Physiological Ecology – Learning Outcomes

Chapter-wide learning goals:

1. Explain how physiological limits can affect species distributions.
2. Explain how the process of adaptation can expand a species' range by changing physiological tolerances.
3. Defend the assertion that temperature and water availability drive plant distributions.
4. Compare and contrast mechanisms used by plants and by animals to avoid heat stress.

Section 1: Climate, Biomes, and Species Distributions

1. Explain why the structure and morphology of the plants in some geographically distant communities are more similar than those from communities that are located more closely together.
2. Explain why temperature and precipitation are so important for understanding the distribution of biomes.
3. Sketch Whittaker's diagram, showing how the type of biome found in an area varies with average temperature and precipitation.
4. Explain why there are no communities in the upper-left corner of Whittaker's diagram.
5. Define potential evapotranspiration (PET) and actual evapotranspiration (AET), and explain how each is affected by temperature and precipitation.
6. Determine monthly potential evapotranspiration and actual evapotranspiration from a climate diagram.
7. Generate hypotheses about the factors that potentially limit a plant species' geographic range using climate diagrams.
8. Draw a graph illustrating how an individual organism's performance (e.g., photosynthetic rate) varies with temperature.
9. Discuss some of the other variables, in addition to temperature and precipitation, that can affect the performance and distribution of plant species.
10. Describe a data set that supports the hypothesis that changes in climate lead to changes in species distributions.

Section 2: Acclimation and Adaptation

1. Compare and contrast adaptation and acclimation as potential mechanisms by which a species might respond to environmental change.
2. Explain how temperature affects enzyme function.
3. Draw a graph illustrating how enzyme activity tends to vary with temperature.
4. Provide an example of a mechanism (e.g., temperature-driven changes in gene expression) by which an individual acclimates.

5. Describe some of the factors limiting an individual's ability to acclimate to changes in their environment.
6. Describe irreversible acclimation.
7. Explain how a population may adapt to an environmental change via the mechanism of evolution by natural selection.
8. Describe some of the factors limiting a population's ability to adapt to environmental change.
9. Show how acclimation and adaptation (and their limits) can affect a species' range.
10. Design an experiment (e.g., common garden) to determine whether an observed difference between two related populations is a result of acclimation or adaptation.

Section 3: Homeostasis

1. Show how a generic budget can be used to determine whether an individual is maintaining homeostasis.
2. Analyze an individual's water budget to determine its most important water sources and losses.
3. Explain each term (i.e., ingestion, metabolic water, osmotic exchange, secretion, and evaporative loss) in an animal's water budget.
4. Describe some adaptations that enable both terrestrial animals and aquatic organisms to maintain water balance.
5. Explain how the trade-off between evaporative water loss and evaporative cooling link an organism's water and heat budgets.
6. Show how an animal's mode of thermoregulation can be described based on the degree to which it is poikilothermic vs. homeothermic and ectothermic vs. endothermic.
7. Explain each term (i.e., absorbed solar radiation, metabolic heat, net thermal radiation, conduction, convection, and evaporation) in an animal's heat budget.
8. Analyze an individual's heat budget to determine its most important heat sources and losses.
9. Describe some physiological adaptations and behaviors that allow animals to modify body temperature by adjusting various heat budget terms.
10. Assess how an organism's surface area affects (or doesn't) the various terms in its heat budget.
11. Explain how countercurrent exchangers allow animals in hot or cool climates to manipulate their heat budgets to maintain performance.

Section 4: Metabolism

1. Describe the trade-off implicit in the statement: Plants "buy" CO_2 by transpiring H_2O.
2. Contrast the costs and benefits associated with the three photosynthetic systems (C_3, C_4 and CAM) that have evolved in plants.
3. Explain the chemical processes of photosynthesis and respiration ($6\ CO_2 + 6\ H_2O \leftrightarrow C_6H_{12}O_6 + 6\ O_2$), indicating when energy is stored and when it is released.
4. Describe how transpiration moves water though a plant.

5. Discuss how relative humidity, plant height, soil composition, and soil salinity interact to determine transpiration rate and cavitation risk.
6. Describe the key role of the light-dependent reactions (i.e., energy capture) and the Calvin cycle (i.e., sugar synthesis), including an explanation of the role of rubisco.
7. Define photorespiration and explain how it can limit photosynthetic rates when the ratio of CO_2 to O_2 is relatively low and/or temperatures are high.
8. Describe the distinct ways in which C_3, C_4, and CAM plants can limit photorespiration, and the conditions under which each photosystem is likely to be most effective.
9. Explain the geographic distribution of C_3 and C_4 plants in terms of the relative costs and benefits of each in different environments.