Essential idea: Hormones are used when signals need to be widely distributed.

T6.6.1 - Insulin and glucagon are secreted by β and α cells of the pancreas respectively to control blood glucose concentration.

- Blood glucose concentration is carefully monitored by negative feedback mechanisms.
- Cellular respiration is constantly lowering blood glucose levels.
- Pancreas consist of two glands: one is exocrine and secretes digestive enzymes into ducts leading to small intestines. Other region is endocrine (called islets of Langerhans) and secrete hormones into blood stream. Islets of Langerhans have two cell types that secrete different hormones.
- Receptors in the pancreas sense when the blood glucose level is too low.
- Alpha (α) cells in the islets of Langerhans in the pancreas synthesize and secrete glucagon into the bloodstream when levels fall. Glucagon stimulates the liver to breakdown stored glycogen into glucose which is released into the bloodstream. Blood glucose levels rise back to their normal limits.
- After a person eats, digestion breaks large carbohydrates into glucose molecules. Glucose levels rise in the blood.
- If the glucose levels get too high, receptors sense the increased glucose levels causing the pancreas to secrete insulin by the Beta cells (β) of the islets Langerhans. Insulin stimulates the absorption of glucose from the blood into skeletal muscles and fat tissue, and thus allowing the liver to convert glucose into glycogen (animal carbohydrate storage molecule). Glucose levels decrease back to the normal range.

Application: Causes and treatment of Type I and Type II diabetes.
The doctors video: [https://www.youtube.com/watch?v=yENeJ70S5QE](https://www.youtube.com/watch?v=yENeJ70S5QE)
Type I diabetes: [https://www.youtube.com/watch?v=Qi6LYhlFdw](https://www.youtube.com/watch?v=Qi6LYhlFdw)

- Is an autoimmune disease characterized by the inability of the pancreas to produce insulin. The insulin producing β-cells of the pancreas are attacked and destroyed by one’s own immune system.
- This type of diabetes usually develops in children, but can occur at any age.
- Therefore, the body loses the ability to take up glucose into its cells and convert glucose into glycogen.
- People that have type I diabetes must take insulin shots or injections.

Type II diabetes
• Occurs when the insulin receptors on certain body cells lose their ability to process or respond to insulin.
• Pancreas still produces insulin.
• Type II diabetes is usually a result of obesity, age, lack of exercise and/or genetic predisposition.
• Type II diabetes is usually considered late onset as it usually occurs later on in life.
• Insulin injections are not needed. Diabetes II can be treated by lifestyle and diet changes.
• Most common form of diabetes.

***Do the data based questions on page 331***

T6 U6.6.2 - Thyroxin is secreted by the thyroid gland to regulate the metabolic rate and help control body temperature.
• Thyroxin is a hormone secreted by the thyroid gland of the endocrine system (in the neck). This hormone is unique because it targets all cells in the body.
• Thyroxin contains iodine; therefore, prolonged deficiency to iodine in the diet prevents the production of thyroxin
• Thyroxin is important in the regulation of the body’s metabolic rate. The body’s metabolic rate is the amount of energy a body uses at rest; combination of the catabolic and anabolic reactions
• Since thyroxin causes an increase in the body’s metabolic rate, there is an increase in oxygen consumption and the hydrolysis of ATP; thereby causing an increase in the body’s temperature
• Increase in thyroxin stimulates the breakdown of lipids and the oxidation of fatty acids
• Thyroxin also stimulates carbohydrate metabolism, including the uptake of glucose and the breakdown of glycogen into free glucose
• In a regular person, if the body’s temperature drops, a release in thyroxin will stimulate heat production causing the body’s temperature to rise
• If there is an excessive amount of thyroxin in the body, hyperthyroidism can occur
• If there is an insufficient amount of thyroxin in the body, hypothyroidism can occur
• Some of the symptoms of hypothyroidism are weight gain, loss of energy, feeling cold all the time, forgetfulness and depression

T6 U6.6.3 - Leptin is secreted by cells in adipose tissue and acts on the hypothalamus of the brain to inhibit appetite.
• Leptin is a hormone made by adipose cells that helps to regulate energy balance by inhibiting hunger. Leptin acts on the receptors in the arcuate nucleus (collection of neurons) of the hypothalamus to regulate appetite in order to achieve energy homeostasis
• The concentration of leptin in the blood is controlled by food intake and the amount of adipose tissue in the body
• If the amount of adipose tissue in an individual increases, then their concentrations of leptin also increases, leading to long term suppression of appetite and reduced food intake
• In obese individuals a decreased sensitivity to leptin can occur, resulting in an inability the recognize when they are full
• Journal article on Leptin and regulation of body weight in mammals http://www.nature.com/nature/journal/v395/n6704/full/395763a0.html
• Article shows that mice containing a recessive/recessive allele (ob/ob) produce a truncated version of the leptin hormone
• This led into severe obesity in these mice as the signal that tells the brain of the mice they are full (leptin) didn’t work anymore

Application: Testing of leptin on patients with clinical obesity and reasons for the failure to control the disease.
Leptin and obesity: https://www.youtube.com/watch?v=oN3woHJ7ZDY

- The discovery of how mice become obese because of the lack of the hormone leptin and the subsequent treatment of the mice with leptin injections, led to human trials to decrease obesity.
- However, trials with humans have had mixed response since the physiology of humans is much different then mice.
- Since most humans have quite a high leptin concentration, it was determined that the many of obesity cases where caused by a change in the receptor protein for leptin, not in the production of leptin.
- A double blind study was conducted by the biotech company Amgen, showed that injections of leptin to many of these individuals, since their receptors didn’t work, failed to control obesity. In individuals that experienced weight loss, there was a big discrepancy in the amount of weight that was lost.
- There also were other side effects such as skin irritation and swelling.

T6 U6.6.4 - **Melatonin is secreted by the pineal gland to control circadian rhythms.**

- Humans adapted to live in 24-hour cycle and have rhythms in behavior that fit this cycle. (circadian rhythms) Two groups of cells in the hypothalamus called suprachiasmatic nuclei. These cells set daily rhythm.
- Melatonin is a hormone made by the pineal gland, a small gland in the brain.
- The secretion of melatonin by the pineal gland is controlled by cells in the hypothalamus.
- Light exposure to the retina is relayed to the suprachiasmatic nucleus (SCN) of the hypothalamus. These fibers from the hypothalamus relay a message to the nerve ganglia of the spinal cord which is relayed back to the pineal gland to release melatonin.
- Melatonin helps control your sleep and wake cycles (circadian rhythms).
- Very small amounts of melatonin are found in foods such as meats, grains, fruits, and vegetables.


- An internal 24-hour clock controls your natural cycle of sleeping and waking hours.
- Melatonin levels generally begin to rise in the mid to late evening, remaining high for most of the night, and then drop in the early morning hours.
- Light from the sun can also affect how much melatonin your body produces. During the shorter days of the winter months, your body may produce melatonin either earlier or later in the day than usual. This change can lead to symptoms of seasonal affective disorder (SAD), or winter depression.
- Natural melatonin levels slowly drop with age. Some older adults make very small amounts of it or none at all.
Application: Causes of jet lag and use of melatonin to alleviate it.

- The SCN of the hypothalamus and the pineal gland continual set the circadian rhythm of the place the person is departing from.
- Therefore, when a person lands in a country that is many time zones different than the origin, they feel sleepy in the day and awake at night
- Jet lag will only last a few days, as the body adjusts to the new times when the light is detected by the cells in the retina during a different time period

Skill: Annotate diagrams of the male and female reproductive system to show names of structures and their functions.
T6 U6.6.5 - A gene on the Y chromosome causes embryonic gonads to develop as testes and secrete testosterone.
- The Y chromosome (small one below) has a gene called the SRY gene that causes the embryonic gonads to become testes and begin secreting testosterone
- SRY codes for a protein called TDF (testis-determining factor) that stimulates the expression of other genes located on the Y chromosome that cause testis development
- If there are two X chromosomes, the gonads develop as ovaries.

If SRY is present, embryonic gonads develop into testis.

If embryo has 2 X chromosomes and no SRY gene, TDF is lacking and embryonic gonads develops as ovaries.

T6 U6.6.6 - Testosterone causes pre-natal development of male genitalia and both sperm production and development of male secondary sexual characteristics during puberty.

Testosterone
- Secreted in the testes of males or the early stage testosterone-secreting cells that will become testes.
- Aid in the development and maturation of the male genitalia as a fetus at about the 8th to 9th week.
- During puberty, testosterone aids in the development of male secondary sexual characteristics such as pubic and facial hair, enlarged penis, broad shoulders, muscle mass, deepening of voice and bone density.
- Stimulates production of sperm and promotes the male libido (sex drive).

T6 U6.6.7 - Estrogen and progesterone cause pre-natal development of female reproductive organs and female secondary sexual characteristics during puberty.
- If the SRY gene on the Y chromosome is not present in the embryo, the gonads develop into ovaries.
- Estrogen and progesterone which are secreted by the mother's ovaries and then by the placenta, will cause the female reproductive organs to develop in the absence of testosterone.
- During puberty, estrogen and progesterone cause the development of secondary sexual characteristics in females, including breast development, menstrual cycle and pubic and armpit hair.

T6 U6.6.8 - The menstrual cycle is controlled by negative and positive feedback mechanisms involving ovarian and pituitary hormones. The roles of FSH, LH, estrogen and progesterone in the menstrual cycle are expected.

FSH (Follicle stimulating hormone)
- Produced and secreted by the anterior pituitary gland.
- Stimulates the growth of the follicles in the ovaries to create a mature Graafian follicle.
- Promotes the thickening of the follicle wall.
- Stimulates the secretion of the hormone estrogen.

LH (Luteinizing hormone)
- Produced and secreted by the anterior pituitary gland.
- Triggers the release of the egg (ovulation).
- Stimulates the growth of the corpus luteum (secretes estrogen and progesterone).
- Stimulates the secretion of hormone estrogen and progesterone.

**Estrogen**
- Produced by the developing follicles in the ovaries and the corpus luteum.
- Promotes the thickening of the uterine wall (endometrium) and the growth of blood vessels, in preparation of egg implantation.
- Inhibits FSH and LH when the estrogen levels are high (around same time as ovulation). This would prevent the development and release of another egg.

**Progesterone**
- Produced by the ovaries and the corpus luteum.
- Helps maintain the thickening of the uterine wall for egg implantation.
- Inhibit the production of FSH and LH.

**Do data-based questions on page 338**

**Application**: The use in IVF of drugs to suspend the normal secretion of hormones, followed by the use of artificial doses of hormones to induce superovulation and establish a pregnancy.
- Generally, IVF treatment begins by taking drugs to halt the regular secretion of the hormones FSH and LH. This in turn stops the secretion of progesterone and estrogen and effectively allows the doctor to take control of the timing and egg production of the woman’s ovaries.
- The woman is then injected with large amounts of FSH to induce the production of many Graafian follicles.
- LH is also injected to promote the release of many ovules (eggs).
- This is called superovulation, which can produce between 10 and 20 eggs.
- The eggs are then stimulated to mature by an injections of HCG (Human Chorionic Gonadotrophin), a hormone usually secreted by the developing embryo.
- The eggs are surgically removed from the ovary of the woman.
- Sperm is collected from the male individual.
- Many sperm (50,000-100,000) are mixed with the eggs in a petri dish.
- The sperm and eggs in the petri dish are incubated at 37°C (body temperature).
• The eggs are analyzed for successful fertilization (two nuclei inside the egg).
• Healthy embryos are selected and are transferred into the female uterus for implantation (up to 3 healthy embryos are transferred into the uterus to increase chance of implantation).
• Pregnancy test is given after about 2 weeks.
IVF - https://www.youtube.com/watch?v=GeigYlb39Rs

**Nature of science:** Developments in scientific research follow improvements in apparatus—William Harvey was hampered in his observational research into reproduction by lack of equipment. The microscope was invented 17 years after his death.

**Application:** William Harvey’s investigation of sexual reproduction in deer.
• William Harvey was best known for his discovery of the circulation of the blood, also was interested in sexual reproduction and how life is formed.
• Aristotle’s theory was called the seed and soil theory, which stated that the male produces a seed (sperm) which then forms an egg when it mixes with menstrual blood of the mother. The egg then develops into a fetus inside the mother and eventually “voila” you have a baby
• Harvey studied the uterus of the deer during mating season by killing them and then dissecting them expecting to find eggs; however, Harvey only found signs of fetal development 2 to 3 months after mating season
• He concluded that Aristotle’s theory of seed and soil was incorrect, but then he was also incorrect in stating that the fetus doesn’t come from the mixture of the male and female seeds.
• He knew he had not come up with the correct method of sexual reproduction


**Utilization:** Hormones are used in a variety of therapies such as replacement therapies.

**Aims:** Scientists are aware that the drugs women take in fertility treatment pose potential risks to health. Should scientific knowledge override compassionate considerations in treating infertile couples?