LABORATORY EXERCISE:
THE ENDOCRINE PHYSIOLOGY OF RATS

OBJECTIVE

Determine the identity of an unknown hormone by observing the effect it had on the organs of a male rat.

BACKGROUND INFORMATION

The command center for the endocrine system is the **hypothalamus**, a small, penny-sized portion of the brain. The hypothalamus acts as an endocrine organ that secretes oxytocin and anti-diuretic hormone (**ADH**, also known as vasopressin). These hormones travel down the pituitary stalk to the posterior pituitary gland where they are released directly into the bloodstream. In addition, the hypothalamus also regulates anterior pituitary gland function through the secretion of releasing hormones: thyroid-releasing hormone (**TRH**), corticotropin-releasing hormone (**CRH**), and gonadotropin-releasing hormone (**GnRH**).

These releasing hormones travel through a specialized blood vessel system that connects the hypothalamus to the anterior pituitary gland. From here, they stimulate the synthesis and secretion of anterior pituitary hormones, which include thyroid-stimulating hormone (**TSH**), luteinizing hormone (**LH**), follicle stimulating hormone (**FSH**), growth hormone (**GH**), adrenocorticotropin hormone (**ACTH**), and prolactin. Each of these hormones is released into the bloodstream to affect specific target organs. This relationship is illustrated in Figure 1.

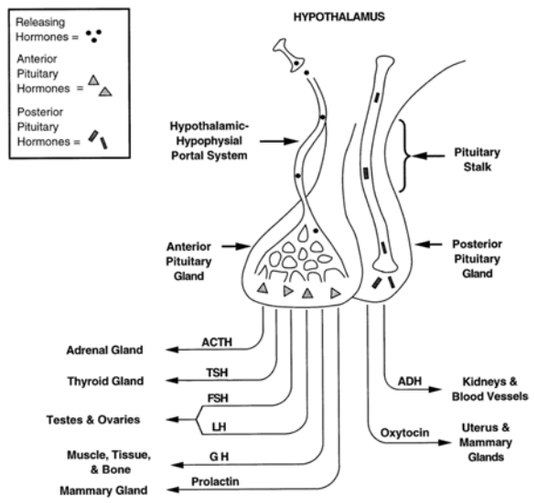

FIG. 1

CHECK YOUR UNDERSTANDING

1) Describe the relationship between the hypothalamus and the anterior pituitary gland.
2) List the hormones released by the anterior pituitary gland.
3) Why is the anterior pituitary called the master gland?
4) What is negative feedback?

FEEDBACK INHIBITION

In the endocrine system, **negative feedback** is used to inhibit further hormone secretion. When a sufficient amount of hormone has been released, it communicates or "feeds back" to suppress the releasing organ. In other words, the gland has released enough hormone to fulfill its function; this is sensed by the body, and production of the hormone ceases. Negative feedback not only inhibits the releasing organ, but can also inhibit the pituitary gland and/or hypothalamus. By using a negative feedback system, the body produces only the amount of hormone it needs without wasting its resources. Conversely, in **positive feedback**, the end product further stimulates the releasing organ. This form of feedback is less common.

THYROID HORMONE

The hypothalamus releases TRH, which travels to the anterior pituitary gland via the bloodstream to stimulate production of TSH. TSH travels to the thyroid gland (located by the trachea) to stimulate the production and release of **thyroid hormone**. Thyroid hormone influences the growth rate of many body tissues and is necessary for proper central nervous system development. Its main function is to increase a person's basal metabolic rate (BMR) and to increase heat production. An excess of thyroid hormone can negatively feed back to inhibit further thyroid hormone release from the thyroid gland, TSH secretion from the anterior Pituitary gland, and/or TRH release from the hypothalamus.

CORTISOL

Similarly, ACTH is released from the anterior pituitary gland in response to CRH secreted from the hypothalamus. ACTH stimulates the adrenal glands (located on top of the kidneys) to secrete **cortisol**, which promotes the breakdown of proteins and fats and helps the body adapt to stress. Cortisol functions to provide the body with fuel by breaking down (catabolism) the materials of the body. Under normal conditions, excess cortisol in the bloodstream will negatively feed back to the hypothalamus (to inhibit CRH release), anterior pituitary gland (to inhibit ACTH secretion), and/or to the adrenal gland (to inhibit further cortisol release). The release of CRH is regulated by negative feedback, circadian rhythms, and stress. Cortisol can also act as an immune-suppressive and anti-inflammatory agent. If cortisol is administered in large doses, its immunosuppressive properties will cause the organs of the immune system to shrink. In this experiment, the THYMUS GLAND will represent the organs of the immune system.

CHECK YOUR UNDERSTANDING

5) Describe the effects of thyroid hormone.
6) Describe the effects of cortisol.
7) Describe the role of LH in males and females.

TESTOSTERONE

LH is released from the anterior pituitary gland in response to GnRH secreted from the hypothalamus. LH is seen in both males and females but has different functions. In the male, LH travels to the Leydig cells that are located in the connective tissue between the seminiferous tubules of the testes. The Leydig cells release **testosterone**, which is responsible for the male sex drive and secondary

sex characteristics, such as increased body hair and a deeper voice. It also has the effect of activating the prostate gland, and the seminal vesicles, which are the structures that add nourishing fluids into semen. An excess of testosterone can cause an increase (anabolic) in muscle mass. Negative effects of testosterone are male pattern baldness and increased secretion of the sebaceous glands, which can lead to acne. Figure 2 presents the relative anatomy of the male reproductive tract.

To simplify the relationship between the reproductive and endocrine systems, we will concentrate only on the male system. The female reproductive system is more difficult to study than the male reproductive system because it is continuously cycling.

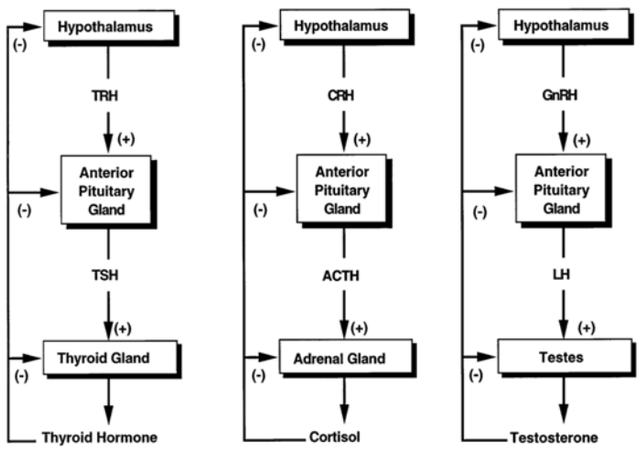

FIG. 3

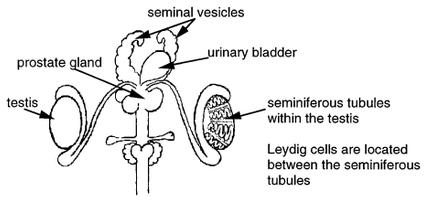

FIG. 2

The pathways of all three hormones under study can be understood by looking at a visual representation in Fig. 3.

EFFECTS OF OVER- AND UNDERSTIMULATION

The glands and tissues of our body enlarge (increase in size) if they are continuously activated; this is called **hypertrophy**. For example, a person who lifts weights will continually stimulate the activated muscles, resulting in hypertrophy. This can be easily observed when comparing a bodybuilder to an average person; the bodybuilder's muscles appear larger in comparison.

In contrast, if a gland or tissue is continuously inhibited it will shrink in size or **atrophy**. For example, if a cast is placed on a person's arm for 6 weeks and then removed, a drastic reduction in muscle mass can be seen. The cast prevented any movement (stimulation) of the limb, allowing atrophy to occur.

LABORATORY PROCEDURE

The data for this laboratory were compiled from sets of male rats, two rats per set. In each set, there was an "intact" rat and a "castrate" rate. The castration involved removal of the testes to eliminate testosterone production. The two rates (intact and castrate) of each group were treated alike in all other ways (food, water, etc.). All rats, except for those in the CONTROL group were injected with a hormone on a daily basis for six weeks, after which they were humanely sacrificed. Autopsies were performed on the animals at that time. It is up to you to analyze the autopsy data in order to determine which hormone (TRH, TSH, ACTH, cortisol, testosterone, or LH) was injected into the rats.

PRE-LAB WORK

Use your knowledge of hormonal regulation to predict the effects of injecting rats with the hormones listed. Complete the table using the following symbols:

- increase in mass: +
- decrease in mass: -
- no change: *leave blank*

TABLE 1. Predicted hormonal effects on different organs

	TRH	**TSH**	**ACTH**	**cortisol**	**Testosterone**		**LH**	
					intact	castrate	intact	castrate
pituitary gland								
thyroid gland								
adrenal glands								
thymus gland								
testes						*n/a*		*n/a*
prostate								
seminal vesicles								
body weight								