These notes are posted on my site for the following reasons:

- for students to copy in their own hand-writing
  - in order to complete their class notes
  - if student did not have enough time in class
  - if student was away and missed this section
- for assistants and tutors to follow progress of the concepts taught

Photocopied/printed notes can not be used during the Unit Notebook Check in class.

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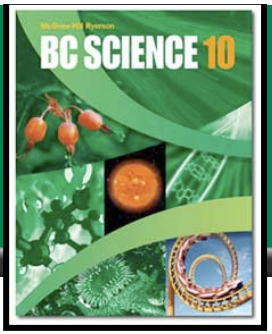
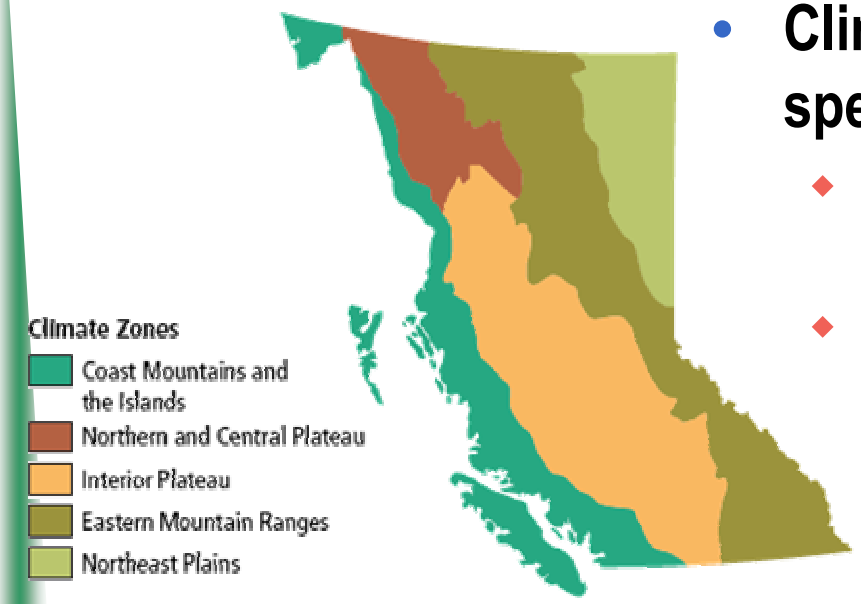
11.1 Natural Climate Change



- "Climate" describes the average conditions of a region.
  - Climate is usually measured over a minimum of 30 years or more.
  - Climate = clouds, precipitation, average temperature, humidity, atmospheric pressure, solar radiation and wind.
  - The size of the region can range from an island to the entire planet.



BC's climate zones

- Climate and geography combine to allow specific organisms to grow.
  - Biogeoclimatic zones have distinct plants, soil, geography and climate.
  - BC has 14 distinct biogeoclimatic zones.

See pages 464 - 465

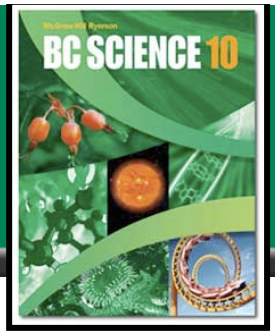
Looking Forward by Studying the Past

- **Paleoclimatologists study long-term patterns in various regions.**
  - **Fossils may show what kind of environment was present.**
  - **Tree rings can show good growing years.**
  - **River sediments can reveal types of rainfall.**
  - **Glacier ice cores show air condition and composition for 1000s of years.**
    - **Gases trapped in the ice, specifically CO_2, reveal long-term atmospheric levels**

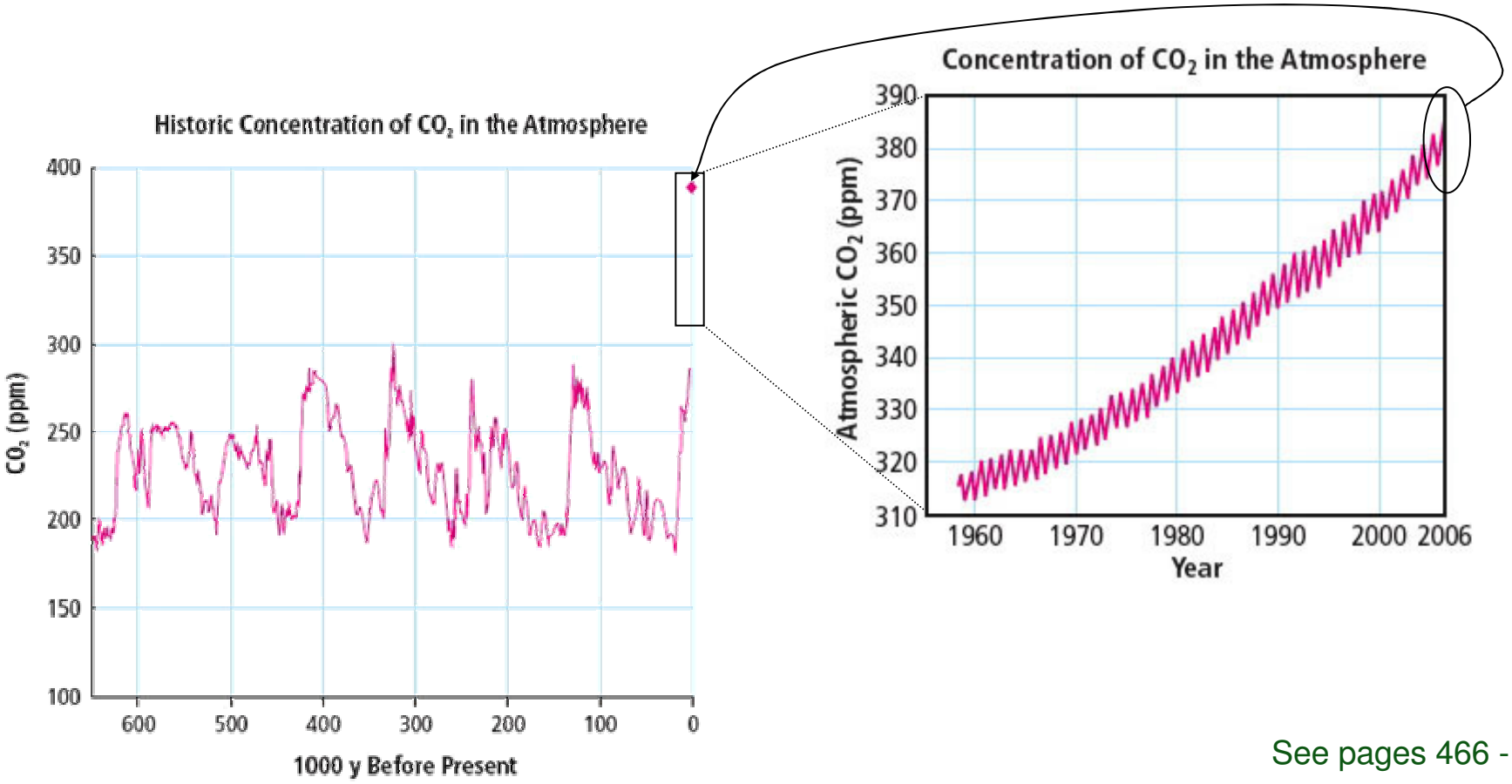
- **Evidence shows Earth's climate has drastically changed often in the past.**
  - **Fossils and sediment evidence show dramatic climate changes in the past**
  - **21 000 years ago, much of Canada and northern Europe were under glaciers**

See pages 466 - 467

Looking Forward by Studying the Past (continued)

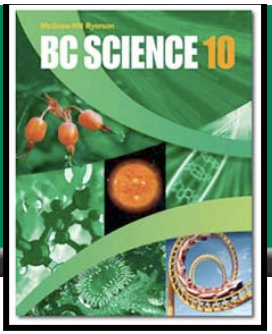


- **Ice core data reveals CO_2 level for the past 650 000 years**
  - **Scientists have also tested the atmospheric air for CO_2 for the past 50 years**

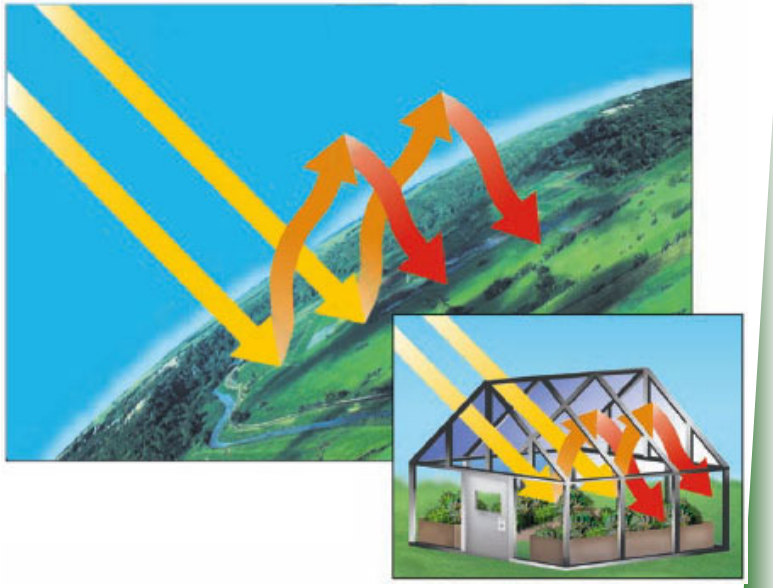


See pages 466 - 467

Factors That Influence Climate: Composition of Earth's Atmosphere



- **Earth is a closed system.**
  - A group of parts that all function together as a whole.
  - Very little (except radiant energy) enters or leaves the system.
    - Earth's atmosphere is the outer boundary.
- **A greenhouse is a closed system that traps thermal energy .**
  - The Earth's "natural greenhouse effect" allows a narrow range of temperatures.
  - Solar radiation comes in, but becomes trapped before being able to escape.
  - Greenhouse gases in the atmosphere trap and hold thermal energy.
    - This keeps Earth an average of 34ºC warmer than it would be otherwise
    - More greenhouse gases could make it too warm.



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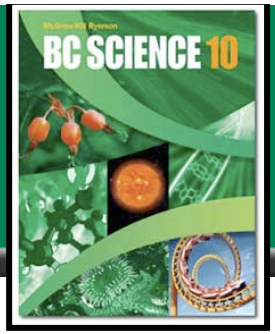
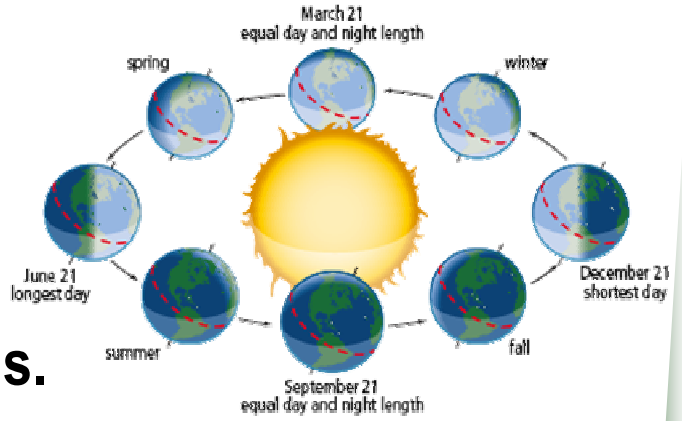
Factors That Influence Climate: Earth's Tilt, Rotation and Orbit



- **Earth's tilt is responsible for seasons in northern hemisphere.**
  - In summer, we are tilted towards the Sun, decreasing the angle of incidence.
  - In winter, tilted away from the Sun, solar radiation has a large angle of incidence
    - Earth tilts between 22.3º and 24.5º (currently 23.5º) in 41 000 year cycles.
    - When tilt is largest, climate should experience the largest extremes.



- **Earth also "wobbles" as it rotates on its axis.**
  - Because axis changes on a 23 000 year cycle, the angle of incidence on solar radiation also changes this way.
- **Earth's revolution around the Sun is elliptical, not circular.**
  - On a 100 000 year cycle, Earth's elliptical orbit becomes more or less circular.
  - When most elliptical, Earth will be farther away from the Sun than usual.

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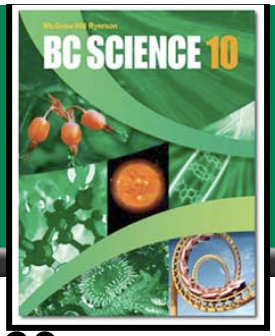
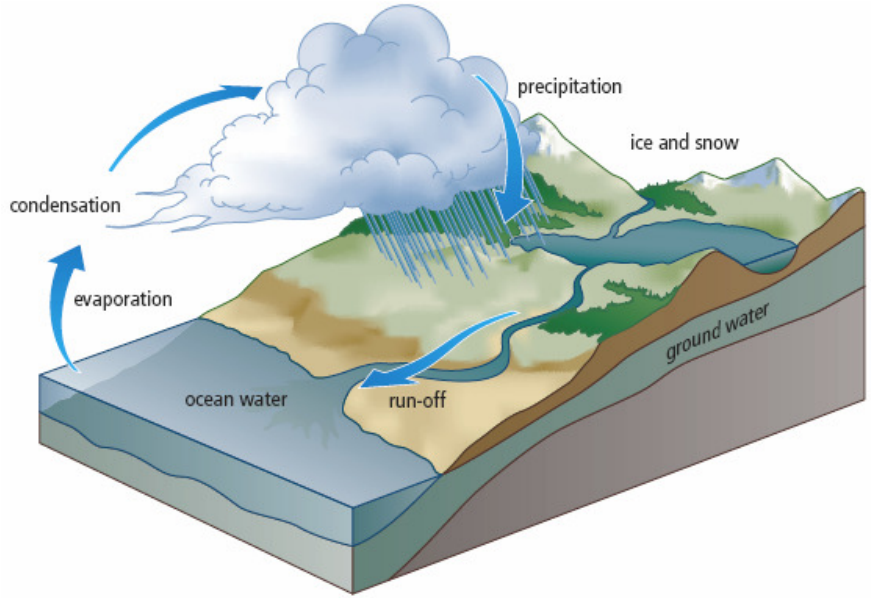
Factors That Influence Climate: The Water Cycle



- **The circulation of water on, above and below Earth's surface.**
  - **70% of all greenhouse gases in the atmosphere is water vapour.**
  - **When temperature increases, more water evaporates.**
  - **Changes in seasons cause natural variations in water vapour.**
  - **More water vapour in the atmosphere may have two effects:**
    - **More solar energy can be trapped by this greenhouse gas.**
    - **More solar energy can be reflected back out to space and never reach Earth.**



The water cycle stores and transfers large amounts of thermal energy.

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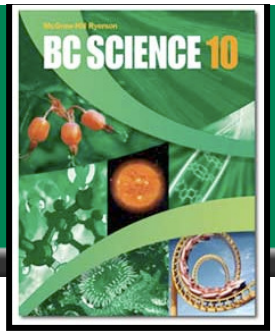
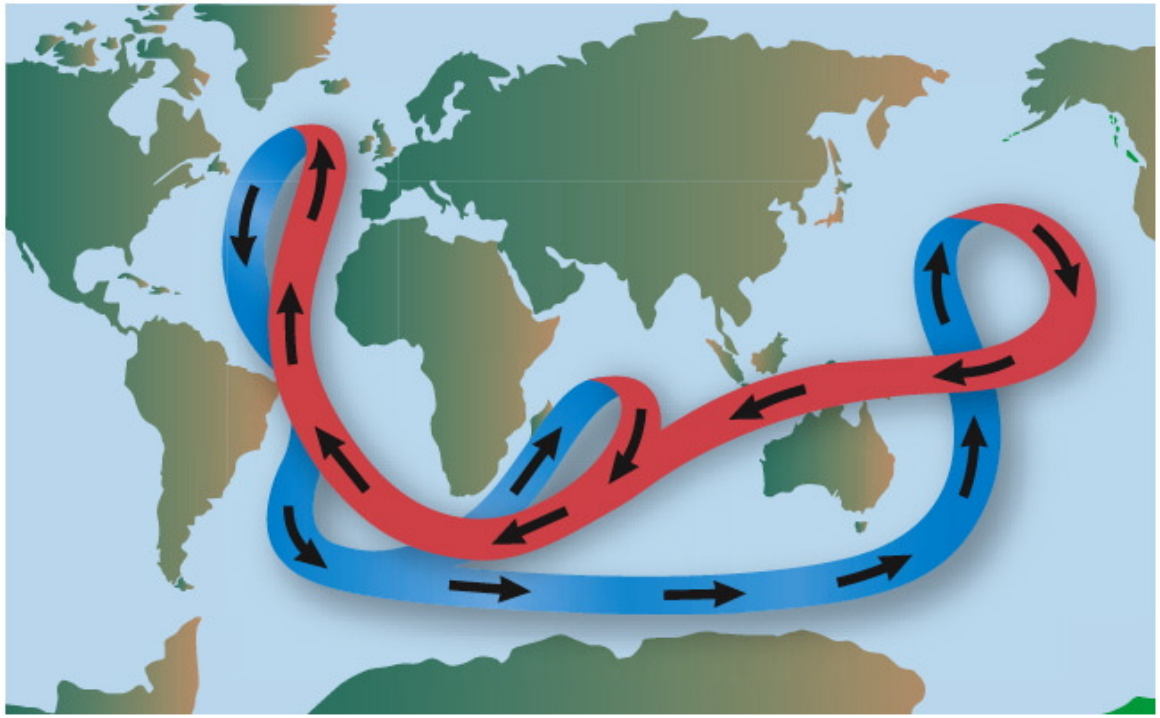
Factors That Influence Climate: Ocean Currents



- **Convection currents in the oceans move large amounts of thermal energy all around Earth.**
  - **Deep ocean currents (200 m and deeper) flow based on density differences.**
    - **They behave like massive convection currents, with warm water rising in the tropics, cold water from the higher latitudes replacing it.**



Deep-ocean currents move cold, salty water below, and warm, less-salty water near the surface.

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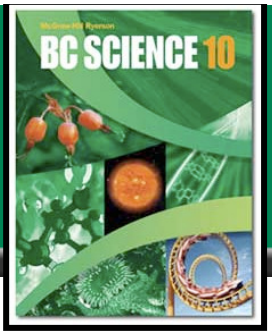
Factors That Influence Climate: Ocean Currents (continued)



- Deep ocean currents (continued)
  - Salinity of water also changes density.
    - Cold water (found at the poles) is more dense than warm water.
    - Salty water (found at the poles) is more dense than fresh water.
  - Large changes in ocean water density can reverse current direction.
- Surface currents (0 - 200 m) warm from solar radiation.
  - The thermocline is the region separating surface and deep ocean currents.
  - Upwelling occurs when cold, deep water rises into surface currents.
    - La Niña is an example of upwelling.
      - When this occurs, cool water at the surface of the Pacific cause warm winters in southeastern North America, and cool winters in the northwest.
    - El Niño is the reverse; warmer water on the surface of the Pacific
      - This results in warm winters in the Pacific Northwest, and in Eastern Canada

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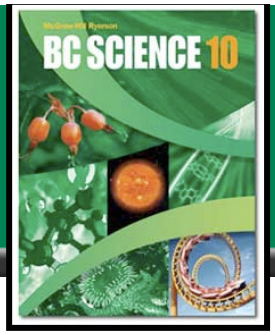
Factors That Influence Climate: The Carbon Cycle



- **Carbon dioxide is a very important greenhouse gas.**
  - **Even though each molecule absorbs only a small amount of thermal energy, there are more CO_2 molecules than any greenhouse gas other than H_2O.**
    - **Without CO_2 to trap infrared radiation from Earth's surface, the average temperature of Earth would be below freezing.**
  - **The carbon cycle maintains a balance of CO_2 in the atmosphere.**
    - **Deep oceans are carbon sinks, as are forested areas.**
      - **CO_2 in the ocean is converted to carbonates (CO_3^{2-}), in shells.**
      - **Phytoplankton use CO_2 for photosynthesis at the surface.**
    - **Weathering of rocks releases carbon.**
      - **Carbonic acid is formed when water reacts with CO2 in the atmosphere.**
    - **Forests take in CO_2, but release CO_2 when burned or when decaying.**

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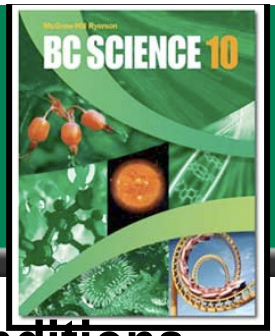
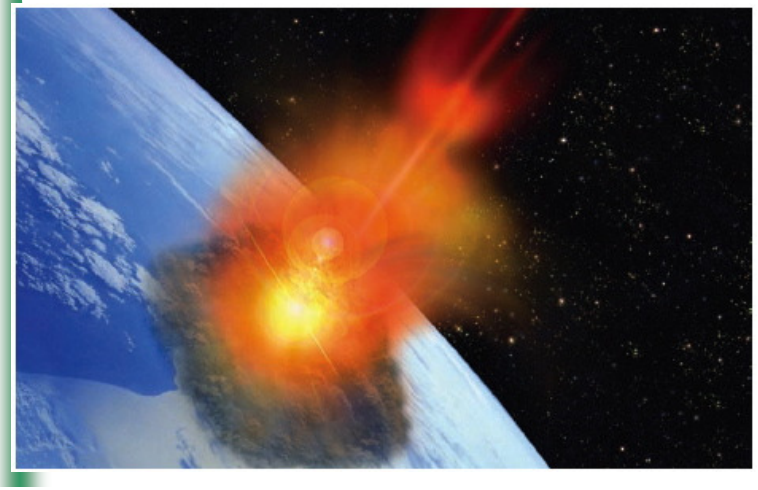
Factors That Influence Climate: The Movement of Tectonic Plates, and Catastrophic Events



- **Large scale disasters can quickly change atmospheric conditions.**
  - **Erupting volcanoes can release ash and molten rock that absorb radiation.**
    - **Water vapour and sulphur dioxide (changed into sulphuric acid) can reflect solar radiation back into space.**
  - **Meteorites and comets are thought to have caused cataclysmic changes.**
    - **These large masses strike Earth, and the result is large quantities of dust, debris nd gases in the atmosphere.**
    - **Solar radiation is affected so much, it is thought that these events are responsible for some of Earth's largest extinction events.**



Large comets and meteor collisions with Earth can cause debris to block solar radiation and change the entire planet's climates.

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Take the Section 11.1 Quiz