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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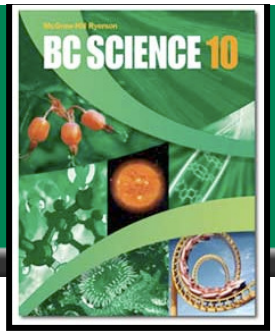
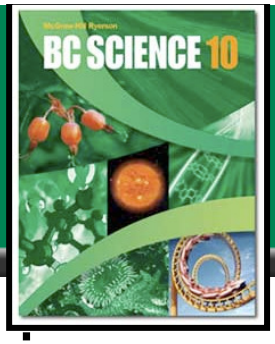
2.2 Nutrient Cycles in Ecosystems



- **Nutrients are chemicals required for growth and other life processes.**
  - Nutrients move through the biosphere in nutrient cycles, or exchanges.
  - Nutrients often accumulate in areas called stores.
  - Without interference, generally the amount of nutrients flowing into a store equals the amount of nutrients flowing out.
- **Human activities can upset the natural balance of nutrient cycles.**
  - Land clearing, agriculture, urban expansion, mining, industry and motorized transportation can all increase the levels of nutrients more quickly than the stores can absorb them.
  - Excess nutrients in the biosphere can have unexpected consequences.
- **There are five chemical elements required for life.**
  - Carbon, hydrogen, oxygen and nitrogen cycle between living things and the atmosphere.
  - Phosphorous cycles in from sedimentary rock.

See pages 68 - 70

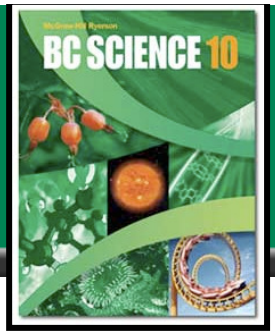
Nutrient Cycles: The Carbon Cycle



- **Carbon atoms are a fundamental unit in cells of all living things.**
  - Carbon is also an essential part of chemical processes that sustain life.
- **Carbon can be stored in many different locations.**
  - Short-term shortage is found in aquatic and terrestrial organisms, and in CO_2 in the atmosphere and top layers of the ocean.
  - Longer-term storage is found in middle and lower ocean layers as dissolved CO_2, and in coal, oil and gas deposits in land and ocean sediments.
- **Sedimentation traps many long-term stores of carbon**
  - Layers of soil and decomposing organic matter become buried on land and under the oceans.
    - Slowly, under great pressure over many years, coal, oil and gas form.
  - Layers of shells also are deposited in sediments on the ocean floor, forming carbonate rocks like limestone over long periods of time.
- **Carbon stores are also known as carbon sinks**

See pages 71 - 72

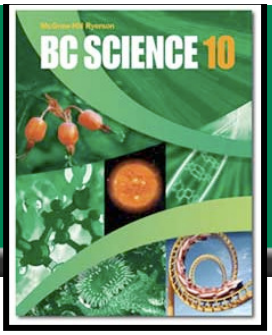
Nutrient Cycles:
The Carbon Cycle (continued)

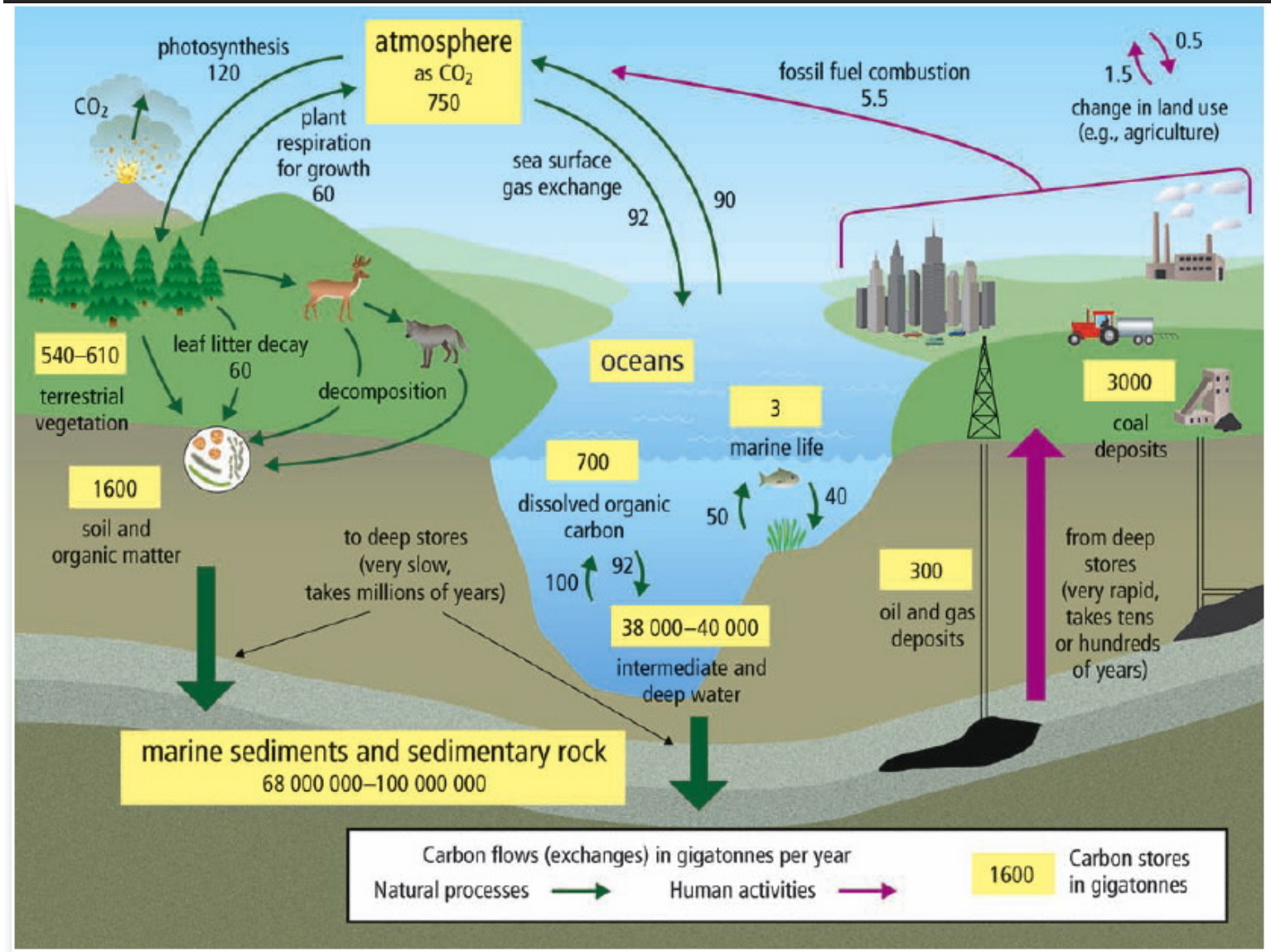


- **Carbon is cycled through ecosystems in a variety of ways.**
  - **Photosynthesis: energy from the sun allows CO_2 and H_2O to react**
    - **$CO_2 + H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + O_2$**
    - **Carbon in the atmosphere is transformed by plants into carbohydrates.**
    - **Photosynthesis also occurs in cyanobacteria and algae in oceans.**
  - **Cellular respiration: carbohydrates release energy in consumers**
    - **$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + \text{energy}$**
    - **The energy released is used for growth, repair and other life processes.**
  - **Decomposition: decomposers break down large quantities of cellulose**
    - **Cellulose is a carbohydrate most other organisms cannot break down**
  - **Ocean Processes: CO_2 dissolves in cold, northern waters and sinks**
    - **Ocean currents flow to the tropics, the water rises and releases CO_2**
    - **This process is called ocean mixing.**
  - **Eruptions and fires - volcanic eruptions can release CO_2**
    - **Forest fires also release CO_2**

See pages 73 - 76

Nutrient Cycles:
The Carbon Cycle (continued)





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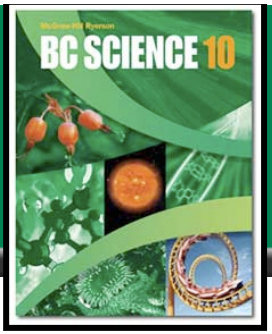
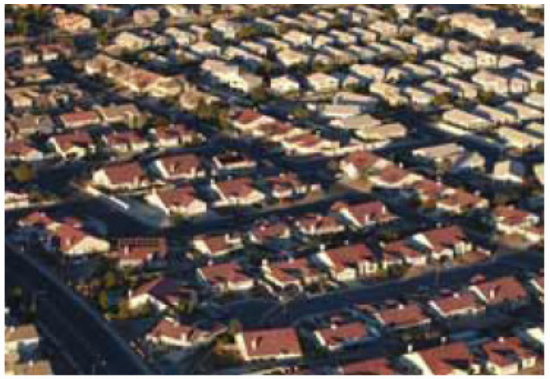
Nutrient Cycles:
The Carbon Cycle (continued)



- **Many human activities can influence the carbon cycle**
  - **Since the start of the Industrial Revolution (160 years ago), CO_2 levels have increased by 30% from the increased burning of fossil fuels.**
    - **The increase in CO_2 levels in the previous 160 000 years was 1% - 3%**
    - **Carbon is being removed from long-term storage more quickly than it naturally would as we mine coal and drill for oil and gas.**
    - **CO_2 is also a greenhouse gas, which traps heat in the atmosphere.**
  - **Clearing land for agriculture and urban development reduces plants that can absorb and convert CO_2.**
    - **Farmed land does not remove as much CO_2 as natural vegetation does.**



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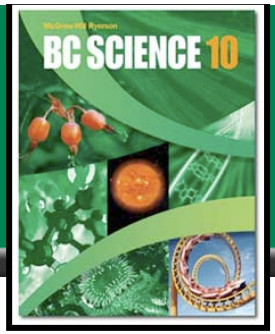
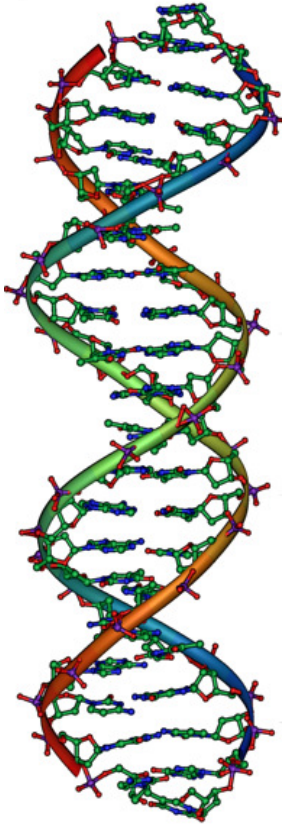
Nutrient Cycles: The Nitrogen Cycle



- Nitrogen is very important in the structure of DNA and proteins.
  - In animals, proteins are vital for muscle function.
  - In plants, nitrogen is important for growth.
- The largest store of nitrogen is in the atmosphere in the form N_2.
  - Approximately 78% of the Earth's atmosphere is N_2 gas.
  - Nitrogen is also stored in oceans, and as organic matter in soil.
  - Smaller nitrogen stores are found in terrestrial ecosystems and waterways.
- Nitrogen is cycled through processes involving plants
  1. Nitrogen fixation
  2. Nitrification
  3. Uptake



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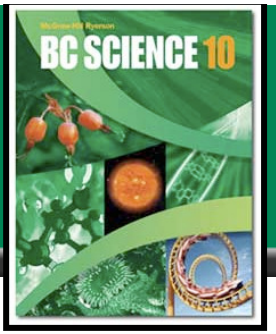
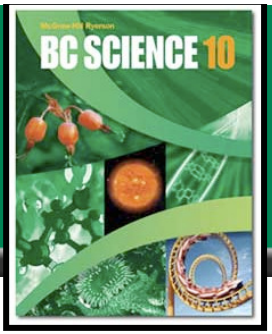
Nutrient Cycles:
The Nitrogen Cycle (continued)



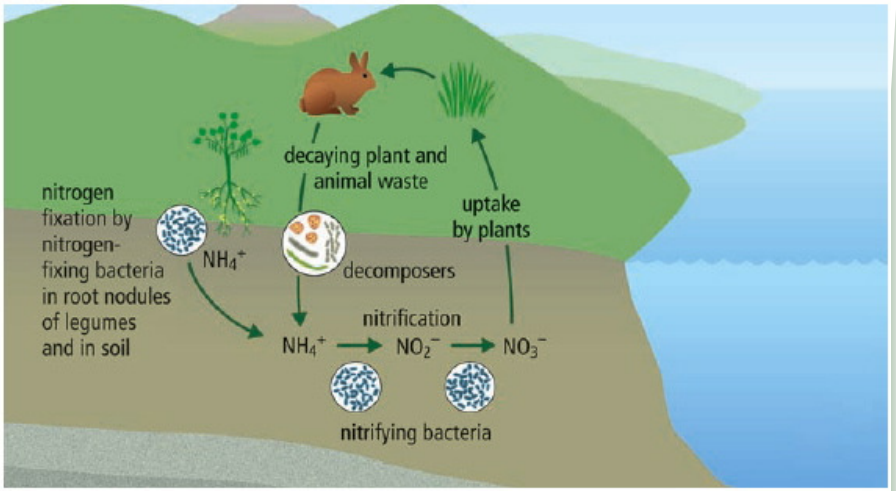
- Nitrogen fixation is the conversion of N_2 gas into compounds containing nitrate (NO_3^-) and ammonium (NH_4^+)
  - Both nitrate and ammonium compounds are usable by plants.
  - Nitrogen fixation occurs in one of three ways
    1. In the atmosphere - lightning provides the energy for N_2 gas to react with O_2 gas to form nitrate and ammonium ions.
       - Compounds formed by these ions then enter the soil via precipitation
       - This only provides a small amount of nitrogen fixation.
    2. In the soil - nitrogen-fixing bacteria like *Rhizobium* in the soil convert N_2 gas into ammonium ions
       - These bacteria grow on the root nodules of legumes like peas.
       - The plants provide sugars, while bacteria provide nitrogen ions.
    3. In the water - some species of cyanobacteria also convert N_2 into ammonium during the process of photosynthesis.

See pages 78 - 79

Nutrient Cycles:
The Nitrogen Cycle (continued)



- **Nitrification occurs when certain soil bacteria convert ammonium.**
  - **Ammonium is converted into nitrates (NO_3^-) by nitrifying bacteria.**
  - **Ammonium is converted to nitrite (NO_2^-), which is then converted to nitrate.**
- **Nitrates enter plant roots via uptake**
  - **These nitrogen compounds compose plant proteins.**
  - **Herbivores then eat plants, and use nitrogen for DNA and protein synthesis.**
- **Nitrogen is returned to the atmosphere via denitrification.**
  - **Nitrates are converted back to N_2 by denitrifying bacteria.**
  - **N2 is also returned to the atmosphere through volcanic eruptions.**



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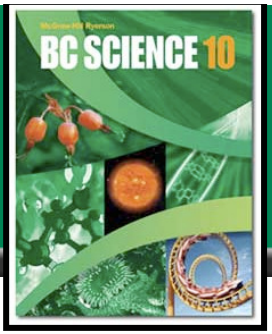
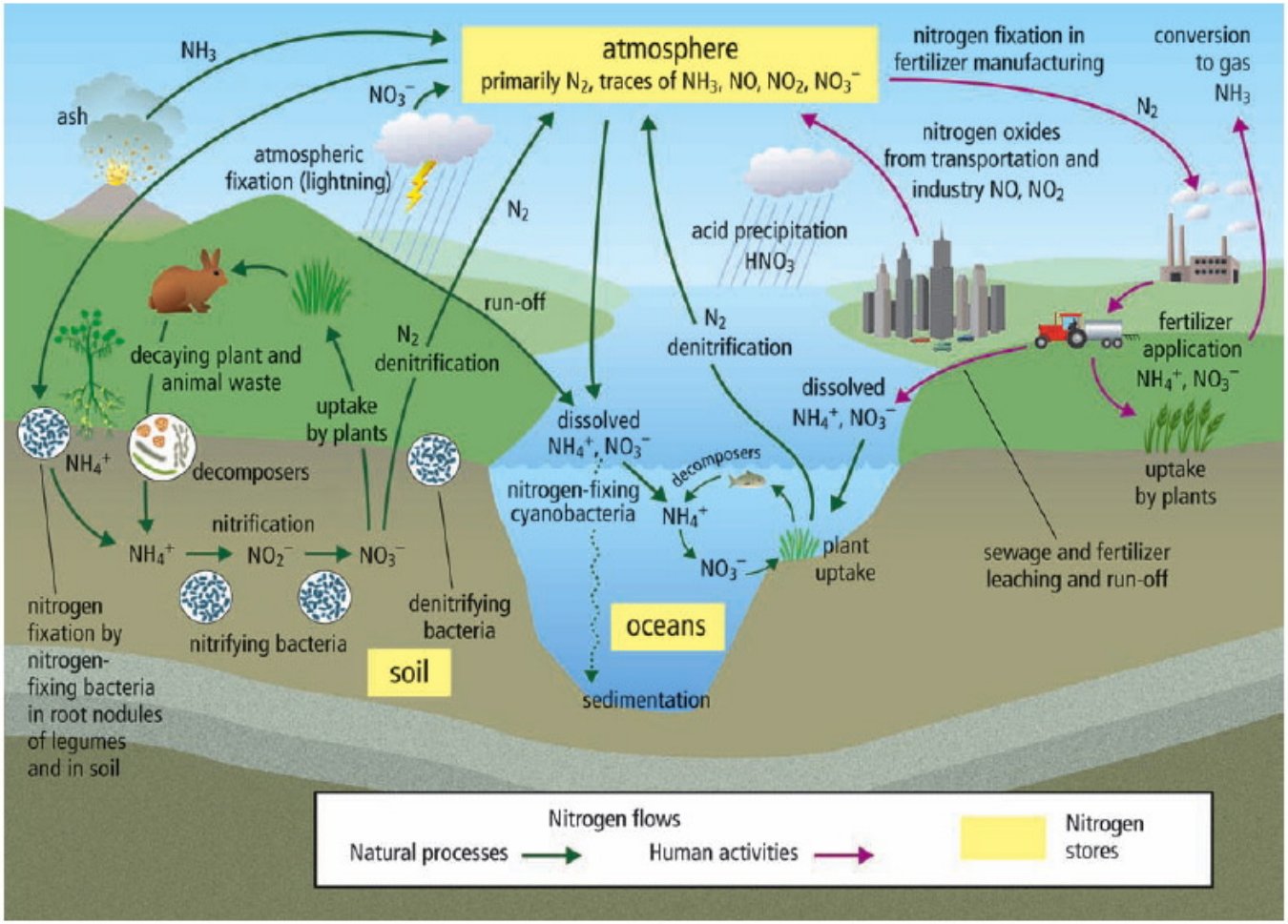
Nutrient Cycles:
The Nitrogen Cycle (continued)



- **Excess nitrogen dissolves in water, enters the waterways, and washes into lakes and oceans.**



- **The nitrogen compounds eventually become trapped in sedimentary rocks, and will not be released again until the rocks weather.**

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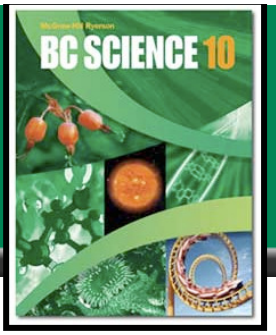
Nutrient Cycles:
The Nitrogen Cycle (continued)

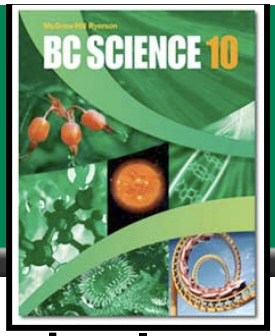


- **Human activities can also affect the nitrogen cycle.**
  - Due to human activities, the amount of nitrogen in the ecosystem has doubled in the last 50 years.
  - Burning fossil fuels and treating sewage releases nitrogen oxide (NO) and nitrogen dioxide (NO_2).

    - Burning also releases nitrogen compounds that increase acid precipitation in the form of nitric acid (HNO_3).
  - Agricultural practices often use large amounts of nitrogen-containing fertilizers.
    - Excess nitrogen is washed away, or <u>leaches</u>, into the waterways.
      - This promotes huge growth in aquatic algae = eutrophication
      - These algal blooms use up all CO_2 and O_2 and block sunlight, killing many aquatic organisms.
      - The algal blooms can also produce neurotoxins that poison animals.

See pages 82 - 83

Nutrient Cycles:
The Phosphorous Cycle



- **Phosphorous is essential for life processes in plants and animals.**
  - Phosphorous is a part of the molecule that carries energy in living cells.
  - Phosphorous promotes root growth, stem strength and seed production.
  - In animals, phosphorous and calcium are important for strong bones.
- **Phosphorous is not stored in the atmosphere.**
  - Instead, it is trapped in phosphates (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$) found in rocks and in the sediments on the ocean floor.
- **Weathering releases these phosphates from rocks.**
  - Chemical weathering, via acid precipitation or lichens, releases phosphates.
  - Physical weathering, where wind, water and freezing release the phosphates.
  - Phosphates are then absorbed by plants, which are then eaten by animals.
  - Weathering doesn't occur until there is geologic uplift, exposing the rock to chemical and physical weathering.

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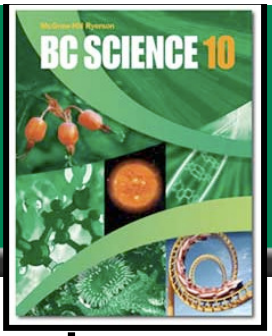
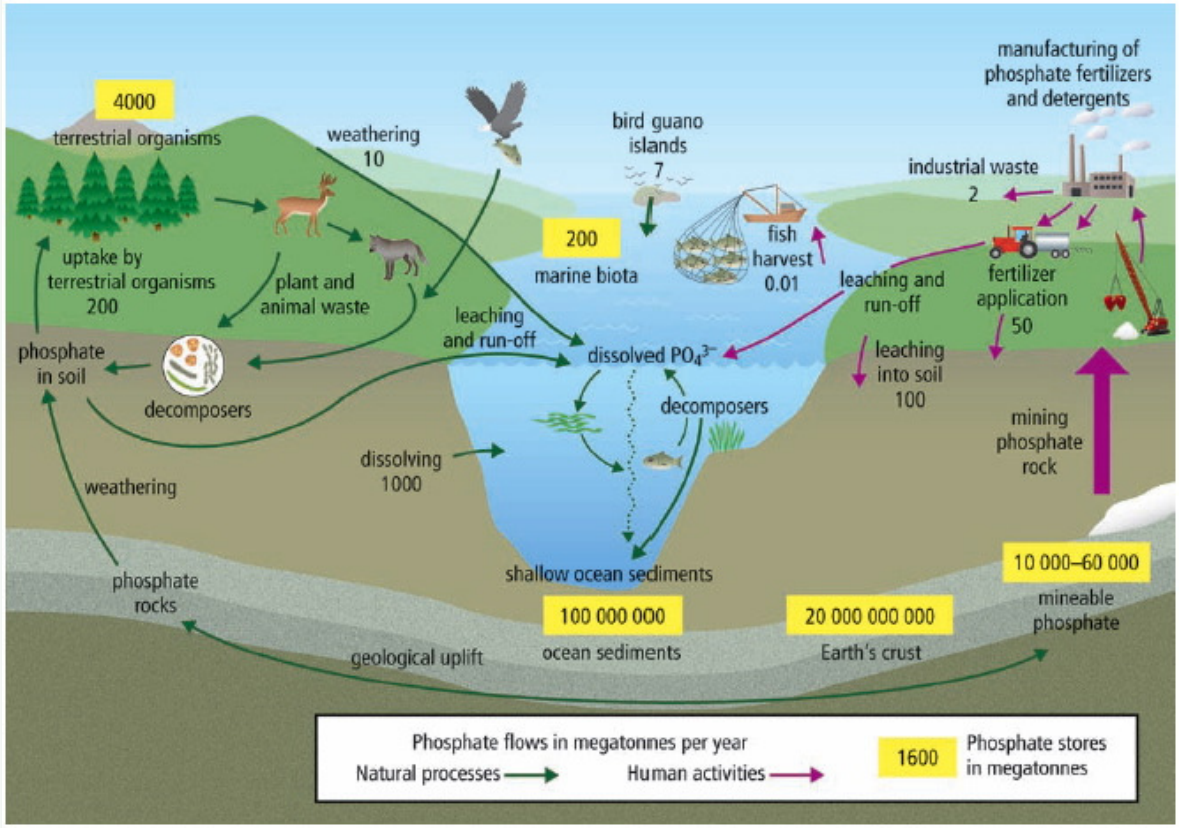
Nutrient Cycles:
The Phosphorous Cycle (continued)



- **Humans add excess phosphorous to the environment through mining for fertilizer components.**
  - **Extra phosphorous, often long with potassium, then enters the ecosystems faster than methods can replenish the natural stores.**



- **Humans can also reduce phosphorous supplies.**
  - **Slash-and-burning of forests removes phosphorous from trees, and it then is deposited as ash in waterways.**

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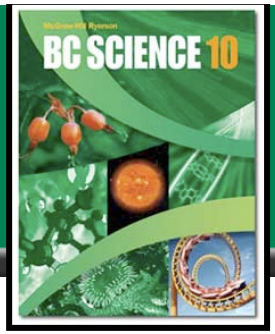
How Changes in Nutrient Cycles Affect Biodiversity



- **Any significant changes to any of these nutrients (C, H, O, N or P) can greatly impact biodiversity.**
  - **Carbon cycle changes are add to climate change and global warming.**
    - **Slight temperature fluctuations and changes in water levels can drastically change ecosystems.**
    - **Changes influence every other organism in those food webs.**
  - **Increased levels of nitrogen can allow certain plant species to out-compete other species, decreasing resources for every species in those food webs.**
  - **Decreased levels of phosphorous can inhibit the growth of algal species which re very important producers in many food chains.**

See pages 86 - 87

Take the Section 2.2 Quiz