Biology 30 Review Notes

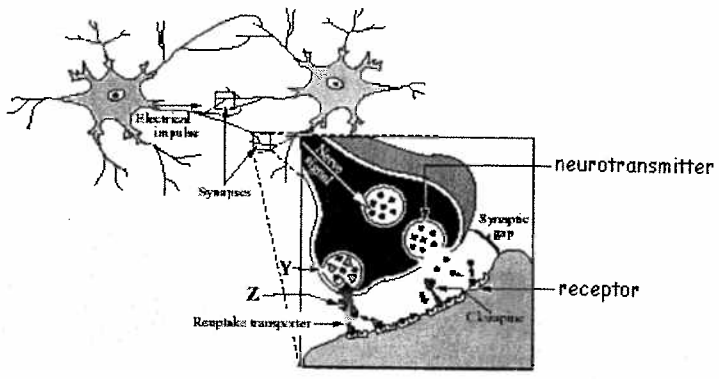
Regulation and change in humans

A **neuron** is a nerve cell specialized for conducting nerve signals. It has long cell extensions called **fibres** which consist of cytoplasm covered with cell membrane. The fibres are either **dendrites**, which carry signals towards the cell body, or **axons**, which carry signals away from the cell body. Neurons that carry signals from sensory organs to the **central nervous system** (spinal cord and brain) are called **sensory neurons**, those that carry signals from the **CNS** to the muscles are called **motor neurons**, and neurons that transmit signals within the CNS are called **interneurons**. Some fibres are covered in a **neurilemma**. That is a membrane that helps the fibre to repair itself should there be an injury. Many of the fibres are also covered with a white **myelin sheath** composed of **Schwann cells**. Between the Schwann cells is a small space where the fibre is exposed, called a **node of Ranvier**.

When the fibre is not transmitting a signal, a **sodium/potassium pump** maintains the **resting potential** that involves keeping **sodium ions** out and **potassium ions** inside the fibre. There are also large organic ions inside the fibre so that the resting potential can be measured at about -60mV. That is, more negative inside the fibre than outside. If a fibre is stimulated strongly enough to reach a **stimulus threshold**, an **action potential** occurs, in which sodium gates open and sodium ions rush in, making the inside of the fibre more positive, then the potassium ions rush out restoring the negative potential inside. This is also referred to as **depolarization**. Then the sodium/potassium pump moves the sodium back out and the potassium back in. If the fibre is non-myelinated, this change at one spot stimulates an action potential at the next adjacent spot, and in this way, action potentials flow in a wave along the fibre. If the fibre is myelinated, the action potentials only occur at the nodes, so the signal skips from node to node. A signal travels faster in a myelinated fibre and requires far less energy. A signal in an individual fibre cannot be strong or weak, we say it is **all-or-none**. If a fibre carries many signals in quick succession it may end up with all the sodium inside and all the potassium outside and the sodium/potassium pump unable to work quickly enough to restore the resting potential. This results in weakened stimulation called **neural fatigue**.

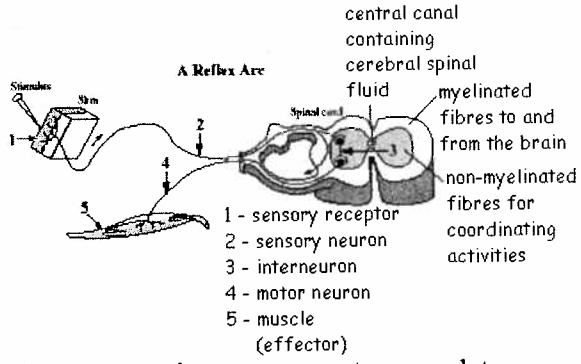
A **synapse** is the space between the end of an axon and the next neuron's dendrite or cell body. When a signal arrives at the end of the axon, **calcium** ions enter the fibre rather than sodium. The calcium stimulates vesicles of **neurotransmitter** to be released into synapse. The neurotransmitter diffuses across the synapse and binds with **receptor sites** on the **postsynaptic membrane**, thus causing depolarization in the next neuron. One such neurotransmitter is **acetylcholine**. Immediately after acetylcholine is released, **cholinesterase** is released into the synapse. The cholinesterase breaks down the acetylcholine to stop the depolarization. Other common neurotransmitters are **norepinephrine**, **seratonin** and **dopamine**.

Two Neurons and a Synapse



During a **reflex response**, a signal travels along a sensory neuron, into the CNS where interneurons coordinate a response that is sent out of the CNS via motor neurons to affect a motor response. The **somatic**

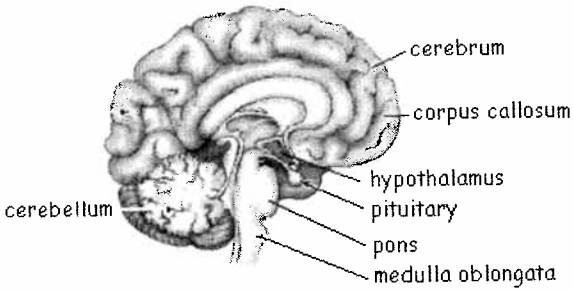
nervous system regulates skeletal muscles that a person can consciously control.



The **autonomic nervous system** regulates muscles of the glands and internal organs of which a person has no conscious control. The **sympathetic** component of the autonomic system prepares the body for action by diverting blood from internal organs to skeletal muscles, heart and brain. As well, the sympathetic system increases blood pressure, and breathing rate. The **parasympathtic** component of the autonomic system normalizes body functions. The neurotransmitter for the sympathetic system is norepinephrine, and the neurotransmitter for the parasympathetic system is acetylcholine.

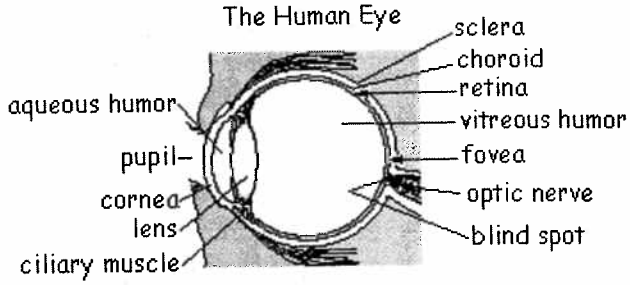
The top of the brain is composed of the two **cerebral hemispheres** of the **cerebrum** that control conscious thought. The cerebrum can be divided into the **frontal lobes** that are responsible for our personality traits, the **occipital lobes** at the back where visual stimuli are coordinated, the **temporal lobes** at the bottom sides that control language and hearing stimuli and above the temporal lobes the **parietal lobes** that regulate touch sensations. Beneath the cerebrum is the **corpus callosum,** a band of myelinated fibres that transmit information between the right and left hemispheres. The **cerebellum** at the back of the skull coordinates muscular movements. The **pons** in front of the cerebellum is a relay centre for information moving to and from the cerebrum. The **medulla oblongata** controls basic functioning such as breathing and heart rate, digestive functions. The **hypothalamus** and the **pituitary** control the endocrine system.

The Human Brain



Sensory organs are all the same in that they all stimulate sensory nerves that carry the information to the CNS. The **eye** converts light signals into action potentials in the **optic nerve**. The eye is a sac that has three layers. The outer layer, the **sclera** is white except the front transparent part called the **cornea**. The middle layer is the **choroid**, mostly black to ensure that light that is not used to make a nerve signal is absorbed and does not bounce around in the eye. The front part of the choroid is modified into the **lens** and the **ciliary muscles** that adjust the shape of the lens, and the **iris**, the colored part of the eye. The inner layer is the **retina** that contains the **rods**, receptors that work well in low light but do not detect color, and the **cones** that require a high level of light but can see color. There are three types of cones - red, green and blue. The **fovea** is a spot directly at the back of the retina. It contains tightly packed cones and is where a person can see with most precision. Inside the eye is fluid, the watery **aqueous humour** in front of the lens and the thicker **vitreous humour** behind the lens.

The Human Eye



Nearsighted people cannot focus on distant objects, because the image focuses before the retina. **Farsighted** people cannot see close objects because the image is not yet focussed when the light arrives at the retina. The problem with **astigmatism** is

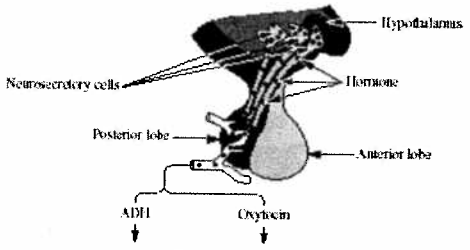
that the cornea does not have a smooth curve so that without corrective glasses one part of the visual field is in focus while other parts are not. A **cataract** is a lens that has become cloudy. **Glaucoma** is damage to the retina caused by excessive pressure from fluid in the eye.

The **ear** consists of an **outer ear** (the **pinna** and **auditory canal**) the **middle ear** starting with the **eardrum (tympanic membrane)**, and the fluid filled **inner ear**. Air pressure inside the middle ear is kept equal to air pressure in the auditory canal by the **Eustachian tube** which allows air to pass between the middle ear and the back of the mouth. Sound is transmitted from the eardrum through the tiny middle ear bones – the **hammer (malleus)**, **anvil (incus)** and **stirrup (stapes)**. Vibrations of the stirrup cause the **oval window** of the inner ear **cochlea** to vibrate, causing vibrations in the fluid of the inner ear which pass out the **round window**. The vibrations of the inner ear fluid cause **hair cells** of the **organ of Corti** to stimulate the **auditory nerve**. The inner ear also contains the **utricle** and **saccule** for stationary balance and the **semicircular canals** for movement balance.

The **endocrine system** involves endocrine **glands**, the **hormones** they produce.

Oxytocin and ADH are synthesized by neurosecretory cells in the hypothalamus. These hormones are stored in the posterior pituitary. They can then be released into the bloodstream where they circulate to target cells.

Hormones of the Pituitary and Hypothalamus



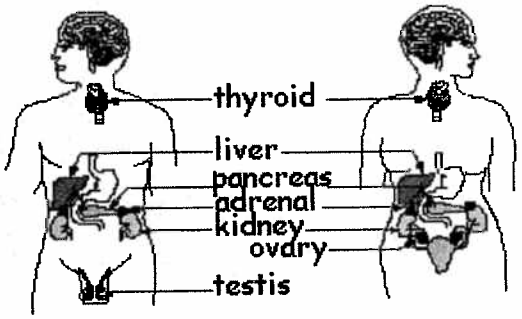
Control of hormone levels in the blood is usually accomplished through **negative feedback**. To illustrate with thyroxin: a high thyroxin level is detected by the hypothalamus which then stops stimulating the anterior pituitary to secrete TSH, therefore the thyroid gland stops producing thyroxin. **Hypothyroidism** - too little thyroxin - causes a lower metabolic rate, resulting in tiredness, apathy and weight gain. In children, hypothyroidism causes slowed mental and physical development.

Hormones and Endocrine Glands

Gland	hormone	Target tissues	effects
hypothalamus	**ADH**	Kidney tubules	Increased reabsorption of water, thereby diluting blood.
	oxytocin	Myometrium of uterus and mammary glands	Stimulates contractions of the uterus for birth. Stimulates the release of milk during breast-feeding.
Anterior pituitary	**Thyroid stimulating hormone (TSH)**	Thyroid gland	Stimulates the thyroid to release thyroxin.
	Adrenocorticoroph ic hormone (ACTH)	Adrenal cortex	Stimulates the adrenal cortex to release hormones such as cortisol
	Growth hormone (HGH)	various tissues, chiefly the long bones	Causes mitosis to stimulate growth.
Thyroid	**Thyroxin**	All body cells	Increases the rate of metabolic activity
Pancreas (beta cells)	**Insulin**	Liver, muscles	Stimulates uptake of glucose (thereby lowering blood glucose) and storage of glucose as glycogen.
Pancreas (Alpha cells)	**Glucagon**	liver	Stimulates the breakdown of glycogen and the release of glucose, thereby raising blood glucose.
Adrenal cortex	**Cortisol**	All tissues	Initiates healing - reduces swelling, releases glucose and other compounds needed for repair of tissues.
	Aldosterone	Kidney tubules	Increase reabsorption of water and salts, thereby increasing the water volume of the body
Adrenal medulla	**Epinephrine/ norepinephrine**	Blood vessels, heart, brain, muscles, lungs	Increased blood pressure, increased blood flow to skeletal muscles, heart, brain, away from internal organs, dilation of pupils, increased breathing rate.
Sex hormones - testosterone, estrogen, progesterone, HCG, prolactin, relaxin - will be dealt with in the reproduction section.			

Hyperthroidism - too much thyroxin - causes a higher metabolic rate, resulting in high blood pressure, sweating, irritability, weight loss.

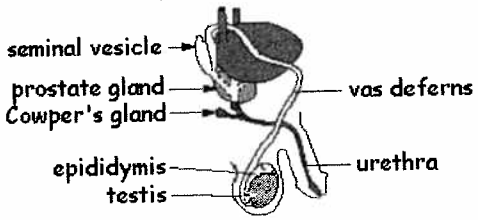
The inability to produce an adequate supply of insulin as a child is called **type I diabetes mellitus**. The blood glucose level can become dangerously high and glucose is excreted with urine. **Type II diabetes mellitus** usually affects older adults and often is due to an inadequate supply of insulin receptors. It can usually be controlled with diet. The endocrine system provides a slower, more generalized form of control than the nervous system.



Reproduction and Development

In **males**, sperm are produced in the **seminiferous tubules** of the **testes**. In the spaces between the seminiferous tubules are the **interstitial cells** that respond to **LH** from the **anterior pituitary** and produce **testosterone**. Within the seminiferous tubules are the **Sertoli cells** that respond to **FSH** from the **anterior pituitary**. They stimulate meiosis in spermatocytes to form sperm. The sperm mature in the **epididymis** and are stored in the **vas deferens**. Upon **ejaculation,** the sperm are moved through the vas deferens past the three sets of glands, the **seminal vesicles**, the **prostate gland** and the **Cowper's glands**, that add fluid to the **semen**. Of primary interest are the **fructose** (sugar) that the sperm can use for nourishment, and the **buffer** that neutralizes the acidity of the woman's vagina. (The acidity helps to resist infections.) As well,

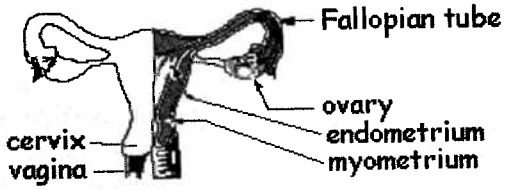
Male Reproductive Structures

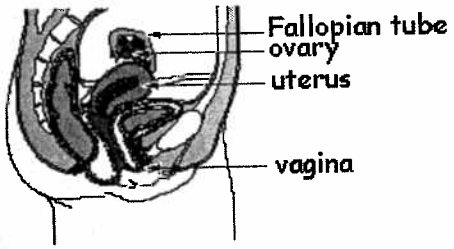


the prostate gland secretes a **prostaglandin** that stimulates the woman's uterine muscles to contract, thus drawing up the semen. The semen is ejaculated out of the **urethra** of the penis. In a male fetus, testosterone causes the **penis** to form and causes the testes to develop and descend into the **scrotum**. At the onset of puberty, testosterone causes the development of primary and secondary male sexual characteristics.

In **females**, **eggs** are produced in the **ovaries**. FSH stimulates **follicular cells** that in turn stimulate meiosis in oocytes. The follicular cells also produce **estrogen** that is secreted into the blood and stimulates thickening of the **endometrium** (the inner layer of the uterus.) Within 10 days the oocyte and its supportive follicular cells are a fluid filled sphere called a **mature follicle**. At about that time, an increase in the secretion of LH from the anterior pituitary causes **ovulation** that occurs a few days later. The egg and some of the follicular cells burst out of the ovary and **fimbrae** sweep to draw the egg into the **Fallopian tube**. The follicular cells that didn't leave with the egg reform into the **corpus luteum**,

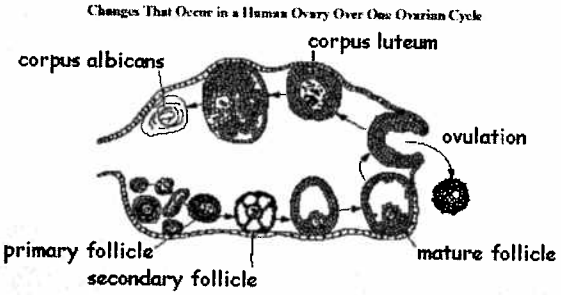
Female Reproductive System



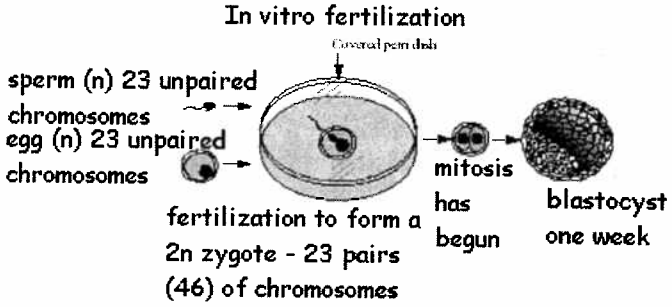


which begins the secretion of **progesterone**. The progesterone causes the endometrium to become **vascularized** (full of blood vessels) and **secretory** (full of glands). If no fertilization occurs, the high level of estrogen in the blood has a **negative feedback** effect on the hypothalamus, so that FSH production drops. The high level of progesterone has a negative feedback effect on the hypothalamus, so that LH production drops. As a result, the corpus luteum degenerates to the non-functional **corpus albicans**. The egg has also died by now so production of estrogen and progesterone have dropped off. Without estrogen and progesterone to support it, the endometrium falls away (**menstruation**) starting at the end of the cycle (about day 28).

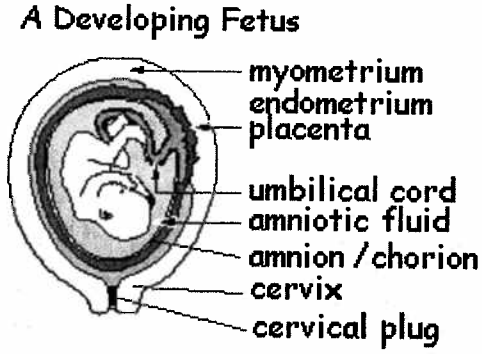
If **fertilization** does occur in the Fallopian tube, the **zygote** quickly begins mitosis to increase the number of cells. Within a few days, it has become a hollow sphere of cells called a **blastocyst**, and has arrived at the uterus.



The outer layer of the blastocyst is called the **chorion**. Cells of the chorion produce **human chorionic gonadotropin (HCG)**. HCG is a hormone that maintains the corpus luteum so that there continues to be a supply of progesterone to support the endometrium. Meanwhile the blastocyst **implants** into the endometrium and continues rapid development. Within a month, the embryo is a tube composed of three layers of tissues. The outer layer, the **ectoderm**, will become the skin and nervous system. The middle layer, the **mesoderm**, becomes the muscles, bones, kidneys, and sex organs. The inner layer, the **endoderm**, becomes the lining of

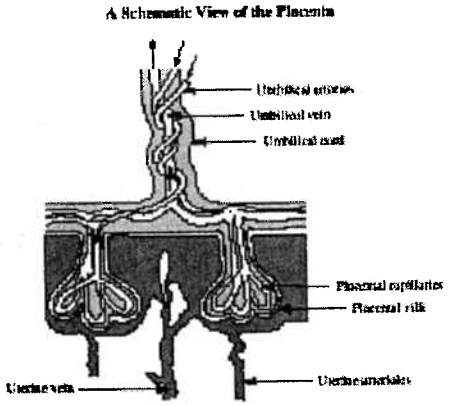


the digestive system, including the liver and pancreas. By two months the embryo floats in a fluid filled sac surrounded by two membranes. The outer membrane, the **chorion**, forms the **placenta**. The inner membrane is the **amnion**. The fluid around the embryo is called **amniotic fluid**. The chorion forms folds called **villi**, that increase surface area for more efficient exchange of materials between mother and fetus. Nutrients, oxygen, wastes, hormones and drugs cross the placenta. Cells cannot cross the placenta, including disease-causing bacteria. Some viruses, however, are small enough to cross the placenta. Some of mother's antibodies can also cross the placenta.



The placenta also produces estrogen and progesterone to maintain the endometrium, so there is no longer a need for the corpus luteum. The production of HCG drops off and the corpus luteum degenerates. Close to birth the level of progesterone drops quickly as the level of **relaxin** and **oxytocin** increase. Relaxin causes the woman's ligaments to loosen. Oxytocin stimulates muscles of the uterus to contract at birth. During birth (**parturition**) the **cervix**

dilates, muscles of the uterus contract to



expel the baby, and the uterus contracts further to pinch the placenta from the endometrium. Following birth, **prolactin** from the anterior pituitary stimulates the synthesis of milk. Oxytocin from the posterior pituitary stimulates the release of milk when the baby suckles.

Ultrasound, **amniocentesis** and **chorionic villus sampling (CVS)** are all technologies that provide information about a fetus. Ultrasound involves bouncing sound waves off the fetus that produce a rough image of the fetus. Amniocentesis involves using a **hypodermic needle** to draw a sample of amniotic fluid. The fluid will have chemicals and cells that have come from the fetus. The cells can be used for DNA analysis or to construct a **karyotype**. CVS provides the same information as amniocentesis by removing a sample of chorionic cells. It has the advantage of being able to be done earlier and seems less dangerous for the fetus. There are several means of birth control. A **condom** or a **diaphragm** serve as a barrier for the sperm. **Birth control pills** are a combination of estrogen and progesterone that have a negative feedback effect on the hypothalamus so that ovulation does not occur. The pill **RU 486** prevents a blastocyst from implanting in the uterus. A **vasectomy** (male) or **tubal ligation** (female) involves closing off the vas deferens or Fallopian tubes to block sperm or eggs. **In vitro fertilization** means that fertilization takes place in a petri dish. A resulting embryo can be implanted into a woman's uterus.

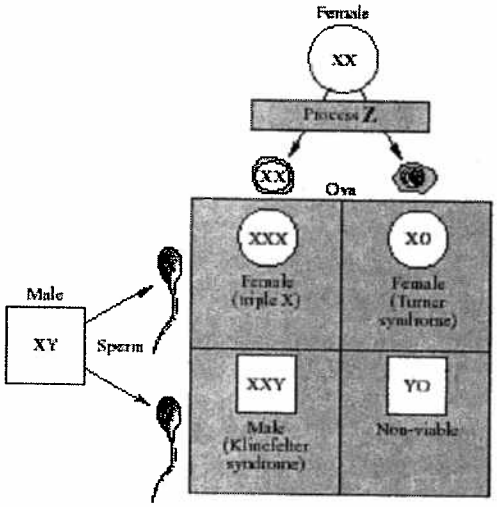
Cells, Chromosomes and DNA

Cells typically move through a **cell cycle**. Most of the time is spent in **interphase**, during which the cell carries out its normal functions. Interphase can be divided into **Gap 1** (G1) which involves some cell growth, **Synthesis** (S) during which the DNA replicates itself and **Gap 2** (G2) which involves more growth. The end of interphase is signaled by the start of **mitosis**. The first part of mitosis is called **prophase** during which **chromatin** condenses into visible **chromosomes**. A chromosome at this point is composed of two identical **chromatids** joined by a **centromere**. As well during prophase, the **nuclear membrane** and **nucleolus** disappear and the two **centrioles** begin to migrate toward the cell poles. As the centrioles move apart, **asters** of **spindle fibres** begin to form from them. Following prophase is **metaphase**, during which the centrioles, now situated at the poles have formed a complete **spindle** and the spindle fibres have drawn the chromosomes to the equator. Next is **anaphase**, in which the spindle fibres contract, drawing the chromatids toward the poles. Lastly is **telophase**. This is when the nuclear membrane and nucleolus begin to reform and the chromosomes uncoil. At the end of telophase is **cytokinesis** in which the cell cytoplasm splits in two. In animal cells, cytokinesis occurs with the cell pinching in the middle (**furrowing**). In plant cells, the cytoplasm splits when a **cell plate** (cell wall) forms down the middle. Mitosis results in two genetically identical cells and is responsible for growth of organisms. Each of the trillions of cells of a human is genetically identical to each other cell due to mitosis. **Cloning** involves placing the nucleus of one cell into an egg cell to produce an organism genetically identical to the donor organism. **Cancer** results from uncontrolled cell division. **Radiation** therapy is used to destroy **cancerous tumors**. **Chemotherapy** involves drugs

aimed to destroy dividing cells. The idea is that since cancer cells are always dividing, the chemotherapy should effectively destroy the cancer cells. Unfortunately, the drugs also destroy normal cells that are dividing.

The production of **gametes** (sperm and eggs) requires the special cell division called **meiosis**, in which the chromosome number is halved (**diploid** to **haploid**). In the case of humans, the 46 chromosomes (23 pairs) of a somatic cell become 23 unpaired chromosomes of a gamete. Meiosis has two cell divisions that occur one after the other. In males, sperm formation is called **spermatogenesis**. It begins with the formation of a diploid **primary spermatocyte**. During prophase I of meiosis I the chromosome pairs come together (**synapsis**) to form **tetrads**. Each tetrad consists of a **homologous pair** of chromosomes, or four chromatids. At this time **crossing over** may occur, in which sections of DNA are exchanged between adjacent chromatids. In Metaphase I it is the tetrads that are pulled to the equator, and during anaphase I it is the homologous chromosomes that are pulled to the poles (This is different from mitosis since in mitosis, it is chromatids that are pulled apart.). This event is called **segregation**, and ensures that the two cells resulting from meiosis I will each have 23 chromosomes made up of two chromatids. These cells, called **secondary spermatocytes**, will not be genetically equal. Meiosis II takes place immediately after telophase I with no interphase in between. Meiosis II looks just like mitosis, although the cells are haploid, not diploid. At the end of spermatogenesis there are four haploid **spermatids**. **Genetic variation** has been achieved by the crossing over during prophase I and by the random sorting of the chromosome pairs during anaphase I. Egg formation, or **oogenesis**, is similar to spermatogenesis, with two significant differences. Firstly, all the primary oocytes a woman will ever have exist before she is born. Following puberty, a number of these begin meiosis each month, although usually only one completes meiosis to become an egg. Secondly, during telophase I and telophase II cytoplasm division is unequal. At the end of meiosis I there is a tiny **first polar body**, that does not survive long, and the very large **secondary oocyte**. From meiosis II of the secondary oocyte, there is another tiny **second polar body** that will die, and the large **ootid**. The ootid will swell to become the mature **ovum**. So, while spermatogenesis results in four small spermatids, oogenesis produces one large ootid. If a woman should produce two eggs at the same time, they may both be fertilized, and **fraternal twins** may result. However, sometimes one zygote will form and begin to undergo mitosis to form a cluster of cells only to split into two clusters that will eventually become **identical twins**. **Nondisjunction** is an error, which occurs during anaphase of meiosis in which both members of the chromosome pair are pulled to one end. One of the resulting cells will have 24 chromosomes and the other 22. Following fertilization a zygote may have 47 chromosomes (**trisomy**, because one pair contains three) or 45 (**monosomy**, because one pair contains one). **Down syndrome** is due to having three chromosomes number 21 (trisomy 21). A photograph can be taken of the chromosomes during mitosis. The chromosomes can be organized into their pairs to observe for chromosomal abnormalities. This is called a **karyotype**.

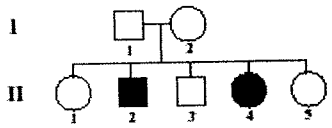
Plant life cycles are complex, with a diploid



adult form called a **sporophyte**, and a haploid adult form called a **gametophyte**. The gametophyte (1n) produces 1n gametes through mitosis. Two gametes fuse (fertilization) to form a zygote (2n) that undergoes mitosis to become the sporophyte (2n). The sporophyte undergoes meiosis to produce 1n spores that undergo mitosis to create 1n gametophytes again.

During the 1800s, the Austrian monk, Gregor **Mendel** studied inherited traits of pea plants and developed laws to explain heredity. He discovered that in an organism, **alleles** (versions of a gene) existed in pairs, but during gamete formation the allele pairs segregated so that a gamete contains unpaired alleles (**law of segregation**). How an organism appears (such as brown eyes or blue eyes) is called its **phenotype**. What its genes are like (BB, Bb or bb) is called its **genotype**. If the alleles of an organism are the same (BB or bb) it is called **pure** or **homozygous**. If the alleles are different (Bb) it is a **hybrid** or **heterozygous**. B (brown eyes) **dominates** over, or prevents the expression of b (blue eyes). Sometimes dominance is **incomplete**, as in when a red-flowered plant crossed with a white-flowered plant produces pink-flowered offspring. Mendel discovered that he could determine if an organism showing the dominant trait was homozygous (BB) or heterozygous (Bb) by crossing it with an organism showing the recessive trait (bb). If any of the offspring show the recessive trait, the organism in question must be heterozygous. Mendel called this procedure a **testcross**. A **Punnett square** is a convenient way to display a particular cross. To determine the **probability** of two independent events occurring, the probability of each is **multiplied**. For example, if a man and woman both heterozygous for eye color have a child, the chance of it being a male is 0.5. The chance of the child having blue eyes is 0.25. The chance of them having a blue-eyed male child is 0.25 x 0.5 = 0.125. Probability has no **memory**. Even if a couple has 5 daughters, when they have their next child, the chance of it being a girl is 0.5. Mendel noted that when he observed two traits during a cross (for example, BbRr x BbRr) the alleles of the two traits segregated independently of each other. This he called his **law of independent assortment**. This law holds true only for genes that do not exist on the same chromosome (**gene linkage**). Many traits are the result of more than simply a dominant or recessive allele. Traits that result from more than two possible alleles are called **multiple alleles**. Human blood types illustrate an example of multiple alleles. The alleles I^A, I^B, and i produce the genotypes I^AI^A, I^Ai (phenotype A), I^BI^B or I^Bi (phenotype B) or ii (phenotype O). I^A and I^B show incomplete dominance, and both dominate over i. Most traits result for genes on the **autosomes**, but some are due to genes on the **sex chromosomes**. These **sex-linked traits** normally affect males who inherit the trait from their mother. Color blindness and hemophilia are two examples of sex linked traits in humans. Both these traits are due to a gene on the X chromosome. Females have two chances to get the correct allele because they are XX, but males, XY, have only one chance to get the proper allele. A **pedigree** is a diagram of a family tree that can show how a trait has passed from generation to generation.

Pedigree of a Family with Cystic Fibrosis



Note: Cystic fibrosis in this family is caused by a recessive allele that is found on chromosome 7.

During the 1950s, **Watson** and **Crick** worked out the **double helix model** for the structure of DNA. DNA is thought to consist of a twisted ladder. The sugar **deoxyribose** and **phosphates** make up the uprights of the ladder and pairs of **bases** form the ladder rungs. The base pairs are **adenine** with **thymine** and **guanine** with **cytosine**. Genetic information is stored in the order of the bases. It is called a **triplet code**, since three bases code for one amino

acid. In the nucleus there are many free **nucleotides**. A nucleotide consists of a base attached to a sugar and a phosphate. During the S phase of interphase, **DNA replicates**. A **polymerase** enzyme unzips the DNA and nucleotides are fitted onto the exposed bases. As a result there are two identical strands of DNA. Protein synthesis has two steps. During the first step, **transcription**, a message of messenger RNA (**mRNA**) is formed. RNA is similar to DNA with three important differences. RNA is a single strand (half of a ladder), the sugar is **ribose** instead of deoxyribose, and where the base thymine is in DNA, RNA has the base **uracil**. The DNA unzips and RNA nucleotides fit onto the coding side of the DNA. The RNA nucleotides do not stay attached to the DNA however. As the mRNA strand is formed, it falls away from the DNA and is transported out of the nucleus to the **ribosomes**. Ribosomes complete the second step of protein synthesis, **translation**. Ribosomes read the mRNA in groups of three bases called **codons**. As a codon is read, a molecule of transfer RNA (**tRNA**) with an **anticodon** site is attached to the complementary to the mRNA codon. At the other end of the tRNA is attached an **amino acid**, so the first amino acid has been put into position. As the next codon is read, the next tRNA is inserted into place and the next amino acid is lined up beside the first. The two amino acids then click together. In this way, a chain of amino acids or a **polypeptide** forms. The polypeptide then will coil into a functional shape as a completed **protein**. The strand of mRNA always begins with an **initiator codon**, and ends when the ribosome reads the **terminator codon**. A **structural gene** is one that codes for the production of a protein, as described above. **Regulator genes** turn on or turn off structural genes. An **oncogene** is one that is responsible for cells becoming cancerous. All the genes that make up an organism are called the **genome**. A **mutation** alters the sequence of bases on the DNA, thus introducing a **genetic variation**. Recently altering the genome of an organism through **recombinant DNA** has become an important technology. Firstly a **restriction enzyme** is used to cut out a needed gene and the same restriction enzyme is used to cut open a bacterial **plasmid**. A plasmid is a ring of DNA that a bacterium can take up from its environment. The, the cut-open plasmids and the DNA containing the needed gene are mixed together, and **ligase** enzymes are used to fasten the new DNA into the plasmids. Then the genetically altered plasmids are taken up be bacteria, which will then make the protein coded for by the inserted gene. The technology **gel electrophoresis** also uses restriction enzymes. DNA is cut into fragments using restriction enzymes, and the DNA fragments are stained with a **radioactive DNA marker**. Then the DNA fragments are placed in gel. An electrical current is used to draw the DNA through the gel. The smaller fragments move more quickly. After some time the gel has bands corresponding to the DNA - a sort of **DNA fingerprint**.

Populations and Communities

Early in the 1900s, **Hardy** and **Weinberg** worked out that the frequency of an allele in a population would not change from generation to generation. This is referred to as the **Hardy-Weinberg equilibrium**, which can be altered if

- there is **migration** of a gene into or out of the population (immigration or emigration), or
- there is **non-random mating** with certain genotypes more likely to leave offspring, or
- the population is very small such that by chance a gene disappears or increases in frequency (**genetic drift**), or
- a **mutation** adds a new gene to the population, or
- **natural selection** favors certain genes for survival.

When the frequency of the alleles that make up the gene pool of a population change over time, the population is evolving.

The two Hardy-Weinberg equations are as follows:

$$p + q = 1.0$$

in which p = all the dominant alleles,
q = all the recessive alleles, and
1.0 = all the alleles for this trait in the gene pool.

$$p^2 + 2pq + q^2 = 1.0$$

in which p^2 = all the homozygous dominant (e.g. BB)
2pq = all the heterozygous (e.g. Bb)
q2 = all the homozygous recessive (bb), and
1.0 = all of the individuals of the population.

The size of a population is increasing if its **natality** and **immigration** exceeds its **mortality** and **emigration**. **Interspecific competition** refers to competition between a population and another population of a different species (e.g. moose and elk). **Intraspecific competition** involves competition between members of the same species. Organisms have relationships with organisms of other species. In **mutualism**, both organisms benefit. In **commensalism**, one organism benefits, and the other is unaffected. In **parasitism**, one organism benefits, and the other is harmed. In **predator-prey relationships**, the size of both populations fluctuates together. When there are more prey animals, the number of predators can increase. The predators keep the prey population from getting too large, and keep the prey population healthy by feeding on the old weak and sick. The **biotic potential (r)** is the maximum rate at which a population can increase its size. All the **limiting factors** that keep a population from growing at its **biotic potential** are called the **environmental resistance**. Limiting factors can be **density-dependent** if the limiting factor has a greater impact if the population density is greater. Density-dependent limiting factors tend to be **biotic**, such as food supply, predators or disease. **Density-independent** limiting factors have the same effect on population regardless of the density of the population. These factors tend to be **abiotic**, such as climate, or natural disasters. The **carrying capacity (K)** refers to the maximum number of individuals that an environment can support. An **r-selected population** is one that relies on its high biotic potential. These are typically small, quick growing organisms which produce large numbers of offspring, provide little parental care that therefore have a very low survival rate. Their population size can increase rapidly, but will fluctuate wildly and can crash as quickly as it rises. If released into a new area, the r-selected population will increase rapidly, exceed the carrying capacity and crash. This is called a **j shaped curve**. A **K-selected population** relies on a high survival rate to maintain a population size that stays close to the environment's carrying capacity. These are usually large, slow growing organisms that produce few offspring, and provide more parental care. Their population numbers increase slowly but remain more stable. If released into a new area, the K-selected population will increase slowly to the carrying capacity and level off. This is known as an **s shaped curve**. Change in a community over time is called succession. If the community begins on bare rock, the change is **primary succession**. This process begins with a **pioneer species** such as lichen or moss, and eventually becomes a **climax community** dominated by one **dominant species**. If an established community is disrupted by fire or disease, and then renews the march toward a climax community, it is **secondary succession**. The **chaos theory** states that it is impossible to take into account all the variables that affect a system as complex as an ecosystem. There will always be a certain amount of randomness that cannot be foreseen.