Physiological and Behavioral Effects of Hyperinsulinism on Goldfish

OBJECTIVES

1. To observe the rapid, pronounced effect(s) that hormones can have on the body.
2. To increase an understanding of the value and significance of the body’s homeostatic mechanisms.

MATERIALS

Goldfish
Beakers
Insulin
Glucose solution (20% recommended)

The endocrine system is the second major controlling system of the body (the first is the nervous system). The role of the endocrine system is to alter the activity of body cells primarily through chemical changes induced through the glands of the endocrine system. These chemical “messengers” are referred to as hormones, and are typically released into the blood for transport throughout the body.

The origin of the word “hormone” is found in the Greek language with the meaning “to arouse” associated with the word. The body’s hormones arouse the body’s tissues and cells by stimulating changes in their metabolic activity. Hormones are quite specific. A given hormone affects only the biochemical activity of select organ or organ systems. Those tissues that respond to the effect of the hormone are referred to as the target tissues or organs.

The most widely understood relationship of the endocrine system with animal behavior is in the area of reproductive behaviors, and we will be examining the role of the reproductive hormones in a future lab. There are many other relationships that exist between the endocrine system and animal behavior. One easily observed interaction is seen in the study of the hormone insulin, and its effects on the homeostatic maintenance of behaviors.

Insulin, a hormone produced by the pancreas to decrease blood glucose levels, is found in virtually all vertebrates. When food is consumed and digested, glucose molecules enter the bloodstream and if enough food is eaten in a small period of time, elevation of blood glucose can occur. Without insulin, the levels of blood glucose can reach such elevated levels that there is great risk for cellular and tissue damage, especially within tissues of the nervous system.
Likewise, too much insulin in the body will cause glucose levels to plummet below normal levels. If the drop in insulin levels is not too severe, the organism will experience mild symptoms of fatigue, anxiety, tremors, and hunger. However, if the drop in glucose through very high levels of insulin grows more extreme, the organism can experience **insulin shock**. Insulin shock occurs when the blood glucose levels drop to such low levels that the brain is no longer sufficiently provided with glucose and begins to malfunction. Symptoms of insulin shock include disorientation, convulsions, unconsciousness, and if left untreated will result in death. Fortunately, we shall see that insulin shock is easily reversed by providing a rapidly metabolized form of glucose to those affected.

Many people with diabetes mellitus need injections of insulin to maintain blood glucose homeostasis. Therefore it is easy for us to use this available source of injectable insulin in behavioral experiments in our laboratory. We shall use goldfish to demonstrate the effects of hyperinsulinism on goldfish behavior. Since the action of insulin is similar in all vertebrates, we can make some generalized conclusions about our results with many other species.

There are three very distinct behavior patterns that can be observed in goldfish. One, **mouth gaping behavior**, is an indication of the fishes’ metabolism. As the metabolism of the fish increases, the mouth gaping behavior increases in goldfish. To observe mouth gaping behavior, researchers simply count the number of times a fish opens its mouth in a set time frame. A second behavior, **operculum movement**, is a behavior that signifies oxygen consumption in the animal. As the number of operculum movements increases in a given unit of time, it is associated with decreased overall oxygen within the body. The operculum movements are an attempt by the fish to increase the flow of water through the gills to increase oxygen absorption. The third behavior easily viewed in the goldfish is **pectoral fin movement behavior**. The movement of these fins, the “arms” of the fish, are vital for balance, directional movements, and maintenance of position in the fish. The number and quality of the fin movement signifies the overall physical state of the fish.

**Experimental Materials**

- goldfish
- insulin
- syringes and needles
- ice
- beakers
- white paper
- timers
- glucose solution

**Experimental Procedure — Normal Behaviors in the Goldfish**

What is the normal behavior pattern in goldfish?

1. Obtain a beaker and fill it with 1–1.5 cm of water.
2. Place one goldfish in the beaker. Allow it to acclimate for 5 minutes.
3. Begin observing the behavioral patterns of the fish in the following order: mouth gaping, operculum movements, pectoral fin movements. Observe each behavior for a period of two minutes. Have each member of your group record these behaviors (this can be simultaneous or consecutive viewing ... you as a group must decide and remain
consistent) and take an average of each set of data collected by individuals in your group. This average for a given behavior will represent the normal rate of each of these behaviors in the goldfish.

4. Repeat the above steps for two other fish.

Experimental Procedure — Behaviors in the Goldfish Exposed to Insulin

What effect will high insulin levels have on the goldfish and its behaviors?

1. Into the beaker of fish you examined in the experiment above, inject 1 ml of insulin into the water surrounding the fish.

2. Repeat steps 3 & 4 above (in experiment 1) and record the behaviors of the fish.

3. Pour into the beaker, 50 ml of sucrose solution. After waiting 2 minutes, again record the behaviors of the fish.

Experimental Procedure — Behaviors in the Goldfish Exposed to Insulin and Cold

What effect will high insulin levels have on the goldfish and its behaviors if the fish are in a cold environment? How will this compare to the room temperature environment?

1. Recreate the situation outlined in the first experiment in steps 1 & 2. However, this time, place the beaker in a bowl containing a quantity of ice.

2. Repeat the steps outlined in experiment two (steps 1–3) for insulin exposure.

3. Record the temperature of the water in which the fish is residing.
QUESTIONS

1. Why is it important to have multiple observations of the same fish that you average?

2. What conclusions can you draw from your results about the action that insulin has on each of the behaviors recorded in the fish?

3. To generalize, what can you say about the overall behavior of the fish in each of the three experiments? How can you compare and contrast them?
4. How has cold altered the effect of insulin on the fish? How has cold altered the effect of recovery in the fish?

5. Create one additional study you feel would be a beneficial addition to this laboratory exercise.