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Investigating Fish Respiration

It is well known that a fish dies from lack of oxygen when taken out of water. However, water contains only 1/30 of the oxygen that is contained in air. In this activity you will investigate the mechanisms that enable fish to remove oxygen from water.

A freshwater fish that has a mass of 100 grams needs the equivalent of 5 cubic centimeters of oxygen (5 cc O_2) each hour, when at rest. When active, it needs four times that amount, or 20 cubic centimeters of oxygen each hour (20 cc O_2).

Humans can absorb oxygen from air drawn into their lungs. Fish, however, must absorb oxygen that is dissolved in water by passing the water over their gills. Because water is 1000 times denser than air, fish must use a large amount of energy to move enough water over its gills to supply its oxygen needs.

1. Only 2 percent of the oxygen intake in humans is used by respiratory muscles. Do you think the percent of oxygen used by respiratory muscles in a fish is higher or lower than this?

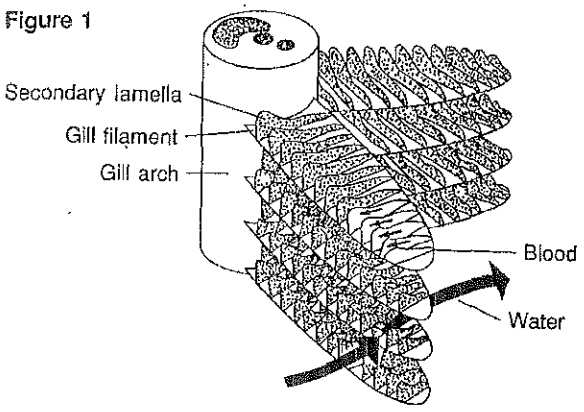
Explain. _____

_____

_____

The rate at which fish remove oxygen from water depends on the flow of blood in the gills and on the amount of water flowing over the gills. Examine Figure 1, which is a diagram of a fish's gill structure. The large arrow indicates direction of water flow. Small arrows show direction of blood flow.

Figure 1



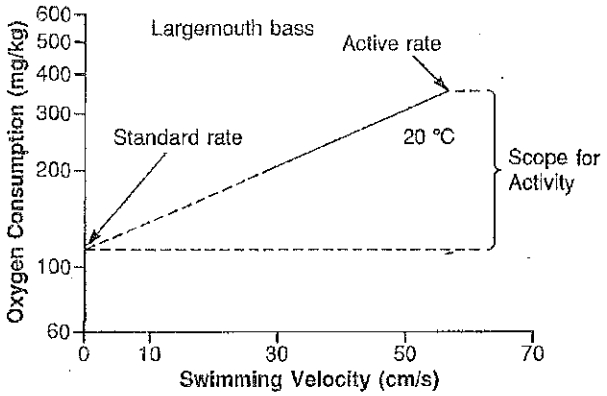
2. Through which structure does the blood flow? _____

3. What is the direction of blood flow in relation to the direction of water flow over the gills?

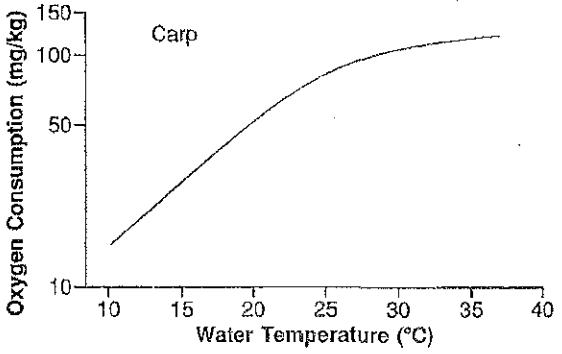
4. The rate of oxygen uptake by gills depends on the surface area, the number, and the thickness of the lamellae across which oxygen must diffuse. What are the two ways to increase the rate of oxygen uptake?

The rate at which fish consume oxygen can be affected by a number of factors. Examine graphs A, B, and C and answer the questions that follow.

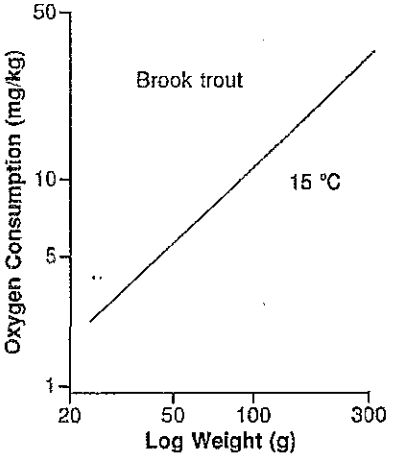
Graph A



Graph B



Graph C



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5. Examine Graph A. How does oxygen consumption vary with swimming velocity? Explain this relationship.

_____

_____

_____

6. How does oxygen consumption vary with water temperature in Graph B?

_____

_____

7. Explain why oxygen consumption varies with body weight.

_____

_____

_____

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5. Examine Graph A. How does oxygen consumption vary with swimming velocity? Explain this relationship.

6. How does oxygen consumption vary with water temperature in Graph B?

7. Explain why oxygen consumption varies with body weight.

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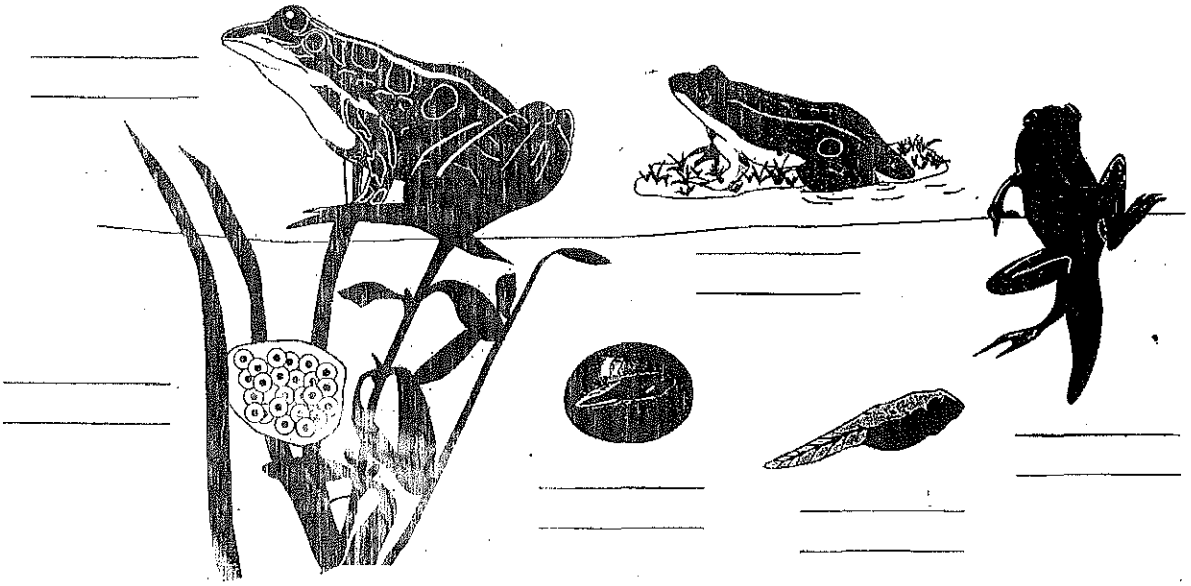
Form and Function in Frogs

Amphibians are descendants of ancestral organisms that evolved some, but not all, of the adaptations necessary for life on land. Although many of these animals spend a great deal of time on land, most of them are restricted to moist areas, and nearly all of them must return to water to breed. In this activity, you will study the form of frogs to see why they must live near water in order to function.

Figure 1 shows the life cycle of a frog. On the lines provided under each stage in the frog's life cycle, describe what is happening.

Figure 1



1. List the adaptive advantages of the tadpole stage and of the adult stage in the frog's life cycle.

2. Describe how the digestive system of the adult frog differs from the digestive system of the tadpole.

3. Differentiate between the respiratory system of the adult frog and that of the tadpole.

4. What is the main difference between the circulatory system of the adult frog and the circulatory system of the tadpole?

5. Animals that live on land usually reproduce by internal fertilization. Frogs reproduce by means of external fertilization. How does external fertilization rely on water?

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CHAPTER 32
Reptiles and Birds
Section 32-2

SKILL ACTIVITY
Drawing conclusions

Investigating How Reptiles Regulate the Temperatures of Their Bodies

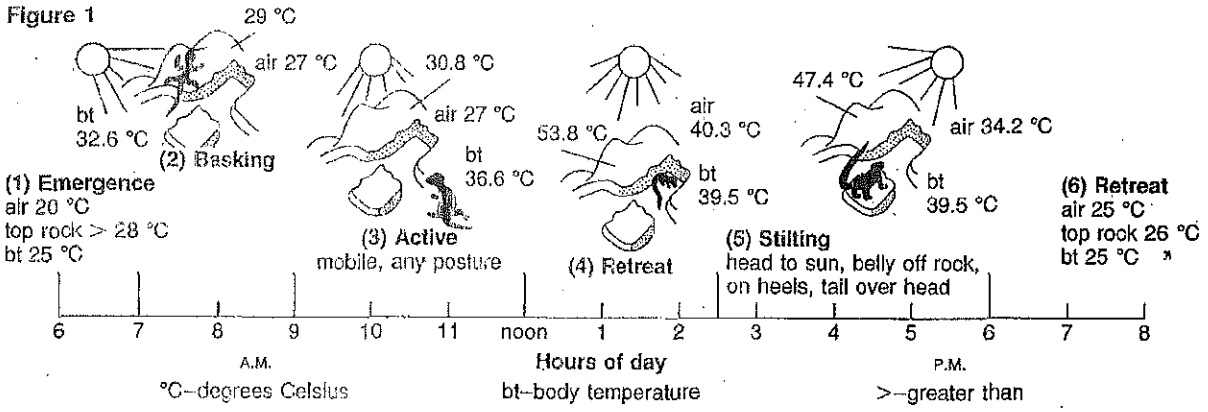
Reptiles are ectotherms. Their body temperatures are influenced by changes in the temperature of their environment. In this activity you will determine how a reptile's behavior helps to maintain its body temperature.

Reptiles have relatively low metabolic rates when they are resting. They do not generate much heat inside their bodies. Because the scales that cover their bodies do not provide good insulation, they lose heat quickly to their surroundings. In order to control their body temperature, therefore, these animals must pick up heat from the environment.

Examine Figure 1. It shows the daily temperature-regulation behavior of a lizard called an agamid. An agamid is a small lizard that lives in the deserts of Australia.

Use Figure 1 to help you fill in the chart below.

Figure 1



Activity	Hour of the Day	Body Temperature (°C)	Air Temperature (°C)	Body Temperature Minus Air Temperature (°C)	Rock Surface Temperature (°C)
1. Emergence	6:00 A.M.	25.0	20.0	5.0	28.0
2. Basking					
3. Active					
4. Retreat					
5. Stilting					
6. Retreat					

1. Many reptiles, including agamids, lie in the sun to warm themselves. Examine Figure 1. The agamid is shown in a flat position with its back turned toward the sun. Explain how the agamid speeds up the heating of its body by lying in this position.

2. The agamid also keeps its belly to the rocks when it basks. How could this behavior speed up heating?

3. What is the agamid's body temperature when it is active?

4. At which time of day is the agamid most active?

5. During which time of day does the greatest difference occur between body temperature and air temperature?

6. Is it easier for the agamid to warm its body to a temperature above that of the air temperature or to cool its body to a temperature below that of the air temperature?

7. How does retreating help the agamid to cool its body temperature?

8. Stilting is a behavior that allows the agamid to remain exposed to the sun even when air temperatures are high. In stilting, the reptile's ribs are pulled in, and its tail is raised. The reptile faces the sun and holds its belly off the ground. How does this behavior help the agamid to keep its body temperatures down?

9. What is the difference between the body temperatures of the agamid during activity and during the night?

10. Why is it not important for the agamid to maintain a high body temperature at night?

11. Keeping the body temperature of captive agamids at a constant 36°C causes harm to the animals. Agamids seem to need a "resting period" during the night in order to stay healthy. If you were a zookeeper, what would you include in the ideal artificial habitat for agamids?

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Exploring Body Temperatures of Birds

Birds are uniquely adapted to their lifestyles in a number of ways. One useful adaptation is the ability of birds to maintain body temperatures within a very limited range, regardless of the temperature of the air around them. In this activity you will examine both the body temperatures and the heartbeat rates of birds.

Birds, like mammals, are endotherms that have relatively high metabolic rates and generate a significant amount of heat, even when they are resting. Birds, however, have higher body temperatures than other animals do. The body temperatures of most mammals are between 35 °C and 40 °C. Amphibians can have body temperatures between 10 °C and 26 °C. The normal range of body temperatures for birds is between 38 °C and 45 °C. This enables birds to remain active throughout a wide range of climates.

Body temperature in birds varies by several degrees during a 24-hour period. During their active part of the day, their temperature increases; when they are at rest it decreases. Look at the data shown in Table 1. It compares body temperatures during the active and inactive hours of the day for four species of birds. Use the data in Table 1 to complete the bar graph in Figure 1.

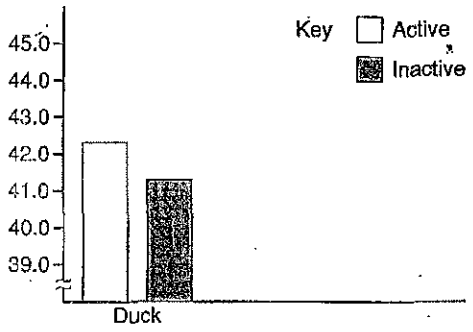
Table 1

Diurnal Cycles in Body Temperatures of Four Species of Birds (°C)

Species	Active Part of Day	Inactive Part of Day
Duck	42.2	41.3
Goose	41.4	39.9
Turkey	41.5	40.5
Pigeon	43.3	41.2

Figure 1

Comparison of Active and Inactive Body Temperatures (°C)



1. Suggest reasons why the temperature of a bird's body varies during the active and the inactive parts of the day.

_____

_____

_____

_____

2. When the air temperature drops, which characteristics of feathers help birds to keep warm?

Their warm body temperatures enable birds to have a very high metabolic rate. Compared to other vertebrates, birds eat more, move more, and take in more oxygen in proportion to their body mass. Birds have relatively large hearts in relation to their body mass. Their hearts also beat faster. Table 2 shows the relative body mass to heart rate for six species of birds.

Complete the graph in Figure 2 by plotting the points that represent body mass and heart rate for each of the six species of birds that are listed in Table 2. Label each point with the name of the species that it represents. Then, draw a smooth curved line that begins at the canary and ends at the turkey. This line will not connect all of the points. However, it will fall within all of the points and show a general relationship between body mass and heart rate. After completing the graph, answer the questions that follow.

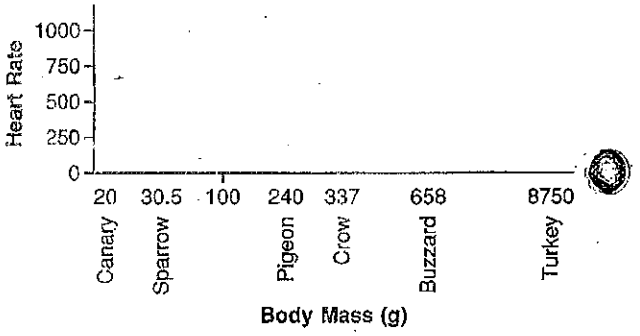
Table 2

Relative Heart Rate to Body Mass of Six Species of Birds at Rest

Species	Average Body Mass (grams)	Average Heart Rate (beats per minute)
Turkey	8750	93
Buzzard	658	301
Crow	337	342
Pigeon	240	192
Sparrow	30.5	460
Canary	20	1000

Figure 2

Relationship of Heart Rate to Body Mass in Birds



3. What is the relationship between body mass and heart rate of the birds in Figure 2?

4. Which behaviors of the six species might account for the advantage of this body mass/heart rate relationship?

5. How are the rapid heartbeats of birds related to their high body temperatures?

6. A bird that has a heart rate of about 150 beats per minute would have a mass located between which two birds on the graph? Show your answer on the graph.