

## **Biology 18A**

### **Ecosystem**

**"And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth." - Ge 1:28**

#### **Questions considered in this topic**

What powers life? How do sunlight and nutrients affect the plants we depend on? How do greenhouse gases and other contaminants degrade the interactions among the plant, animal, and microbial populations that comprise ecosystems?

#### **Ecology**

1. The study of interrelationships between all living things and all nonliving factors in a defined area.
  - a. How organisms and non-living conditions influence and cause changes in ecosystems.
  - b. The flow and use of energy in ecosystems.
  - c. The history and predictability of ecosystem changes.
2. Ecology is the study of cause and effect relationships and dynamics involving organisms and their environment.
3. Ecosystems are geographical areas of biotic and abiotic components defined for experimental study.
4. Ecosystems can exist within ecosystems.
5. Ecosystems can be defined in your digestive tract, in your ears, on your skin, in your driveway, in the gutter, in a tree, in a forest, in a state, etc.
6. Ecosystems include all variables, living and non-living, such as weather, climate, terrain, biodiversity, nutrients, temperature, reproduction, food chain, pollution, etc.
7. Ecologists: Observe, interpret, and experiment to explain ecological relationships and recommend solutions to current and predicted problems.

#### **Abiotic environment**

1. Sometimes referred to as the physical factors
2. Factors include radiation, wind, atmosphere pressure, temperature, light, humidity, water, topography, gravity, precipitation, and soil.
3. Water/humidity: Deserts, oceans, lakes, ponds, rivers, subterranean
4. Atmospheric pressure: Ocean floor, sea level, mountain peaks
5. Temperature: Arizona desert; NW Arkansas; North Pole, AK
6. Topography: lay of the land: level, hilly, mountainous. Rocks, sand, gulleys, etc.
7. Gravity: earth and moon
8. Wind: Kansas, Oklahoma, Tahiti Islands
9. Seasonal cycles: temperature differences cause air mass differences, which cause frontal weather and change in precipitation cycles.
10. Precipitation causes erosion and change of the landscape.

#### **Biotic Community**

1. Communities are made of different **Populations**, which are made of individual **organisms**.
2. Communities refer only to living organisms. The abiotic environment is not included.
3. Ecosystem refers to the biotic and abiotic aspects of a defined area.

#### **Ecological hierarchy:**

1. Atoms, molecules, genes, cells, tissues, organs, organisms, species, populations, communities, ecosystems, biomes, biosphere, and Astroecology.

2. Biomes are ecosystems in similar climates regardless of geographical location. Similar climates give rise to similarities among the ecosystems. These similar ecosystems make up a biome. For example, the human biome is made of ecosystems in humans; the arid biome is made of ecosystems in arid climates. Other biomes include terrestrial, freshwater, marine, deserts, and forests, etc.
3. Zonation: Location of biomes based on common altitude, latitude, or temperature, moisture, etc.
4. Habitat: dwelling place of a population. Where it lives.
5. Ecological niche: the different roles of a population in an ecosystem. Its activity (eating, clearing, damming, etc.). Organisms can share a habitat but different niches.
6. Biosphere (*life, ball*) refers to the sum total of all ecosystems on earth.

### Population relationships

1. Symbiosis: the close interaction of different species living together.
2. Neutralism: no effect on each other
3. Amensalism: A population harms another while not being affected by the other.
4. Parasitism: A population that harms another while benefitting by the other over time.
5. Commensalism: One population benefits and the other is not significantly affected.
  - a. *Cymothoa exigua* (tongue-eating louse). Only known relationship where an organism replaces the organ of another.
6. Mutualism: Two populations benefit each other
7. Obligatory: dependent on each other
8. Competition: depend on the same food source
9. Predation: One population kills and eats another quickly that is usually smaller and more vulnerable than itself.

### Ecosystem dynamics

1. Energy flows irreversibly through ecosystems, but materials are recycled.
  - a. Energy is not recycled. It is used to sustain life and make recycling of materials possible.
  - b. The sun is the earth's primary energy source.
  - c. Energy flow keeps the wheel of resources turning and cycling like a paddle wheel in a river.
2. Energy flow is the means whereby materials are recycled.
  - a. O cycle, N cycle, C cycle, H<sub>2</sub>O cycle, etc.
  - b. Adam, George Washington, and you
    - i. Oxygen/Carbon cycle: Respiration (O<sub>2</sub>) by all life; Photosynthesis (CO<sub>2</sub>)
    - ii.  $C_6H_{12}O_6 + O_2 \rightleftharpoons CO_2 + H_2O$
  - c. Nitrogen cycle:
    - i. Nitrogen fixing bacteria in roots and soil (N<sub>2</sub> > Ammonia NH<sub>3</sub> > Ammonium NH<sub>4</sub>/Nitrate NO<sub>3</sub>). Lightening can also produce nitrate.
    - ii. Assimilation: Plants absorb Nitrates, nitrite ions, ammonium ions or amino acids, which are consumed by herbivores, which make organic Nitrogen such as protein.
    - iii. Ammonification: Death or waste involves bacteria or fungi converting organic nitrogen (such as protein) back to ammonium.
    - iv. Nitrification: Converts ammonium (NH<sub>4</sub>) to nitrate (NO<sub>3</sub>).
    - v. Denitrification: reduction of nitrates to nitrogen gas (NO<sub>3</sub> > N<sub>2</sub>)
3. Lightning storm or human activity causes forest fires and change ecosystems.
  - a. Effects: some pines will not release seeds until a fire & undergrowth cleared out.
  - b. Possible decrease or extinction of individuals, populations, communities.
  - c. Nutrient release, erosion vulnerabilities, and microbial impact.
  - d. Soil texture change, humidity change, and temperature change
4. Excessive wind, ice and snow prevent growth of trees and change conditions in ecosystem to produce the **timberline**, the boundary where trees do not grow.

5. Currents in atmosphere or waters: caused by uneven heating on the earth's surface change conditions in ecosystems.
6. Volcanoes and other geothermal phenomena change ecosystems.
7. Ecosystems can change into new types of ecosystems such as sand dunes.

### Food Chain

1. The linear progression of five food consumption levels from producer to consumers.
  - a. **Primary producers** are autotrophs that convert solar energy into chemical energy.
  - b. First level **consumers** eat producers. These are herbivores.
  - c. Second level consumers eat herbivores. These are carnivores.
  - d. Tertiary level consumers eat the second level carnivores.
  - e. Quaternary level consumers eat the tertiary level consumers.
  - f. Decomposers consume dead organisms.
2. These levels of consumption are called trophic levels.
3. 90% of energy is lost (entropy) at each trophic transition.
4. **Food webs** diagram many food chains to show the direction of energy and food. Webs are more accurate descriptions of the complex interrelationships between food chains.
5. **Detritus** food chain: decomposing dead organic matter is vital to the recycling of elements back into the food chains.

### Ecological pyramids

1. A quantitative representation of the numbers of organisms, their energy relationships, and their biomass in an ecosystem.
2. Pyramid arrangement of **population** sizes shows that the number of organisms decreases as trophic levels increase.
3. Pyramid arrangement of **energy** shows that decrease in chemical as trophic levels increase.
4. Pyramid arrangement of **biomass** quantity shows a decrease dry material mass of organisms as each trophic level increases.

### Cause and effect relationships governed by intelligently designed laws makes outcomes predictable.

1. Belief in Jesus Christ and the Bible opened the doors to scientific discovery and the industrial revolution.
2. Sir Isaac Newton: "This most beautiful system of the sun, planets, and comets, could only proceed from the counsel and dominion of an intelligent and powerful Being....This Being governs all things, not as the soul of the world, but as Lord over all; and on account of his dominion he is wont to be called *Lord God* "pantokrator," or *Universal Ruler*...."<sup>2</sup>
3. Sir Isaac Newton: "Since every particle of space is *always*, and every indivisible moment of duration is *everywhere*, certainly the Maker and Lord of all things cannot be *never* and *nowhere*...."<sup>3</sup>
4. Sir Isaac Newton: "Gravity explains the motions of the planets, but it cannot explain who set the planets in motion. God governs all things and knows all that is or can be done."<sup>5</sup>
5. Francis Bacon: "Small amounts of philosophy lead to atheism, but larger amounts bring us back to God."
6. Robert Boyle, "God [is] the author of the universe, and the free establisher of the laws of motion."
7. Johannes Kepler, "...Those laws are within the grasp of the human mind. God wanted us to recognize them by creating us after his own image so that we could share in his own thoughts... and if piety allow us to say so, our understanding is in this respect of the same kind as the divine, at least as far as we are able to grasp something of it in our mortal life."
8. Insights and predictions about ecological dynamics are possible because of intelligently designed laws that govern relationships in living and no-living systems.

### Man and the Biosphere

1. Human history
  - a. Unlike other living organisms, man has the ability to understand and choose how he will affect his environment.
  - b. Man is “in control” of the earth. God gave man dominion over the earth and everything in it to subdue it and to prevail over it.
  - c. Proverb 12:10 “A righteous man regardeth the life of his beast....”
  - d. There is a flow to human history driven by thought and knowledge because man acts on what he knows and believes.
  - e. Human activity affects the biosphere with agriculture, mining, urbanization, damming rivers, pollution, etc.
  - f. By linking observed events to preceding events, the serial progression of cause and effect in human activities reveals not only intellectual and social changes in humanity but ecological changes in the biosphere as well.
  - g. The wheel increased **productivity** with animal drawn carts and improved **military** tactics. It harnessed **energy** with water wheels, and advanced **technology** with spinning wheels and flywheels.
  - h. Industrial Revolution brought more widespread change with increased productivity, economic opportunity, transportation, agriculture, health, urbanization, and population with the harnessing of steam.
  - i. Adam Smith’s, *The Wealth of Nations*, promoted capitalism arguing that industrialization increases wealth for all, as evidenced by raised life expectancy, reduced working hours, and no work for children and the elderly. This continued changes taking place in the world.
  - j. Karl Marx, *The Communist Manifesto*, promoted socialism arguing that industrialization polarized society into the bourgeoisie (owners of businesses, factories and the land) and the proletariat (the working class). Feudal economy to capitalism to socialism to communism.
  - k. Romanticism opposed industrialism and promoted nature and natural activity in human culture.
  - l. Man’s way of thinking and his world view dictates the conclusions derived about priorities and actions to take in solving problems.
2. Lessons learned
  - a. The Australian Rabbit
    - i. Thomas Austin enjoyed rabbit hunting, 2) no natural predator, 3) proliferated like rabbits, 4) invaded grazing lands, 5) controlled with poisons, hawks, snakes, weasels, viral disease, mosquito vectors, 6) only 88% effective, 7) a resistant population grew.
  - b. Chemicals: DDT- biological magnification: plants -> worms -> birds. Consumers overloaded with DDT in tissues.
  - c. Biological pest control
  - d. Acid rain from industrial smoke stacks
  - e. Beijing smog problems
  - f. Nitrogen runoff from turkey farms leads to hypoxic conditions in lakes. Has caused ‘blue baby syndrome.’
  - g. Political manipulations and science scandals in Global warming debate
    - i. Global warming: man-made climate or man-made hype?
    - ii. Generalizes climate cycles over time.
    - iii. Heat sources: Sun, Volcanoes & other geothermal phenomena
    - iv. Heat retention: **green house** gasses in order of amount and influence: water vapor, carbon dioxide, methane, nitrous oxide, and ozone.
    - v. Average earth surface temperature since 1850 to 2010 increased by 1.53 degrees C according to the Intergovernmental Panel on Climate Change (IPCC).
    - vi. Scientists accused of climategate scandal to hide and misrepresent data associated with IPCC and Climate Research Unit (CRU). 1) censored

- date, 2) manipulated computer programming to prejudice predicted outcomes, and 3) attacked their critics and global warming skeptics.
- vii. “The most likely explanation for the lack of significant warming at the Earth’s surface in the past decade or so is that natural climate cycles—a series of La Niña events and a negative phase of the lesser-known Pacific Decadal Oscillation—caused shifts in ocean circulation patterns that moved some excess heat into the deep ocean.”<sup>1</sup>
  - viii. “The “pause” in global warming observed since 2000 followed a period of rapid acceleration in the late 20th century. Starting in the mid—1970s, global temperatures rose 0.5 °C over a period of 25 years. Since the turn of the century, however, the change in Earth’s global surface temperature has been close to zero.”<sup>1</sup>
  - ix. Little ice age from 1350 to 1850. Three warming trends occurred during this time.
  - x. Temperatures normal rise and fall. It is dishonest to choose the lowest temperatures to begin with and the highest temperatures to end with.
  - xi. The big question is: Is **man** capable of significantly affecting land, atmosphere, and oceans to alter the earth’s global climate?

### **Human stewardship in the biosphere**

1. Endangered species recovery efforts has saved bears, pelicans, the bald eagle, and many others. Biodiversity is sustained through these efforts.
2. What about humans? As human population increases, consumption of resources and production of waste increases.
  - a. Total land surface area of Earth is about 57,308,738 square miles: 24% is mountainous and about 33% is desert. This leaves about 15.77 billion acres of habitable land.
  - b. For 7 billion people that is 2.3 acres of land each.
3. What are the resource and waste limitations in our biosphere? What is the maximum level of consumption possible? What is the maximum level of waste that can be managed? How many people can the earth support? How much fresh water is available?
  - a. Sociobiologist Edward O. Wilson claims that Earth has a maximum carrying capacity of 9 billion to 10 billion people. (The Future of Life" (Knopf, 2002)
  - b. Claims that arable (usable to grow food) estimated to be 3.5 billion acres can feed 10 billion vegetarians, but would only feed 2.5 billion U.S. omnivores. But we currently have over 7 billion in the world.
  - c. "In truth, no one knows when or at what level peak population will be reached," population biologist Joel Cohen of Columbia University.
  - d. Fertility rate is falling to the "replacement level" — 2.1 children per woman
4. Ecological footprint: the measurement of individual human impact on the environment in the biosphere. This is used to compare consumption and to derive a standardization of living standards for humanity based on maximum use of resources. Standardization involves equalizing resources and living standards.
5. Human variables that affect their ecosystems
  - a. Agricultural space: energy and material resource measurement for human footprint can be measured in acreage per human. Sunlight energy captured per acre of earth surface is used to determine how much energy and resource is available for all living things on earth and humans. Increase yield of energy resource means increase in available energy to support life.
  - b. Population size and growth rate
  - c. Consumption of resources
  - d. Disease, medicine, and death
  - e. Dependent population v productive population
  - f. Housing
  - g. Transportation
  - h. Economy

- i. Technology for more efficient gathering and use of materials and energy.
- j. Waste production
- 6. Sustainability
  - a. The effort to minimize harmful human impact on ecosystems in order to sustain the health and vitality of ecosystems and human welfare.
  - b. Waste control: The 3 R's: Reduce, Reuse, Recycle
    - i. Biodegradable: decomposable materials
    - ii. Non-biodegradable: cannot be decomposed
  - c. Sewage: decomposers convert waste to reusable elements.
- 7. Politics and humanity
  - a. Decisions are only as good as the information known and thought about.
  - b. Man is not the problem. Bad choices and sin create problems.
  - c. Unequal distribution of wealth is not the problem. Sin is the problem.
  - d. Increasing human consumption and limited earth resources requires management of resources to sustain quality of life.
  - e. Decisions are being made to management humans by defining quality of life, how many children per family, how much money is enough, how much consumption is enough, how much lifespan is enough, etc.
  - f. Limited resources of earth acreage, materials, and energy conversion means that humans will be managed like cattle. All human variables will be standardized and regulated to sustain human life in a sustainable biosphere.
  - g. Will the Lord return before the human population consumes more than the earth can produce? Who will make the decisions that govern your life? Can you trust someone else to be fair to you?
  - h. How should a Christian live a socially engineered culture of human management?

---

<sup>1</sup>NOAA, November 8, 2013, <http://www.climate.gov/news-features/climate-qa/why-did-earth%E2%80%99s-surface-temperature-stop-rising-past-decade>

ACT sample questions

1. <http://www.bestsamplequestions.com/act-sample-questions/act-sample-questions-science/act-sample-questions-science.html>