

## Chapter 13

# The Endocrine System

- *The Endocrine System and Homeostasis*

(By Cameron McDonald & Jenelle Willcott)

- *Endocrine Glands*

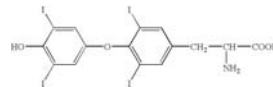
(By: Megan Stride and Bailey Ball)

*Biology 3201*

## 12.1

### Endocrine System & Hormones

❖ The endocrine system consists of the hormone producing glands and tissues in the body.



❖ What are hormones?

❖ hormones are chemicals that circulate throughout the blood and control organs and tissues in the body.

❖ When a hormone affects organs, those organs are known as target organs.

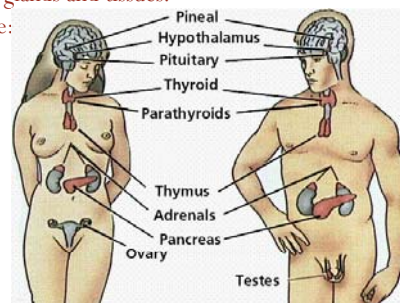
## Target Organs

- ❖ Each target organ is only affected by a particular hormone because of specific receptors on the surface of the target organ. Only a certain hormone can fit into this receptor.
- ❖ This is usually called the *lock – and – key hypothesis*
- ❖ The Endocrine System also plays a large role in the body's control of homeostasis. This system has a number of functions:
  - Control of heart rate
  - Control of Blood pressure
  - Control of immune response
  - Control of reproduction
  - Control of emotional state
  - Control of the overall growth and development of the body.

## The Endocrine System

- ❖ The endocrine system consists of many glands and tissues.
- ❖ Some of the glands that it consists of are:

- pituitary gland
- thyroid gland
- parathyroid gland
- adrenal gland
- thymus gland
- pineal gland



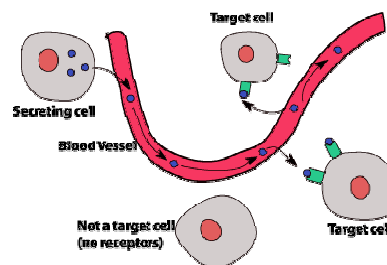
- ❖ It also contains the pancreas and reproductive tissues (ovaries and testes)
- ❖ Some other organs such as the liver, skin, kidney and parts of the digestive and circulatory systems produce hormones as well.

## Components of the Endocrine System

- ❖ There are two types of glands in the human body
  1. Endocrine glands
  2. Exocrine glands
- ❖ Endocrine glands are ductless glands which secrete their hormones directly into the bloodstream.
- ❖ Exocrine glands release their secretions through ducts or tubes
  - ❖ ie. Sweat glands, salivary glands and tear glands.
- ❖ Hormones carry the signals to one or more organs or tissues in the body causing a series or biochemical processes inside the target organ.
- ❖ Although only very small quantities of hormones are produced and secreted into the blood, their impact in the target is huge.

## Components of the Endocrine System

- ❖ Hormones which are secreted into the blood come into contact with virtually all cells and tissues as they circulate through the body.
- ❖ However, they trigger a response only in those cells which have specific receptor sites for the hormone.



## Factors In Hormone Production & Function

❖ The level of hormone production in the body can increase or decrease in response to changing metabolic needs in the body.

❖ A number of factors can affect this level:

- Fluid level
- Infection
- Physical injury
- Emotional stress



## Factors In Hormone Production

❖ The impact of specific hormone on a target tissue depends on a number of things:

- Hormone production and secretion
- Hormone concentration in the blood
- The rate of blood flow to a target organ
- The half – life of the hormone

❖ The Half life of a hormone is the length of time in which a hormone remains viable in the blood before it is degraded by the liver or other tissues. It can range from several hours to several days.

## Endocrine System Disorders

- ❖ Normal functioning of the endocrine system can be disrupted by many different medical problems.
- ❖ These medical problems include:
  - Tumors
  - infection
  - Autoimmune disease
  - Physical injury
  - Genetic disorders
  - Industrial pollutants
  - Food additives.



Example of a genetic disorder, premature aging disorder.

## Treatments

- ❖ There are some medical treatments for endocrine disorders. These include
  1. Hormone replacement therapy (more on this one later in Chapter 15)
  2. Medications which moderate endocrine activity (ie. Diuretics that reduce blood pressure by making you pee)
  3. Changes in diet
  4. Surgery to remove the affected tissue or organ

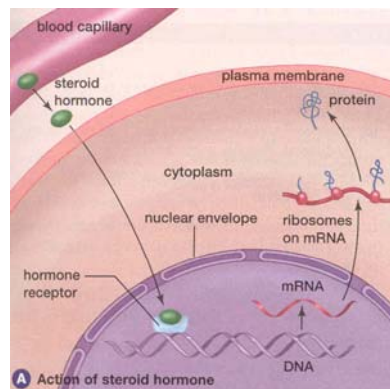


## Types of hormones

- ❖ **Antagonistic Hormones** are hormones which are produced by the endocrine system that can also interact with each other.
- ❖ The two types of hormones which are produced by the endocrine system are:
  1. Steroid hormones
  2. Non – steroid hormones
- ❖ Steroid hormones are made from cholesterol. Each type of steroid hormone is made of a central structure of four carbon rings attached to side rings of specific chemicals.

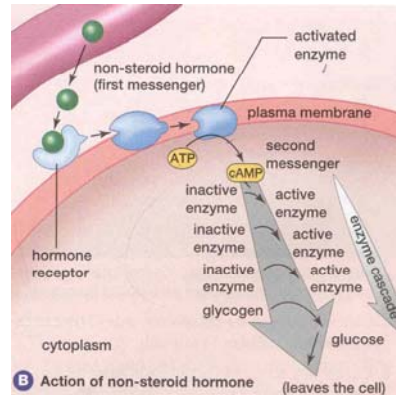
## Steroid Hormones

- ❖ Most steroid hormones are hydrophobic and are therefore carried throughout the bloodstream by a special carrier.
- ❖ Steroid hormones are fat soluble. This allows them to pass through the membrane of a cell where they bind to a receptor protein inside the nucleus. The hormone receptor structure then binds to DNA. This causes the activation of certain genes and protein synthesis.
  - ❖ An example of a steroid hormone is cortisol.



## Non-Steroid Hormones

- ❖ Non – steroid hormones are composed of either proteins, peptides, or amino acids. These substances are not fat soluble and thus do not enter cells. These substances are not fat soluble and thus do not enter cells. These hormones bind to receptors on the surface of target cells. This triggers a chain of chemical reactions within the cell.
- ❖ The *first messenger* hormones bring a message to the target cell when they bind to its membrane. After they bind with the cell's membrane, a special substance call *cyclic AMP* is produced, this is the *second messenger*. The second messenger is responsible for the chain of chemical reactions within the cell.



## Types of Non-Steroid Hormones

- ❖ There are a number of hormones which use second messengers to affect cells. These include:
  - Adrenaline
  - Adrenocorticotrophic hormone (ACTH)
  - Glucagon
  - Luteinizing hormone (LH)
  - Follicle stimulating hormone (FSH)
  - Anti – diuretic hormone (ADH)
 (We will look at the functions of each of these hormones later)
- ❖ Substances such as caffeine and nicotine are considered to be stimulants and can have an effect on the endocrine system. (See Page 426)

## 12.2 Endocrine Glands

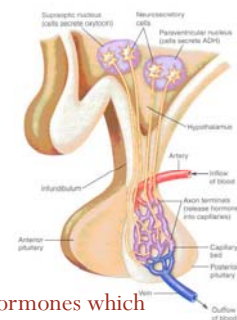
- ❖ Both the nervous system and the endocrine system are control systems which are used to help maintain homeostasis in the body.
- ❖ The nervous system uses bioelectrical signals that travel along the nerve cells while the endocrine system releases hormones into the bloodstream and these circulate throughout the body.
- ❖ The nervous system acts by using a rapid, short – lived response while the endocrine system produces a slow, longer response.



## Endocrine Glands

- ❖ These systems also work with each other. In fact the hypothalamus, a part of the nervous system, and the pituitary gland, a part of the endocrine system, control many critical physiological processes in the body. These include:

- Metabolism
- Kidney function
- Appetite
- Mental alertness
- Reproduction
- Growth and development

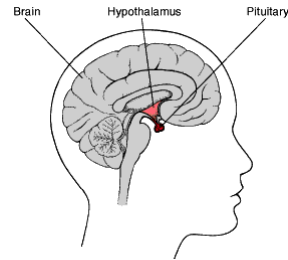


- ❖ The hypothalamus and the pituitary gland both release hormones which influence the activity of other hormone producing glands.



## The Pituitary Gland

- ❖ The hypothalamus is connected to the pituitary gland by a network of blood vessels called a portal system.
- ❖ This allows the nervous system to exert its control over the hormones produced in the pituitary gland and other endocrine glands.

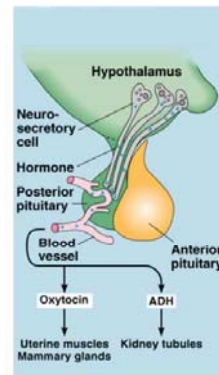


## The Pituitary Gland

- ❖ The pituitary gland is referred to as the master gland because it produces hormones which control the production of hormones in other endocrine glands. These hormones are called tropic hormones.
- ❖ Eg. The pituitary gland produces a hormone called the thyroid stimulating hormone (TSH) and this hormone stimulates the thyroid gland to produce the thyroid hormone.
- ❖ The pituitary gland is made up of two glands:
  1. The anterior pituitary gland
  2. The posterior pituitary gland

## The Anterior Pituitary

- ❖ This lobe of the pituitary gland produces five types of endocrine hormones, human growth hormones and four tropic hormones.



## Human Growth Hormone

- ❖ This hormone regulates growth and development of the body.
- ❖ It is also called somatotropin
- ❖ Three things this hormone does that causes the body to grow and develop are:
  - ❖ Increases absorption of calcium from the intestines
  - ❖ Increases cell division and development
  - ❖ Stimulating protein synthesis and lipid metabolism

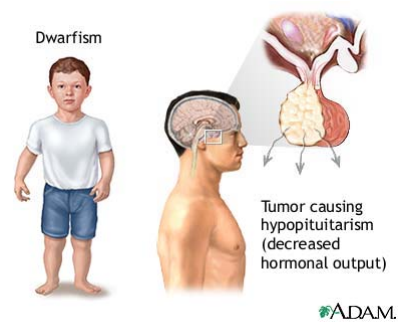


## Human Growth Hormone

- ❖ The half life of HGH is only 20 hours.
- ❖ HGH triggers the production of growth factors in the liver and other tissues.
- ❖ The level of HGH in the body decreases with age. It is thought that the features of aging such as smaller muscle mass and wrinkles is due to the small amount of this hormone.
- ❖ If level of HGH is low during childhood, a condition called pituitary dwarfism may occur.

## Pituitary Dwarfism

- ❖ People with this disorder have a short stature with normal length arms and legs.
- ❖ Some treatment involved for these individuals are
  1. Giving the dwarf child HGH which has been extracted from cadavers.
  2. Inserting sections of DNA, which are responsible for HGH production, into bacteria. These bacteria then produce HGH as a waste product, this HGH is then used to treat dwarfism.



## Gigantism

- ❖ If too much HGH is produced during childhood than a condition called *gigantism* occurs.
- ❖ Individuals with this disorder have abnormally long skeleton bones.
- ❖ Treatment for this disorder include;
  - Surgical removal of a tumor from the pituitary gland
  - Irradiation of the gland tissue.



## Acromegaly

- ❖ Acromegaly is a condition caused when an adult body produces too much HGH. The cause of the increased production of HGH is a tumor in the pituitary gland. Symptoms of this condition may include;
  - thickening of bone tissue.
  - abnormal growth of the head, hands and feet.
  - spinal deformities
- ❖ Treatment of acromegaly includes:
  - surgical removal of the tumor
  - radiation therapy
  - injection of a growth hormone blocking drug

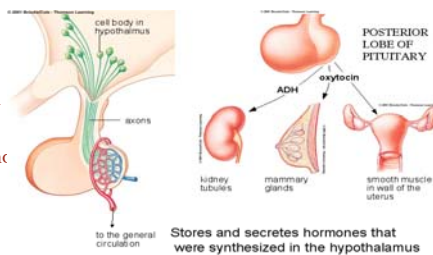


## Prolactin

- ❖ This hormone, which is also produced by the anterior pituitary gland, stimulates the development of mammary gland tissue and milk production (lactogenesis).
- ❖ The hypothalamus regulates the production of prolactin. The hypothalamus secretes a hormone called dopamine which inhibits the production of prolactin. In late pregnancy, an increase in the hormone estrogen will stimulate prolactin production. Also, after a child is born breast feeding stimulates nerve endings in the nipples which stimulates the hypothalamus to release prolactin secreting hormones.

## The Posterior Pituitary

- ❖ This gland is made up of secretory nerve cells which were produced in the hypothalamus.
- ❖ The hypothalamus makes two hormones called anti – diuretic hormone (ADH) and oxytocin which are stored in the posterior pituitary gland until needed.



## Anti-diuretic Hormone

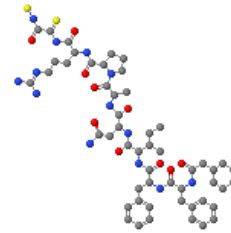
- ❖ This hormone has two major roles in the human body
  - ❖ It regulates the levels of sodium in the bloodstream. Specialized cells in the hypothalamus, called osmoreceptor cells monitor the level of sodium in the blood. If sodium levels are too high, ADH is secreted from the posterior pituitary gland to bring it back to a normal level
  - ❖ ADH is also secreted from the pituitary gland in response to decreased blood pressure which results from loss of blood due to torn or damaged blood vessels. ADH will cause a severed artery to constrict and reduce blood loss while increasing blood pressure.

## Anti-diuretic Hormone

- ❖ There are a number of factors which can inhibit the secretion in ADH;
  - Head trauma (head injury) which causes damage to the pituitary gland or hypothalamus.
  - The development of tumors in the pituitary gland.
  - Inflammation due to infection.
- ❖ If the body does not produce enough ADH, a disorder called diabetes insipidus may result. Symptoms of this disorder include:
  - ❖ Increased thirst and dehydration.
  - ❖ Frequent urination ( dilute )
  - ❖ An enlarged urinary bladder.
    - ❖ This disorder can be treated by giving the patient the ADH hormone.

## ADH

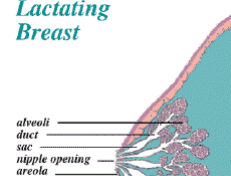
- ❖ If the body produces too much ADH, the kidneys will begin to retain more water and produce a concentrated urine.
- ❖ This will cause an increase in the volume of the blood and a decrease in the blood's sodium concentration. (increasing blood pressure)
- ❖ A low level of sodium can cause a twitchiness in both nerve fibers and muscle tissue.



## Oxytocin

- ❖ This hormone plays an important role both during and after childbirth in women.
- ❖ It triggers muscle contractions during childbirth and stimulates the release of milk from the breasts after birth.

### *The Lactating Breast*



When the baby sucks, a hormone called oxytocin starts the milk flowing from the alveoli, through the ducts (milk canals) into the sacs (milk pools) behind the areola, and finally into the baby's mouth.

## Oxytocin & Milk Production

- ❖ The action of this hormone during and after birth is what is known as a positive feedback loop
- A. Pressure from the baby's head against the walls of the uterus causes pressure receptors to send an impulse to the hypothalamus which triggers the release of oxytocin from the posterior pituitary.
  - The oxytocin causes the uterine muscles to contract more forcefully and each contraction causes the release of more oxytocin.
- B. A child suckling at the breast of its mother is also an example of a positive feedback loop. As the child feeds from the mother's breast, a suckling reflex is initiated. The reflex triggers oxytocin secretion from the pituitary gland.
  - The extra oxytocin stimulates contraction of smooth muscles of the mammary glands (breasts). This induces the child to suckle at the breast.

## Oxytocin

- ❖ It has been suggested that the secretion of oxytocin causes pleasure to the mother during contact with the newborn. This arouses feelings of strong affection which creates a mother – child bond.
- ❖ The production of oxytocin is also a factor in male erections and the female orgasm.

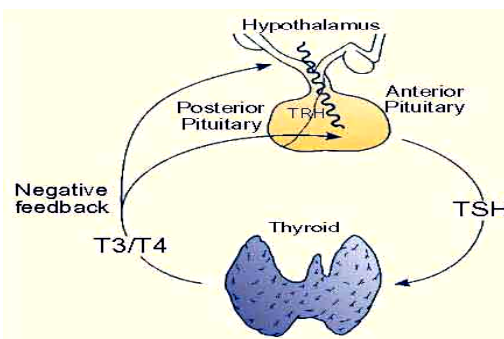




## The Thyroid & Parathyroid Glands

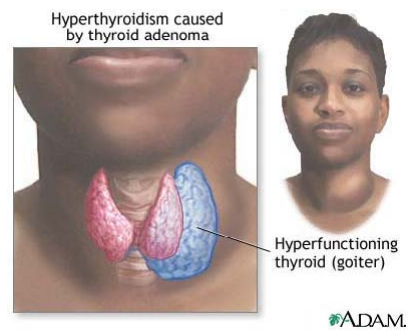
- A thyroid gland is a butterfly – shaped gland located below the larynx in the neck that produces the hormone thyroxine. The thyroid gland contains four small glands called parathyroid glands
- The anterior pituitary gland produces a hormone called thyroid stimulating hormone (TSH). TSH stimulates the thyroid gland to produce thyroxine.
- Thyroxine is a molecule that contains four atoms of iodine. It causes an increase in the metabolism and oxygen consumption of the heart, skeletal muscle, liver and kidney.
- The thyroid gland uses about 30% of the iodine in the blood which is used to make thyroxine.

- This Diagram shows how negative feedback by hormones keeps the amount of thyroxine at a level suitable to the body's needs.



## Hyperthyroidism

- Hyperthyroidism is an excess of thyroxin production which is also known as Grave's disease.
- This occurs when antibodies attach to TSH receptors on thyroid cells. This causes the cells of the thyroid gland to continually produce thyroxine.



## Hyperthyroidism Continued

- Excess thyroxine causes a number of problems such as:
  - Enlargement of the thyroid gland - Goiter
  - Muscle weakness
  - Increased metabolism
  - Excessive heat production
  - Sweating
  - Warm skin
  - Increased appetite, but weight loss
  - Bulging or protruding eyes.



## Treatments for Hyperthyroidism

- Surgical removal of the thyroid gland.
- Thyroid blocking drugs.
- Treatment with radioactive iodine.
- Injections of thyroid hormone.

## Hypothyroidism

- Hypothyroidism is a decrease in thyroxine output which is caused by iodine deficiency.
- Symptoms of hypothyroidism include:
  - Reduced metabolism
  - Reduced tolerance to cold temperatures
  - Decreased heart rate
  - Decreased appetite, but weight gain
  - Decreased mental capacity
  - Weakness and fatigue
  - Poor physical development



This is an example of the resolution of the puffiness following proper treatment of hypothyroidism with desiccated thyroid

## Goiter

- Goiter is a swelling of the thyroid gland caused by insufficient levels of iodine in an individual's diet.
- Low levels of iodine in the diet causes an increase in cell division in the thyroid gland causing it to expand. As the gland swells, a bulge occurs in the neck of the individual.
- Early treatment for the goiter involved adding iodine to the diet of individuals and adding iodine to drinking water.

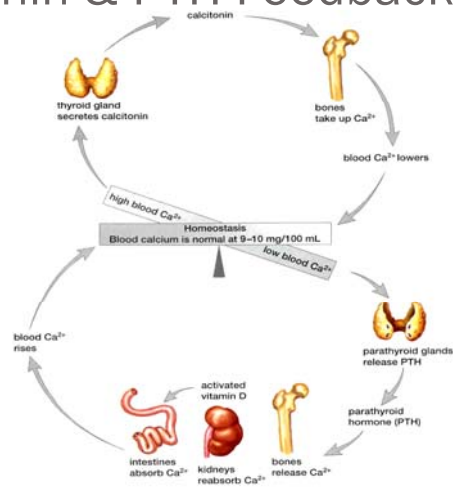


## Calcitonin & Parathyroid Hormone

- Calcitonin is a hormone that is produced by the thyroid gland which regulates the level of calcium in the blood.
- Parathyroid hormone is made by the parathyroid glands.
- Calcitonin and parathyroid hormones are antagonistic hormones. They have opposite effects on blood calcium levels.
- Calcitonin production causes the level of calcium in the blood to become lower. This is due to the effect that more calcium is being deposited into bone tissue and into the skeletal system. The kidneys also excrete more calcium from the body urine.
- Parathyroid hormone causes the level of calcium in the blood to increase. PTH stimulates bone tissue to release calcium into the blood and causes the blood stream to reabsorb calcium from the kidneys.

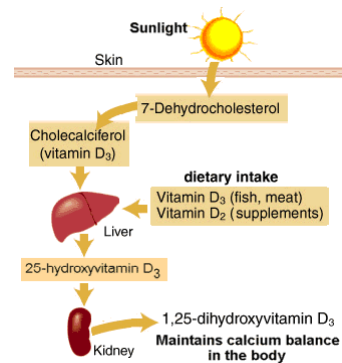
## Calcitonin & PTH Feedback Loop

See Page 434



## Vitamin D

- Vitamin D is a steroid hormone which also helps to regulate the level of blood calcium.
- The role of vitamin D is to maintain blood calcium levels. It increases the release of calcium into the blood from bone tissue. It also increases the retention of calcium in the kidney.



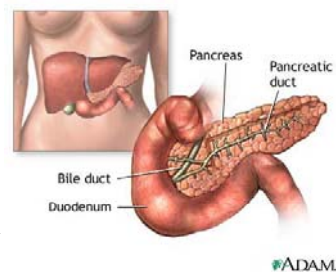
## Vitamin D Deficiency

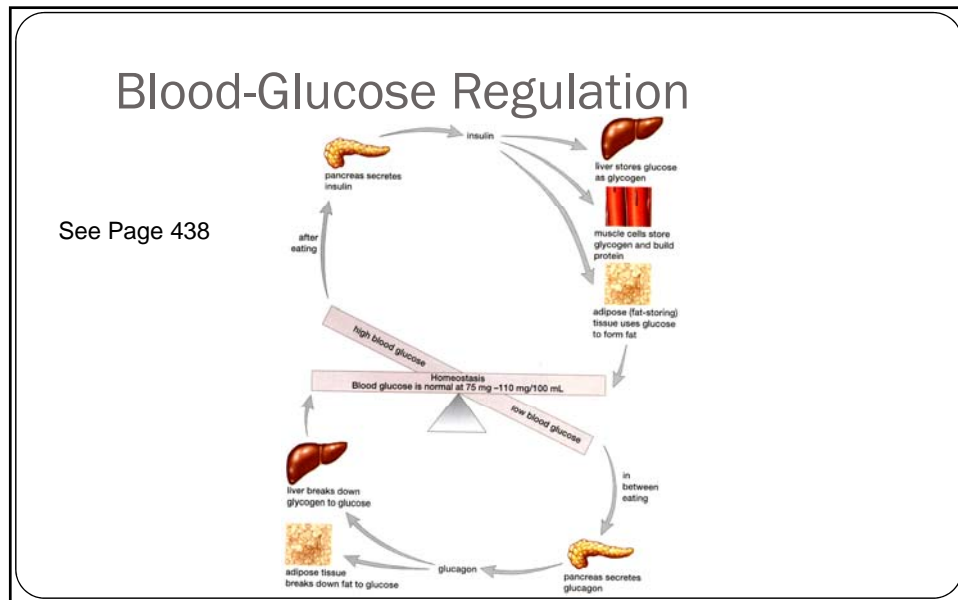
- A lack of vitamin D will result in low levels of blood calcium which can cause problems such as soft bones in adults or rickets in infants.
- Symptoms of these disorders include:
  - A lack of normal growth and development
  - Skeletal deformities
  - Susceptibility to bone fractures
  - Skeletal pain
  - Muscular weakness



## The Pancreas

- The pancreas is a small gland located near the small intestine. It contains two types of tissues which act like endocrine and exocrine glands.
- As an exocrine gland, the pancreas produces two non-steroid hormones called glucagon and insulin.
- These two hormones regulate how the body stores and releases carbohydrate molecules.
- **Insulin** is a hormone which forces the body to store excess nutrients. Examples of this include; glycogen (starch) which is stored in the liver, fat which is stored in adipose tissue and protein which is stored in muscle tissue.
- **Glucagon** has an opposite influence on the body. It triggers the release of glucose, fatty acids and amino acids from cells back into the bloodstream.





## Diabetes

- Diabetes is a problem which can arise in the pancreas.
- There are two types of diabetes. Type 1 Diabetes and Type 2 diabetes.

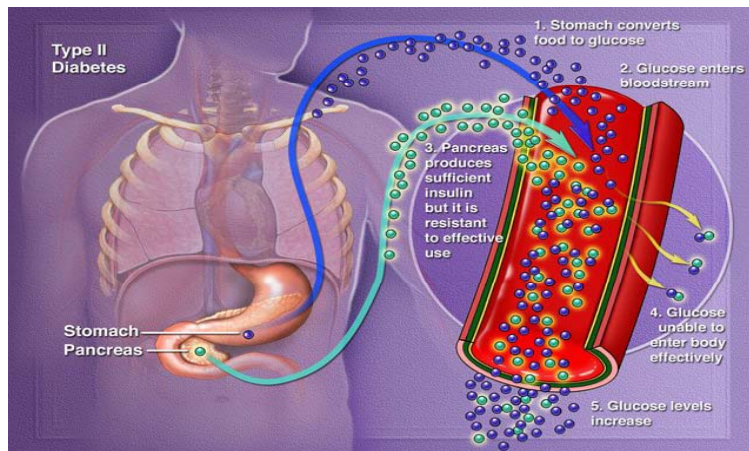
### Type I Diabetes

- An autoimmune disorder in which the body's own immune system attacks the pancreas because it no longer recognizes the pancreas as belonging to the body. Once the attack begins, the body loses its ability to produce insulin over night.

### Type II Diabetes

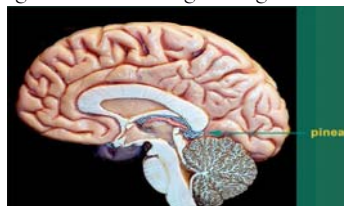
- Occurs in adults over the age of 40. Ninety percent of all diabetics have type 2 diabetes. In this case the body either produces too little insulin or the body fails to recognize the insulin which is produced

## Type II Diabetes



## The Pineal Gland

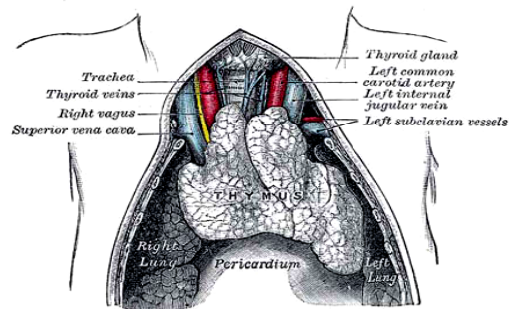
- The pineal gland is a small, cone – shaped structure located in the center of the brain.
- The pineal gland produces two hormones; cortisol and melatonin. The production of these hormones follows a daily 24 hour cycle which is referred to as a circadian rhythm.
- Cortisol hormone production is greatest at night and peaks just before a person wakes. The level of the hormone decreases during the daytime.
- Melatonin is also produced in high amounts during the night time and decreases during the day.





## The Thymus Gland

- The thymus gland is located in the upper chest cavity between the left and right lobes of the lungs.
- This gland produces a hormone called thymosin which stimulates the production and maturation of lymphocytes to T cells. This gland disappears after puberty.



## Seasonal Affective Disorder

- This disorder, also known as SAD, is a condition that produces symptoms of depression and an overwhelming desire for sleep.
- It affects 20 percent of the people in northern countries. It only affects a small population of the residents of southern countries.
- When levels of melatonin are above normal, people can develop the symptoms of SAD
- Exposure to bright lights for 2 to 3 hours each day can lessen the symptoms of this disorder.

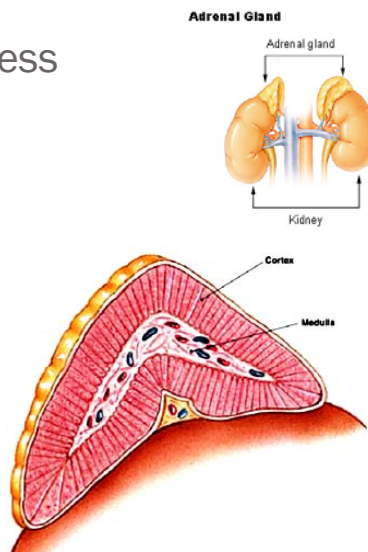


'YOU'LL HAVE TO EXCUSE GERALD — HE SUFFERS FROM SEASONAL AFFECTED DISORDER...'

## 13.3

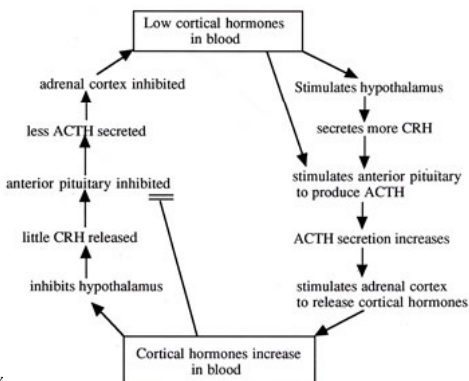
### The Adrenal Glands and Stress

- Humans have two adrenal glands which are located on top of each kidney.
- The adrenal gland has a major role to play in the body's response to stress and is made up of two layers; an outer layer called the adrenal cortex and an inner layer called the adrenal medulla.
- Both the cortex and medulla are regulated by the hypothalamus of the brain.
  - See Page 441, figure 13.8



### The Adrenal Cortex

- The adrenal cortex produces two types of hormones,
  - Cortisol
  - Aldosterone
- Cortisol is hormone which stimulates the synthesis of carbohydrates.
- Aldosterone regulates the body's salt water balance.
- The adrenal cortex also produces the male sex hormones called androgens and the female sex hormones called estrogens.



See page 441

## Cortisol

- Cortisol causes an increase in the process of gluconeogenesis
  - Gluco = sugar, neo = new, genesis = creation → making new sugars
- This is the process in which carbohydrates are made from amino acids and other substances in the liver. The carbohydrate is converted to glucose (simple sugar) when needed by the body.
- Cortisol also has other function
  - it prompts the breakdown of lipids in fat tissue to be used for energy.
  - it inhibits metabolism.
  - it stops protein synthesis in most organs.
- Medically, cortisol is used as an anti-inflammatory. It decreases the build up of fluids in a region of inflammation. It suppresses the production of T-cells and antibodies from the immune system which can cause further inflammation.

## Physiological Response To Stress

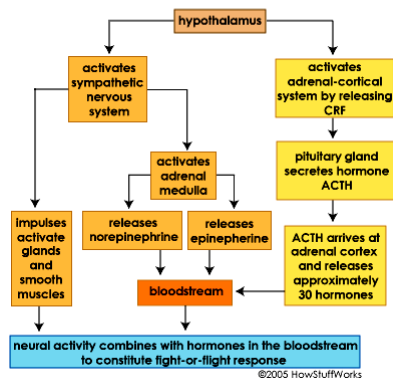
- Any form of physical or emotional stress stimulates a response in the hypothalamus.
- The response follows a particular pattern
  1. The hypothalamus produces more CRF.
  2. Next, the anterior pituitary gland produces ACTH hormone.
  3. ACTH triggers the adrenal cortex to produce high levels of cortisol.
  4. Extra cortisol helps relieve some of the negative effects of stress.



## Fight-or-Flight Syndrome

- Increased levels of cortisol may also cause
  - An increase in gluconeogenesis which provides additional energy for cells.
  - An increased interaction with insulin to increase food intake and redistribution stored energy from muscle to fat tissue.
  - A depressed immune function by reducing the availability of proteins needed to make antibodies and other immune system substances

### Fight-or-flight Response

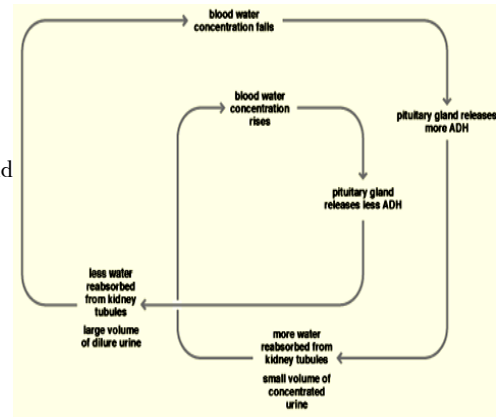


## Fight-or-Flight Characteristics

- The sudden flood of adrenaline, norepinephrine and dozens of other hormones causes changes in the body that include:
  - heart rate and blood pressure increase
  - pupils dilate to take in as much light as possible
  - veins in skin constrict to send more blood to major muscle groups (responsible for the "chill" sometimes associated with fear -- less blood in the skin to keep it warm)
  - blood-glucose level increases
  - muscles tense up, energized by adrenaline and glucose (responsible for goose bumps -- when tiny muscles attached to each hair on surface of skin tense up, the hairs are forced upright, pulling skin with them)
  - smooth muscle relaxes in order to allow more oxygen into the lungs
  - nonessential systems (like digestion and immune system) shut down to allow more energy for emergency functions
  - trouble focusing on small tasks (brain is directed to focus only on big picture in order to determine where threat is coming from)

## Aldosterone

- Aldosterone has two main functions:
  - Osmoregulation or the process of regulating the amounts of water and salts in the blood.
  - Regulation of blood pressure
    - Aldosterone stimulates the reabsorption of sodium from the kidneys and colon.



## Sex hormones

- The adrenal cortex also produces small amounts of the sex hormones
  - Androgens (male sex hormones)
  - Estrogens (female sex hormones)
- Although both hormones are found in each sex, males produce more androgens and females produce more estrogens.
- Androgens promote muscle and skeletal development in both males and females.
- Estrogens play a major role in the female reproductive system.

## The Adrenal Medulla

- This part of the adrenal gland secretes two hormones
  - Adrenaline (epinephrine)
  - Noradrenaline (norepinephrine)
- Adrenaline is the major hormone which is secreted by the body in response to a stressful situation.
- The adrenal medulla secretes 85% adrenaline and 15% noradrenaline.

## Affect of Adrenaline

- These hormones affect the body in a variety of ways
  - Increase heart rate and blood pressure.
  - Cause widening of blood vessels in the heart and respiratory system.
  - Stimulate the liver to break down glycogen to glucose and releasing it into the blood.
- See also the list of fight or flight response characteristics

## Adrenaline & Anaphylactic shock

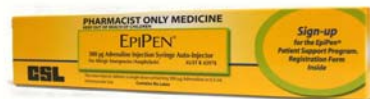
- Anaphylactic shock is a severe allergic reaction to antigens from sources such as
  - Bee stings
  - Peanuts
  - Sources of latex
  - Intravenous medication
- When these antigens enter the blood stream they trigger a chain reaction which we call anaphylactic shock.



#ADAM

## Treatment of Anaphylactic Shock

- Emergency treatment of this reaction involves injection of the adrenaline hormone by a device called Epi – Pen
- Without immediate treatment an individual could die within minutes.



## Chapter 13 Review

- Answer the following questions
- Page 447 – 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 18
- Due date: TBA
- Chapter 13 test - ???