Chapter 52: Ecology and the Biosphere

1. What is ecology?

Ecology is the scientific study of the interactions between organisms and the environment.

2. What are the different types of questions that might be studied by an ecologist at each level of the biological hierarchy?

Organismal ecology, which includes the subdisciplines of physiological, evolutionary, and behavioral ecology, is concerned with how an organism's structure, physiology, and behavior meet the challenges posed by its environment. A population is a group of individuals of the same species living in an area. Population ecology analyzes factors that affect population size and how and why it changes through time. A community is a group of populations of different species in an area. Community ecology examines how interactions between species, such as predation and competition, affect community structure and organization. An ecosystem is the community of organisms in an area and the physical factors with which those organisms interact. Ecosystem ecology emphasizes energy flow and chemical cycling between organisms and the environment. A landscape (or seascape) is a mosaic of connected ecosystems. Landscape ecologists focus on the factors controlling exchanges of energy, materials, and organisms across multiple ecosystems. The biosphere is the global ecosystem – the sum of all the planet's ecosystems and landscapes. Global ecology examines how the regional exchange of energy and materials influences the functioning and distribution of organisms across the biosphere.

5. What is biogeography? What factors determine the distribution of organisms?

Biogeography is the geographic distribution of species. Species distributions are a consequence of both ecological and evolutionary interactions through time. Dispersal, the movement of individuals or gametes away from their area o origin or from centers of high population density, contributes greatly to the global distribution of organisms. Some organisms do not occupy all of their potential range. When individuals seem to avoid certain habitats, even when the habitats are suitable, the organism's distribution may be limited by habitat selection behavior.

6. List and describe five examples of biotic factors in the distribution of species.

Often, negative interactions with predators or herbivores restrict the ability of a species to survive and reproduce. Sea urchins limit the distribution of seaweeds. The presence or absence of pollinators, food resources, parasites, pathogens, and competing organisms can act as a biotic limitation.

7. List and describe five examples of abiotic factors in the distribution of species.

Species distribution is influenced by water, oxygen and light availability, temperature, salinity, and geology. Environmental temperature affects biological processes. Cells may rupture if the water they contain freezes below 0ºC, and the proteins of most organisms denature above 45ºC. Terrestrial organisms face a nearly constant threat of desiccation, and the distribution of terrestrial species reflects their ability to obtain and conserve water. Water affects oxygen availability in aquatic environments and in flooded soils. Oxygen concentration can be particularly low in both deep ocean and deep lake waters and sediments where organic matter is abundant. The salt concentration of water in the environment affects the water balance of organisms through osmosis. Most aquatic organisms are restricted to either freshwater or saltwater habitats by their limited ability to osmoregulate. Most terrestrial organisms can excrete excess salts from specialized glands or in feces or urine.

Too little sunlight can limit the distribution of photosynthetic species. Most photosynthesis in aquatic environments occurs relatively near the surface. High levels of light can also induce temperature stress if animals and plants are unable to avoid the light or to cool themselves through evaporation. At high elevations, the sun's rays are more likely to damage DNA and proteins because the atmosphere is thinner, absorbing less UV radiation. In terrestrial environments, the pH, mineral composition, and physical structure of rocks and soil limit the distribution of plants, contributing to the patchiness of terrestrial ecosystems. The pH of soil can limit the distribution of organisms directly, through extreme acidic or basic conditions, or indirectly, by affecting the solubility of nutrients and toxins. In a river, the composition of rocks and soil that make up the substrate can affect water chemistry. In freshwater and marine environments, the structure of the substrate determines the organisms that can attach to it or burrow into it.

8. What is climate? What abiotic factors are its components?

The most significant influence on the distribution of organisms is climate, the long-term, prevailing weather conditions in a given area. Temperature, precipitation, sunlight, and wind are particularly important components of climate.

9. Explain how Earth's curvature and axis of rotation influence the amount of sunlight reaching a given area.

Earth's tilted axis of rotation and its annual passage around the sun cause strong seasonal cycles in middle to high latitudes. In addition to these global changes in day length, solar radiation, and temperature, the changing angle of the sun over the course of the year affects local environments. For example, the belts of wet and dry air on either side of the equator move slightly northward and southward with the changing angle of the sun, producing marked wet and dry seasons around 20º north and 20º south latitude, where many tropical deciduous forests grow. In addition, seasonal changes in wind patterns alter ocean currents, sometimes causing the upwelling of cold water from deep ocean layers. This nutrient-rich water stimulates the growth of surface-dwelling phytoplankton and the organisms that feed on them.

10. Why is the Pacific Northwest so rainy? What causes the Mediterranean climate?

Ocean currents influence climate along the coasts of continents by heating or cooling overlying air masses that pass across the land. Coastal regions are also generally wetter than inland areas at the same latitude. The cool, misty climate produced by the cold California Current that flows southward along western North America supports a coniferous rain forest ecosystem along much of the continent's Pacific coast and large redwood groves farther south. Conversely, the west coast of northern Europe has a mild climate because the Gulf Stream carries warm water from the equator to the North Atlantic.

Because of the high specific heat of water, oceans and large lakes tend to moderate the climate of nearby land. During a hot day, when land is warmer than the water, air over the land heats up and rises, drawing a cool breeze from the water across the land. In contrast, because temperatures drop more quickly over land than over water at night, air over the now warmer water rises, drawing cooler air from the land back out over the water and replacing it with warmer air from offshore. However, this local moderation of climate can be limited to the coast. In regions such as southern California and southwestern Australia, cool, dry ocean breezes in summer are warmed when they contact the land, absorbing moisture and creating a hot, arid climate just a few kilometers inland. This climate pattern also occurs around the Mediterranean Sea.

11. Explain the "rain shadow" effect.

Like large bodies of water, mountains influence air flow over land. When warm, moist air approaches a mountain, the air rises and cools, releasing moisture on the windward side of the peak. On the leeward side, cooler, dry air descends, absorbing moisture and producing a "rain shadow." This leeward rain shadow determines where many deserts are found, including the Great Basin, the Mojave Desert, the Gobi Desert, and the small deserts found in the southwest corners of some Caribbean islands.

12. What effect does elevation have on climate?

Mountains also affect the amount of sunlight reaching an area and thus local temperature and rainfall. South-facing slopes in the Northern Hemisphere receive more sunlight than north-facing slopes and are therefore warmer and drier. Every 1,000-m increase in elevation produces an average temperature drop of ~6ºC, equivalent to that produced by an 880-km increase in latitude. This is one reason that high-elevation communities at one latitude can be similar to those at lower elevations much farther from the equator.