CHAPTER 18

An Introduction to Ecology and the Biosphere

Part 1 • Levels of Ecology

An Overview of Ecology

• Ecology is the scientific study of how organisms interact with their environment.
• Environmental characteristics are classified into two major components.
  – Physical and nonliving chemical characteristics, such as temperature, soil moisture, or CO₂ availability, are called abiotic characteristics.
  – Any characteristics relating the environment to living organisms, such as population density or bacterial load, are called biotic characteristics.

Studying the Environment

• The first step in finding out about ecology is to discover and describe organisms’ natural history.
• This includes the discovery of new species and how they live.

Four Levels of Ecology

• (1) Organismal Ecology
  – This is the least inclusive level of ecology.
  – It exposes how well individual organisms cope with the challenges of their abiotic environment.

• (2) Population Ecology
  – At this level, ecologists study groups of individuals of the same species living in the same area.
  – Among the most important population-level factors are population density and growth.

• (3) Community Ecology
  – This is the study of species assemblages and their environmental interactions.
  – At this level, ecologists uncover how all the species in an area interact together, e.g. in a food web.
(4) Ecosystem Ecology
- This is the most inclusive and complex type of ecology since it includes both abiotic and biotic factors.
- Important observations include energy flow and chemical cycling.

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Part 2 • Abiotic Factors

Abiotic Factors
- Abiotic factors determine which type of organism can live where.
- These factors are not influenced by the organisms themselves.
- Even the human population has to deal with the abiotic factors in the environment we occupy.
  - In the desert we deal with heat and water loss.
  - In temperate climates we deal with seasons.

Energy Source—Sunlight
- The energy in all ecosystems can ultimately be traced back to the sun.
- Availability of sunlight affects aquatic and terrestrial environments.
  - A challenge in the water is light fading with depth.
  - On land shading by other organisms is a problem.
- In response, plants and animals have evolved many different adaptations to cope with sunlight, or its lack, especially in extreme environments.

Energy Source—Earth
- Hydrothermal vents provide chemotrophic bacteria with the energy needed to power an ecosystem.
  - These organisms use inorganic chemicals in light-independent processes similar to photosynthesis.

Temperature
- Environmental temperature has a critical effect on metabolism, especially in active thermoregulators.
- Some organisms have extraordinary adaptations for life at extreme temperatures, hot or cold.
Water

- Water exists in three forms on earth (solid, liquid, gas), and organisms need to be able to deal with those forms that occur in their environments.
- Freshwater organisms are in danger of picking up too much water and lysing their cells.
- Marine organisms have to balance their cells against the high salt concentration.
- For terrestrial organisms, the main water problem is the potential lack of water.

Nutrients

- Soil type and nutritional load defines which types of plants can survive in terrestrial landscapes.
  - Since soils are distributed patchily, so are the organisms that depend on them.
- The composition of the soil in and along streams and rivers affects their water chemistry.
  - Factors include soil structure, pH, and the availability of nitrogen and phosphorus
  - In aquatic systems, levels of dissolved $O_2$, salinity, and water movement are important.

Wind

- Wind patterns and storms can have a serious effect on organisms’ use of their environment or on their growth patterns.
- Many plants depend on wind to disperse pollen and seeds.
- Other organisms require wind to blow in nutrients.

Periodic Disturbances

- Catastrophic disturbances can have huge negative impact on biological communities.
  - Some of these disturbances are irregular and random (e.g., earthquakes, volcanism, fire).
  - Other disturbances have a certain degree of periodicity (e.g., hurricanes, tornadoes, floods).
- After a disturbance, ecological succession takes place.

Evolutionary Adaptations of Organisms

- In response to an environment’s ecology, certain adaptations come to the forefront.
- The continued interactions with an environment will select for certain phenotypes and against others.
  - Evolutionary adaptations are specializations to deal with the environment.
  - Abiotic factors change constantly, sometimes predictably (e.g., climate based on location, seasons) but often unpredictably (e.g., the day’s weather).
### Adjusting to Environmental Variability

- There is a limited set of options an individual has to deal with environmental conditions.
- An individual’s capacity to cope does not make an evolutionary contribution, since evolution manifests itself at the population level.
- The three areas of adaptation in which natural selection acts on a population are physiology, anatomy, and behavior.

### Physiological Responses

- Well-adapted organisms can quickly respond to abiotic fluctuations in their home environment.
  - Long-term abiotic changes require the ability to acclimate, which requires **physiological plasticity**.
  - **Acclimation** is gradual and reversible.
- Among vertebrates, birds and mammals can tolerate the greatest temperature extremes because they are endotherms; reptiles are ectotherms and have limited cold-tolerance.

### Anatomical and Behavioral Responses

- There are many anatomical features that allow organisms to cope with environmental challenges.
  - These include changes in body shape or the evolution of specific anatomical features.
  - Some of these may be reversible (e.g., winter fur).
- Most behavioral adaptations are limited to animals since plants lack the ability to move around.
  - These adaptations include localized movement (e.g., sun to shade), seasonal migrations, specialized mating, and changing of food sources.