Chapter-wide learning goals:

1. Explain how physiological limits set by temperature and/or precipitation can affect species distributions.
2. Compare and contrast adaptation and acclimation as potential mechanisms by which a species might respond to environmental change.
3. Use a heat budget to illustrate how an individual maintains homeostasis.
4. Contrast the trade-offs associated with the three photosynthetic systems (C3, C4 and CAM) that have evolved in plants.

Section 1: Trade-Offs and Species Distributions

1. Discuss the characteristic relationship between temperature and performance across a range of biological scales from enzymes to species.
2. Predict whether a species would be successful in an area, given data on the physiological tolerances of the species and environmental data for the area.
3. Explain why temperature and precipitation do such a good job of predicting the distribution of plant communities.
4. Name the two environmental variables that most broadly explain where plants and plant communities are found.
5. Discuss some of the other variables, in addition to temperature and precipitation, that can affect the performance and distribution of plant species.
6. Describe a data set that supports the hypothesis that changes in climate lead to changes in species distributions.
7. Sketch Whittaker's diagram showing how the type of plant community found in an area varies with average temperature and precipitation.
8. Explain why there are no communities in the upper-left corner of Whittaker's diagram.
9. Generate hypotheses about the factors that potentially limit a plant species' geographic range using climate diagrams.
10. Explain the relationship between temperature and potential evapotranspiration.
11. Determine when temperatures are below freezing using a climate diagram.
12. Determine the potential evapotranspiration from a climate diagram.
13. Draw a graph illustrating how individual performance (especially performance of ectotherms) varies with temperature across a variety of variables including growth rates, locomotion, adult body size and, in some cases, sex.
14. Define a species' fundamental niche based on the species' physiological tolerances.
15. Provide an example of how temperature could limit the distribution of an ectotherm, like a lizard, by affecting its performance.

Section 2: Adaptation and Acclimation

1. Draw a graph illustrating how enzyme activity tends to vary with temperature.
2. Discuss the characteristic relationship between temperature and performance across a range of biological scales from enzymes to species.
3. Describe some of the limits individuals face when attempting to acclimate to changes in their environment.
4. Describe an example of a mechanism that allows individuals of some species to acclimate to changes in some environmental variable.
5. Provide an example of irreversible acclimation.
6. Describe some of the limits populations face as they adapt to a changing environment.
7. Explain how evolution by natural selection could allow a population to maintain performance as some aspect of its environment changes.
8. Provide contrasting examples to show that, while individuals sometimes benefit from acclimation, they sometimes do not.

9. Design an experiment to determine whether two subpopulations have acclimated or adapted to their respective environments.
10. Evaluate results of experimental data from an experiment designed to distinguish between adaptation and acclimation.

Section 3: Homeostasis

1. Analyze the ability of an individual to modify its heat budget to maintain homeostasis.
2. Explain each term in an equation describing the heat budget for an organism.
3. Estimate the metabolic heat gain of a mammal or bird, given the appropriate equation.
4. Defend the hypothesis that mammals evolved to be homoeothermic in order to forage at night, when competition for food was minimal.
5. Estimate an animal's heat gain from absorbed radiation given its exposed area, solar radiation, and absorption coefficient, and the appropriate equation.
6. Provide examples of some of the adaptations that have evolved to help minimize (or maximize) the amount of solar energy individuals absorb.
7. Estimate the heat an object loses to the ground via conduction, given the appropriate equation.
8. Explain how an organism's surface area affects the energy it loses via re-radiation.
9. Explain how wind speed and surface area affect the energy lost via convection.
10. Explain how evaporation of water from a surface (e.g., skin or tongue) causes the surface to cool.
11. Explain how an organism's surface-to-volume ratio affects its heat budget.
12. Describe the behavioral choices animals make that allow them to avoid overheating, including how the various terms in their heat budget are affected.
13. Describe some of the adaptations that have evolved in plants that allow them to avoid overheating, including how the various terms in their heat budget are affected.
14. Analyze the ability of an individual to modify its water budget to maintain homeostasis.
15. Explain each term in an equation describing the water budget for an organism.
16. Describe some of the adaptations terrestrial animals have to minimize water lost via secretion.
17. Explain why many aquatic organisms have special adaptations to ensure that they don't gain too much water via absorption or, conversely, loose it via secretion.
18. Explain how animals can gain water by breaking down food.
19. Explain how the trade-off between water loss and evaporative cooling link an organism's water and heat budgets.

Section 4: Metabolism

1. Describe how C3 plants can limit photorespiration if water is abundant and why the strategy doesn't work when water is scarce.
2. Explain the stoichiometric equation that relates photosynthesis and respiration, including when energy is stored and when it is released.
3. Describe the key reactants and products of the light reactions in photosynthesis (i.e., water is consumed while NADPH, ATP, and O_2 are produced).
4. Describe the key reactants and products of the light-independent (dark) reactions in photosynthesis (i.e., sugar is produced as NADPH, ATP and CO_2 are consumed).
5. Explain how photorespiration can limit photosynthetic rates when the ratio of CO_2 to O_2 is relatively low and/or temperatures are high.
6. Describe how C4 photosynthesis helps plants cope with higher temperatures in dry environments.
7. Describe how CAM photosynthesis helps plants cope with desert environments.
8. Contrast how plants and animals acquire the energy and nutrients they need.
9. Explain why many plants form mutualisms with fungi known as mycorrhizae.
10. Draw a graph showing how the basal metabolic rates (total energy requirement per day) and mass-specific metabolic rates (energy requirement per kg per day) vary with body mass in mammals.
11. Discuss the trade-off plants face if they are to maximize their height and transpiration rates while avoiding the risk of cavitation.

12. Discuss challenges facing a plant attempting to photosynthesize in a given environment using the equation for water potential.
13. Explain why transpiration rates increase as atmospheric water potential drops (i.e., as relative humidity decreases).
14. Explain why the water potential at the top of the plant tends to decrease (become more negative) as the plant gets taller.
15. Explain why the water potential at the roots (and consequently at the top of the plant) drops (becomes more negative) as the proportion of very fine particles and/or concentration of salt increases in the soil matrix.
16. Explain how stomata can limit the risk of cavitation when atmospheric water potentials are particularly low (negative).
17. Summarize some of the trade-offs associated with the structure of a plant's xylem, paying particular attention to role of pit membranes.
18. Explain why cavitation is most likely when the difference between the potential at the top of the plant and the atmosphere is greatest.
19. Describe what happens when cavitation occurs.