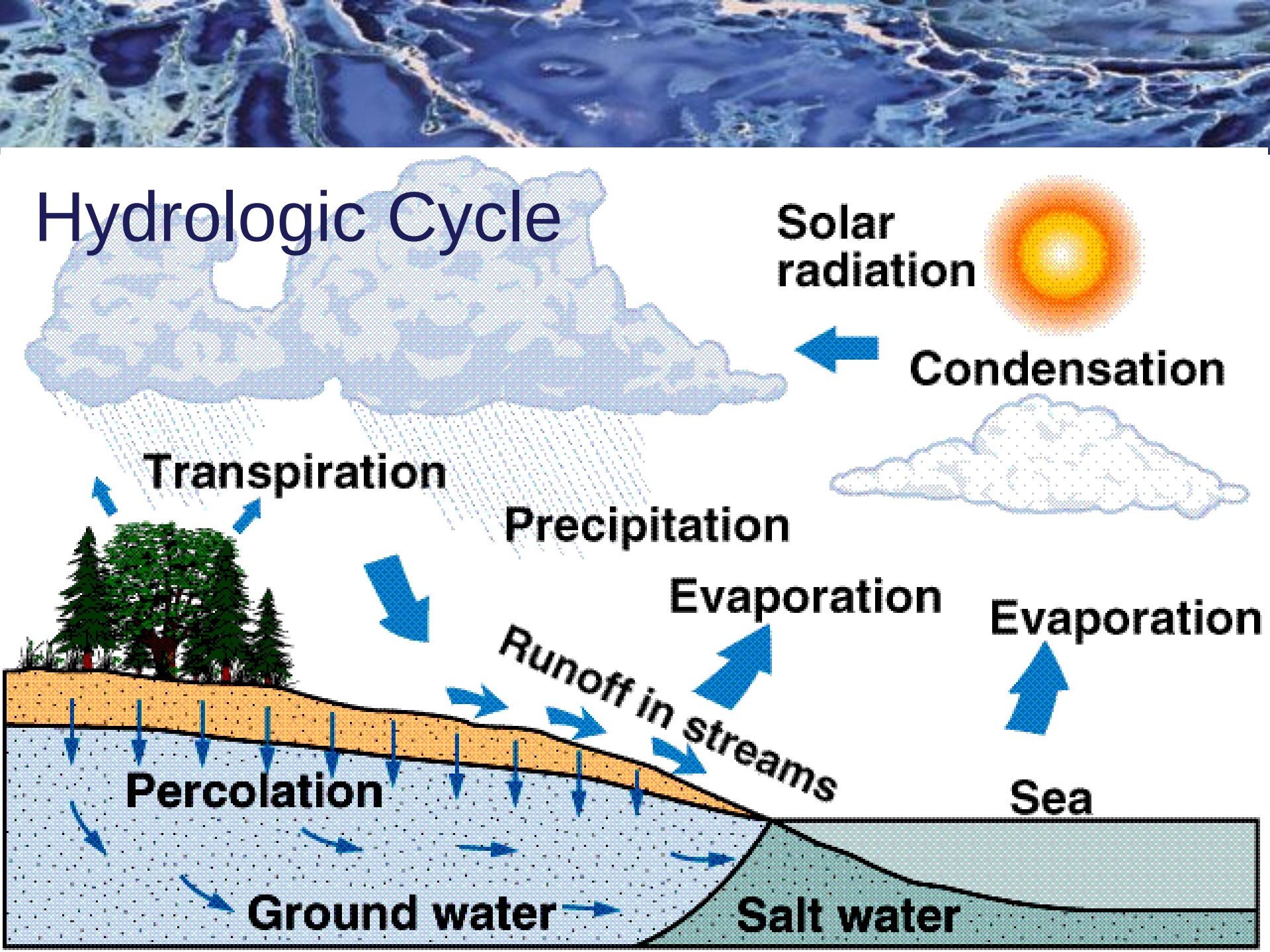




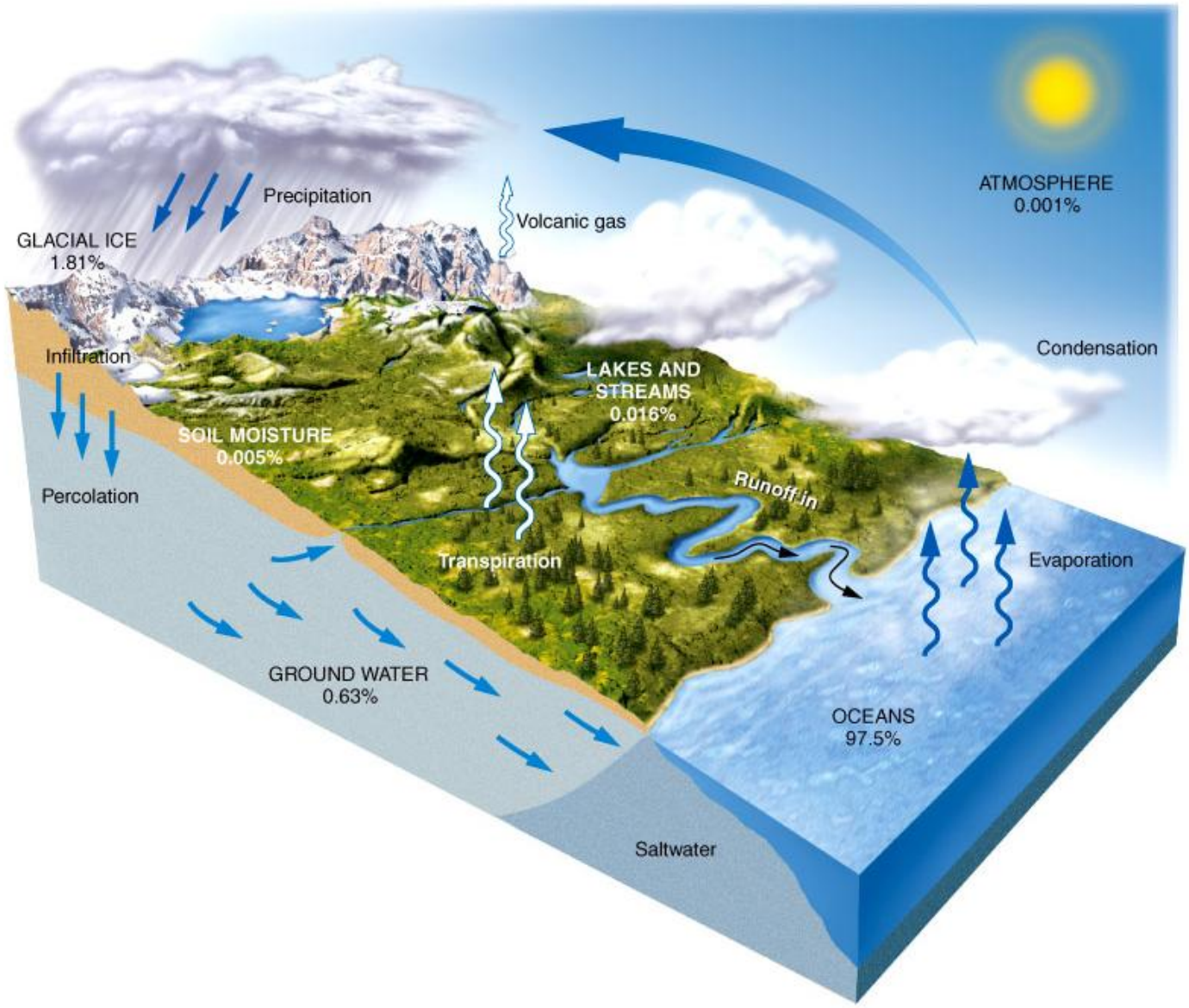



# Rock Cycle

# Hydrologic Cycle



Principal processes and reservoirs of the hydrologic cycle



# Geologic Time

| Eon | Era | Period | Epoch | Age at Base* (start) |
|---|---|---|---|---|
| Phanerozoic | Cenozoic | Quaternary | Recent (Holocene) | 0.1 Ma |
| | | | Pleistocene | 1.6 Ma |
| | | Tertiary | Pliocene | 5.3 Ma |
| | | | Miocene | 23.7 Ma |
| | | | Oligocene | 36.6 Ma |
| | | | Eocene | 57.8 Ma |
| | | | Paleocene | 65 Ma |
| | Mesozoic | Cretaceous | | 144 Ma |
| | | Jurassic | | 208 Ma |
| | | Triassic | | 245 Ma |
| | Paleozoic | Permian | | 286 Ma |
| | | Pennsylvanian | | 320 Ma |
| | | Mississippian | | 360 Ma |
| | | Devonian | | 408 Ma |
| | | Silurian | | 438 Ma |
| | | Ordovician | | 505 Ma |
| | | Cambrian | | 551 Ma |
| Precambrian | Proterozoic | Vendian | | 680 Ma |
| | | | | 2500 Ma |
| | Archean | | | 3960 Ma |
| Hadean | | | | 4550 Ma |

## Table 1.1 Some Important Ages in the Development of Life on Earth

| Millions of Years Before Present | Noteworthy Life | Eras | Periods |
|---|---|---|---|
| 4 | Earliest hominids | Cenozoic | Quaternary |
| | First important mammals | | Tertiary |
| 65 | Extinction of dinosaurs | | |
| | First dinosaurs | Mesozoic | Cretaceous |
| | | | Jurassic |
| 245 | | | Triassic |
| | | Paleozoic | Permian |
| | | | Pennsylvanian |
| | | | Mississippian |
| 300 | First reptiles | | Devonian |
| | | | Silurian |
| 400 | Fishes become abundant | | Ordovician |
| | First abundant fossils | | Cambrian |
| 545 | | | |
| 3,500 | Earliest single-celled fossils | Precambrian | (The Precambrian accounts for the vast majority of geologic time.) |
| 4,500 | Origin of the Earth | | |