Part B: *Unit Study Notes and Exam Questions*

Unit 1 Sustaining Earth's Ecosystems

By the end of this unit you should be able to:

1. Explain the interaction of abiotic and biotic factors within an ecosystem
   This includes being able to:
   - ☐ define *abiotic*, *biotic*, *biome*, and *ecosystem*
   - ☐ identify distinctive plants, animals, and climatic characteristics of Canadian biomes (tundra, boreal forest, temperate deciduous forest, temperate rainforest, grasslands)
   - ☐ identify biotic and abiotic factors in a given scenario or diagram
   - ☐ describe the relationships between abiotic and biotic elements within an ecosystem, including
     - air, water, soil, light, temperature (abiotic)
     - bacteria, plants, animals (biotic)
   - ☐ design and analyse experiments on the effectiveness of altering biotic or abiotic factors (e.g., nutrients in soil: compare two plant types with the same nutrients, compare one plant type with different nutrients)
   - ☐ explain various relationships with respect to food chains, food webs, and food pyramids, including
     - producer
     - consumer (herbivore, carnivore, omnivore)
     - predation (predator-prey cycle)
     - decomposers
     - symbiosis (mutualism, commensalism, parasitism)
   - ☐ illustrate the cycling of matter through abiotic and biotic components of an ecosystem by tracking
     - carbon (with reference to carbon dioxide—CO_2, carbonate—CO_3^{2-}, oxygen—O_2, photosynthesis, respiration, decomposition, volcanic activity, carbonate formation, greenhouse gases from human activity (combustion)
     - nitrogen (with reference to nitrate—NO_3^-, nitrite—NO_2^-, ammonium—NH_4^+, nitrogen gas—N_2, nitrogen fixation, bacteria, lightning, nitrification, denitrification, decomposition)
     - phosphorus (with reference to phosphate—PO_4^{3-}, weathering, sedimentation, geological uplift)
   - ☐ identify factors that affect the global distribution of the following biomes: tropical rainforest, temperate rainforest, temperate deciduous forest, boreal forest, grasslands, desert, tundra, polar ice (permanent ice)
   - ☐ using examples, explain why ecosystems with similar characteristics can exist in different geographical locations (i.e., significance of abiotic factors)
   - ☐ identify the effects on living things within an ecosystem resulting from changes in abiotic factors, including
     - climate change (drought, flooding, changes in ocean current patterns, extreme weather)
     - water contamination
     - soil degradation and deforestation

2. *Assess the potential impacts of* bioaccumulation
   This includes being able to:
   - ☐ define, using examples, the terms *bioaccumulation*, *parts per million (ppm)*, *biodegradation*, and *trophic levels* (with *reference to producers and to primary*, secondary, and tertiary consumers)
   - ☐ identify a variety of contaminants that can bioaccumulate (e.g., pesticides, heavy metals, PCBs)
   - ☐ describe the mechanisms and possible *impacts of bioaccumulation* (*e.g.*, eradication of keystone species, reproductive impacts)
   - ☐ compare the impact of bioaccumulation on consumers at different trophic levels (e.g., red tide in oysters and humans; *heavy metals in fish and humans; PCBs* in fish, birds, whales)
   - ☐ research and analyze articles on the causes and effects of bioaccumulation (e.g., mercury contamination in Inuit communities and the Grassy Narrows *First Nation community*)
3. Explain various ways in which natural populations are altered or kept in equilibrium
   This includes being able to:
   - ☐ explain how species adapt or fail to adapt to environmental conditions, with reference to the following:
     - natural selection
     - proliferation
     - *predator-prey cycle*
     - ecological succession
     - climax community
     - extinction
     - adaptive radiation
   - ☐ describe the impact of natural *phenomena* (*e.g., drought, fire,* temperature change, flooding, tsunamis, infestations—pine beetle, volcanic eruptions) on ecosystems
   - ☐ give examples of how foreign species can affect an ecosystem (e.g., Eurasian *milfoil, purple loosestrife,* Scotch broom, American bullfrog, European starling in B.C.)
   - ☐ give examples of how traditional ecological knowledge (TEK) can affect biodiversity
     (*e.g., spring burning by Cree in northern* Alberta)
   - ☐ research and report on situations in which disease, pollution, habitat destruction, and exploitation of resources affect ecosystems

By the end of this unit, you should understand the following key ideas:

1. Biomes and ecosystems are divisions of the biosphere.
2. Energy flow and nutrient cycles support life in ecosystems.
3. Ecosystems continually change over time.

To help you study you should have the following:

- *BC Science 10* student book, pages 2 to 161. Note the practice exam questions on page 158 to 161.
- BC Science 10 Provincial Exam Data Pages, pages 5, 6, 8, and 9
- BC Science 10 Provincial Exam Vocabulary List, page 1
- Access to www.bcscience10.ca

Chapter 1 Biomes and ecosystems are divisions of the biosphere.

1.1 Biomes

I. Summary of Key Points

- Biomes are the largest divisions of the biosphere.
- The large regions within biomes have similar biotic and abiotic components.
- The interaction of these components determines the characteristics of biomes.
- Temperature and precipitation are the main abiotic factors that influence the distribution of biomes and the organisms within them.
- Organisms have adaptations for survival in the specific environmental conditions of their biome.

II. Study Notes

What Is a Biome?

1. The **biosphere** is the thin layer of air, land, and water at Earth's surface where living things exist.
2. A **biome** is a large area of the biosphere that has characteristic **climate** (long-term weather conditions in an area, including rainfall and temperature), plants, animals, and soil.
3. Examples of biomes include **aquatic** (related to water) biomes, such as the tropical ocean, and **terrestrial** (related to land) biomes, such as desert, tropical rainforest, and permanent ice.
4. Biomes are classified based on many qualities, such as water availability, temperature, and interactions between biotic and abiotic factors.
   - **Biotic** factors are all organisms in the environment, including bacteria, plants, and animals.
   - **Abiotic** factors are all non-living parts of the environment, such as air, water, soil, light, and temperature.
5. The interactions between biotic and abiotic factors determine what characteristics a biome will have.

Quick Check

Identify each of the following as either a biotic or an abiotic factor.

1. (a) crab _____
   (b) ocean temperature _____
   (c) lake water _____
   (d) dissolved oxygen _____
   (e) tides _____
   (f) seaweed _____

1.2 Ecosystems

I. Summary of Key Points

- The abiotic components of an ecosystem support the life functions of the biotic components of the ecosystem.
- Organisms within communities constantly interact to obtain resources such as food, water, sunlight, or habitat.
- Examples of these interactions in ecosystems include commensalism, mutualism, parasitism, competition, and predation.
- Every organism has a special role, or niche, within an ecosystem.

II. Study Notes

Parts of an Ecosystem

1. Within biomes are different ecosystems.
2. An **ecosystem** is a network of interactions linking biotic factors (organisms) and abiotic factors (air, water, soil, etc.).
3. Ecosystems can take up many hectares of land, such as the antelope brush grasslands of South Okanagan Valley, or can be small, such as a rotting log.
4. Within ecosystems are different habitats.
5. A **habitat** is where an organism lives, such as between the rocks at the bottom of a tidepool or in the bark of a rotting log.

Quick Check

1. Put the following divisions of life on Earth in order from the smallest to the largest:

   biome, biosphere, ecosystem, habitat

   _____
   _____
   _____
   _____

Abiotic Interactions in Ecosystems

1. Abiotic components of ecosystems include the following.
   - *Oxygen* is produced by the green plants and certain micro-organisms and is used by animals and most other micro-organisms.
   - Without *water*, no organism would survive. The cells of most living things contain between 50 and 90 percent water. Water carries nutrients from one place to another in an ecosystem.
   - ***Nutrients***, such as carbon, nitrogen, and phosphorus, are materials that organisms need to live and grow.
   - *Light* is required for **photosynthesis**, a chemical reaction that converts solar energy into chemical energy usable by plants. Photosynthesis provides energy to the ecosystem. The forest canopy receives more light than the forest floor; deep water receives less light than surface water.
   - *Soil* not only contains water and nutrients but also is home to many plants and animals.

Chapter 2 Energy flow and nutrient cycles support life in ecosystems.

2.1 Energy Flow in Ecosystems

I. Summary of Key Points

- In an ecosystem, energy flows from producers (plants) to primary consumers (herbivores) to secondary and tertiary consumers (carnivores).
- Food chains and food webs model this energy flow and these feeding relationships.
- Each step on a food chain is called a trophic level.
- Food pyramids model how energy is lost at each trophic level in an ecosystem.

II. Study Notes

How Energy Flows in Ecosystems

1. Within an organism's niche, the organism interacts with the ecosystem by:
   - obtaining food from the ecosystem
   - contributing energy to the ecosystem
2. The flow of energy from an ecosystem to an organism and from one organism to another is called energy flow.
3. Plants are called **producers** because they produce food in the form of carbohydrates during photosynthesis.
4. Organisms that feed on other organisms are called **consumers.**
   - A consumer may also be an energy source if it is eaten by another consumer.
5. Organisms contribute to energy flow even after they die.
   - **Biodegradation** is the process by which dead organic matter is broken down naturally by biological agents, especially bacteria.
   - **Decomposers** are organisms, such as bacteria and fungi, that change wastes and dead organisms into usable nutrients for other organisms in soil and water.

Quick Check

1. Plants use sunlight and nutrients to produce carbohydrates. What it the term that describes the role of plants in an ecosystem? _____
2. What does the term *energy flow* describe about an ecosystem? _____
   _____
3. What is the role of a decomposer in an ecosystem? _____
   _____
4. Describe each of the following as a producer, consumer, or decomposer (more than one may apply).
   (a) breaks down fallen leaves _____
   (b) does not need to consume other organisms to live _____
   (c) assists with biodegradation _____
   (d) is the first step in energy flow through an ecosystem _____
   (e) may consume another consumer _____

2.2 Nutrient Cycles in Ecosystems

I. Summary of Key Points

- Earth's biosphere is like a sealed terrarium in which all nutrients that support life and all wastes that are produced are constantly recycled within its boundaries.
- The carbon cycle, nitrogen cycle, and phosphorus cycle move nutrients into and out of terrestrial and aquatic ecosystems.
- Human activities such as land clearing, agriculture, industry, and motorized transportation can affect nutrient cycles.

II. Study Notes

The Cycling of Nutrients in the Biosphere and the Carbon, Nitrogen, and Phosphorus Cycles

1. Nutrients are chemicals that are required for plant and animal growth and other life processes.
   - All the nutrients that support life and all the wastes that are produced recycle through the biosphere.
2. Nutrients move through the biosphere in nutrient cycles, or exchanges.
3. Nutrients are accumulated in "stores" for short or long periods in Earth's atmosphere, oceans, and land masses.
4. Without interference, the amount of nutrients flowing into a store generally equals the amount of nutrients flowing out.
5. Human activities can upset the natural balance of nutrient cycles.
   Example: Clearing forest land for agriculture, roads, and cities reduces the total amount of carbon (in the form of carbon dioxide) taken from the atmosphere by plants.
6. 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.
7. Four essential chemical nutrients are:
   - carbon, oxygen, and nitrogen, which cycle between organisms and the atmosphere, and are found in proteins and DNA in every living organism
   - phosphorus, which cycles in from sedimentary rock

Quick Check

1. What does "nutrient" mean? _____
   _____
2. What is an example of human activity that can decrease the amount of carbon taken from the atmosphere by plants? _____
   _____
3. List four chemical elements that move through the biosphere as part of nutrient cycles.
   _____ _____
   _____ _____

2.3 Effects of Bioaccumulation on Ecosystems

I. Summary of Key Points

- Synthetic chemicals enter the environment in air, water, and soil.
- Plants take up some of these chemicals and the chemicals bioaccumulate in the fat tissues of herbivores and carnivores.
- Synthetic chemicals become biomagnified in food pyramids and harm organisms.
- Heavy metals such as lead, cadmium, and mercury also bioaccumulate in the environment and negatively affect organisms.
- Scientists are working to find ways to remove harmful environmental chemicals.
- In bioremediation, oganisms are used to help clean up chemical pollution.

II. Study Notes

Bioaccumulation

1. One of the biggest changes humans have made to the environment is the introduction of synthetic (human-made) chemicals.
2. **Bioaccumulation** is the accumulation of a substance, such as a toxic (poisonous) chemical, in various tissues of a living organism.
   - Many harmful chemicals cannot be decomposed naturally.
   - These chemicals can be eaten or absorbed and sometimes cannot be removed from the body of the organism effectively.
3. **Keystone species** are species that can greatly affect population numbers and the health of an ecosystem. Example: Salmon are a keystone species in many British Columbia forest ecosystems.
   - Salmon are an important food source for many animals, and their decaying bodies are a rich source of nitrogen for trees.
   - Salmon retain harmful chemicals in their body fat and transfer these chemicals to the other organisms.
4. **Biomagnification** is the process in which chemicals not only accumulate but become more concentrated at each trophic level.
   - At each level of the food pyramid, chemicals that do not get broken down build up in organisms.
   - When the consumer in the next trophic level eats organisms with a chemical accumulation, they receive a huge dose of the chemical(s).

Quick Check

1. What is bioaccumulation? _____
   _____
2. (a) How can the low-level presence of a harmful chemical stored in the body fat of salmons result in dangerously high levels of that same chemical in bears? _____
   _____
   (b) What is this process called? _____
3. Bears prey on salmon. The bears take salmon out of the water and into the forest. It has been estimated that bears leave half of the salmon that they catch on the forest floor. Explain why bears are a keystone species in British Columbia. _____
   _____
   _____

Chapter 3 Ecosystems continually change over time.

3.1 How Changes Occur Naturally in Ecosystems

I. Summary of Key Points

- Over time, living organisms have changed as the abiotic and biotic factors in their environments have changed.
- The process that makes change in living things possible is called natural selection.
- In natural selection, the best-adapted members of a species will survive and reproduce.
- Changes also take place in ecosystems.
- Ecological succession refers to changes that take place over time in the types of organisms inhabiting an area.
- There are two types of ecological succession: primary succession and secondary succession.

II. Study Notes

How Organisms Adapt to Change

1. **Natural selection** is the process, proposed by Darwin, where environmental factors favour the selection of fit individuals.
2. Sometimes, organisms are born with unique characteristics that give them an advantage within their niche.
   - A salmon with a slightly larger tail may be able to swim faster or farther in a river.
3. Individuals with advantages are better able to reproduce and pass along their traits.
4. Individuals with unfavourable characteristics have less chance to reproduce and pass along their traits.
   - A salmon with a smaller tail may never have a chance to spawn because it cannot swim to the correct location.
5. An example of natural selection is the Galapagos finch.
   - There are thirteen species of finches on the Galapagos Islands that developed from a single species on the mainland. Four species are shown in Figure 3.1.
   - Each species has unique characteristics, such as differently sized beaks, which allow it to thrive in its own niche and not compete with other finches for resources.
6. **Adaptive radiation** is the process by which members of a species adapt to a variety of habitats.

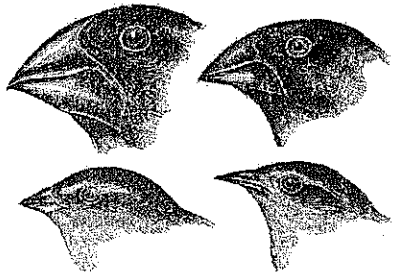

FIGURE 3.1 Illustration of beak differences in four Galapagos finches

3.2 How Humans Influence Ecosystems

I. Summary of Key Points

- A sustainable ecosystem provides economic opportunities today while maintaining biodiversity and ecosystem health for the future.
- Economic sustainability is threatened by habitat loss that results from human activities, such as urban development and deforestation.
- Other human activities, such as certain agricultural practices and overfishing, also change ecosystems, decrease biodiversity, and affect ecosystem health.
- Better resource management practices in activities such as forestry, agriculture, and mining can help sustain ecosystems.

II. Study Notes

Understanding Sustainability

1. A sustainable ecosystem provides economic opportunities today while maintaining biodiversity and ecosystem health for the future.
2. Human expansion into ecosystems has resulted in the destruction or fragmentation of habitats.
3. Aquatic ecosystems, such as wetlands and estuaries, include unique populations of plants, animals, and micro-organisms that are threatened by human expansion and the release of toxins (poisons) far upstream.
   - **Estuaries** are coastal bodies of water where rivers or streams (freshwater) meet the ocean (salt water).
   - Micro-organisms affected by human expansion include **phytoplankton** (plant-like micro-organisms) and **zooplankton** (animal-like micro-organisms), which are the basis of many aquatic ecosystem food chains.

The Effects of Land and Resource Use, Habitat Loss, and the Effects of Deforestation

1. **Deforestation** is the practice in which forests are logged or cleared for human use and are not replanted.
   - Deforestation of tropical rainforests continues at an alarming rate.
   - Deforestation reduces the number of plants and animals in an ecosystem and results in soil degradation.
2. **Soil degradation**, which means the soil becomes less healthy and less able to support life, occurs when water and wind erosion removes topsoil from bare land.
   - *Topsoil, the upper layer of soil, is where most of the nutrients, water, and air are found for plant growth.*

Quick Check

1. What does "sustainable ecosystem" mean? _____
2. Deforestation of tropical rainforests continues to occur. Give two negative effects of deforestation. _____
3. What is soil degradation? _____

3.3 How Introduced Species Affect Ecosystems

I. Summary of Key Points

- *Native species are organisms that naturally inhabit an area.*
- Introduced species are introduced into an ecosystem and are usually beneficial or harmless.
- Some introduced species are invasive and can destroy ecosystems.
- These species reproduce rapidly and are often aggressive.
- Lacking natural predators, they easily outcompete native species and alter habitats.

II. Study Notes

Native Species and Foreign Species

1. **Native species** are plants and animals that naturally inhabit an area.
2. **Foreign species** are organisms that people intentionally or accidentally have introduced into regions where they did not exist previously.
   - Foreign species are also called introduced species.
   - Many foreign species are harmless or even may be beneficial.
3. Invasive species are organisms that can take over the habitat of native species or invade their bodies, weakening their immune systems.
   Example: Purple loosestrife was brought to North America several hundred years ago and has destroyed wetlands because it quickly reproduces and chokes out other plants.
   - Introduced invasive species in British Columbia include Eurasian milfoil, Norway rat, American bullfrog, and European starling.

Quick Check

1. What is the difference between a native species and a foreign species? _____
2. What is the definition of an invasive species? _____

The Impact of Introduced Invasive Species

1. The rapid spread of introduced invasive species is a major cause of global biodiversity loss.
2. Invasive species often have high reproduction rates, are aggressive competitors, and lack natural predators in new habitats.
3. Invasive species often take advantage of their new habitat, resulting in their proliferation.
   - **Proliferation** means to grow or multiply by rapidly producing new tissues, cells, or offspring.
4. Foreign species can affect native species through:
   - *Competition:* Native species have an established balance in the competition for food and habitat, and the invasive species disturbs this balance. The European starling outcompetes British Columbia's western bluebird for nesting habitat.
   - *Predation:* If the invasive species is a predator, it may have a huge advantage since the native species may have no methods to survive against it. The Norway rat preys on British Columbia's ground-nesting birds, and the American bullfrog preys on British Columbia's native frogs.
   - *Disease and Parasitism:* By weakening certain species, a micro-organism invading an ecosystem can drastically alter the entire ecosystem and the niches within it.
   - *Habitat Alteration:* Some invasive species can change the physical structure of the ecosystem by digging, burrowing, blocking sunlight, or changing the ecosystem's chemistry. Eurasian milfoil forms wide, dense mats at lake surfaces, cutting off sunlight to organisms below. It grows from plant fragments, which are often spread by boats.