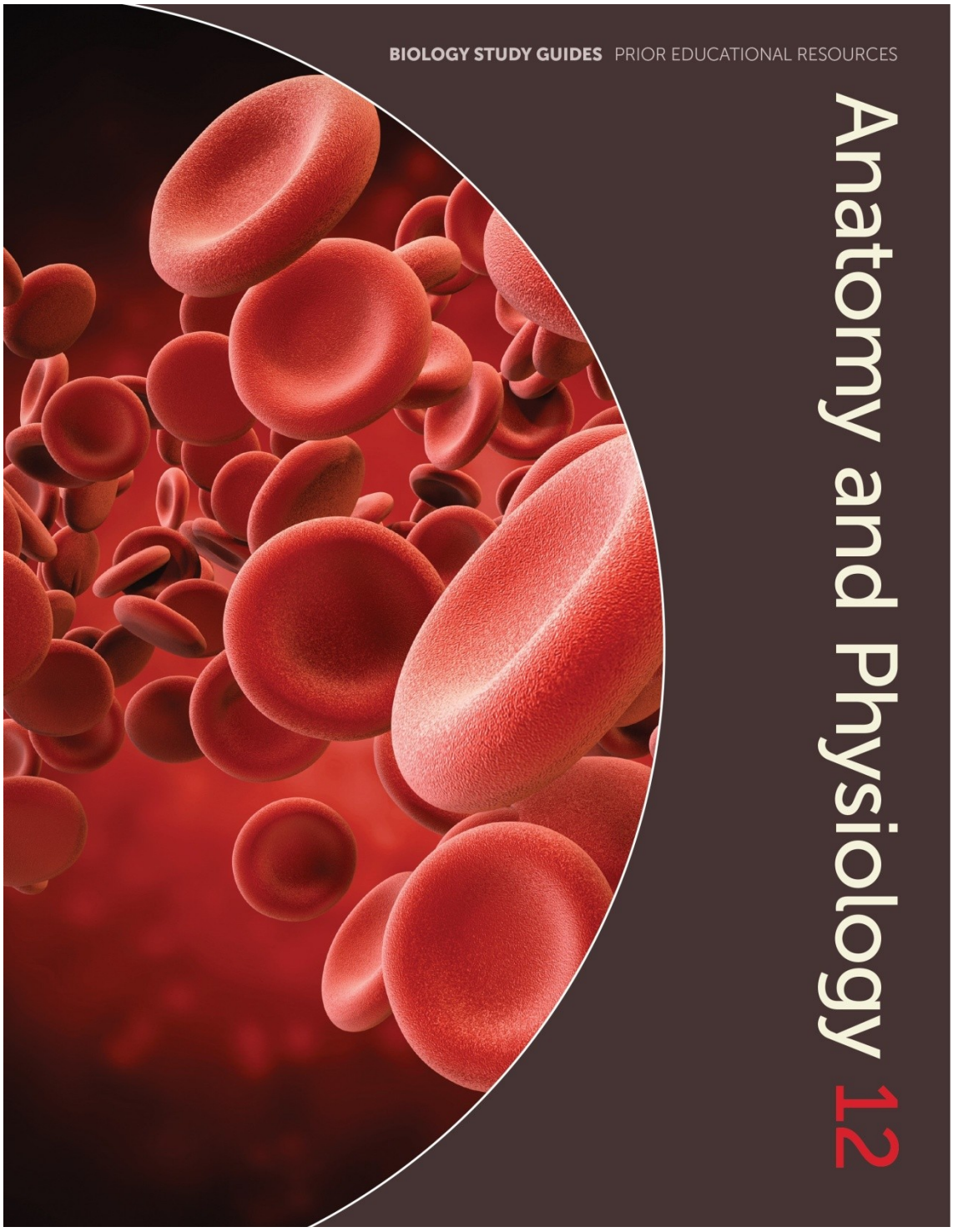

PREVIEW PACKAGE

Thanks for your interest in the new *Anatomy and Physiology 12* student resource book! Please enjoy this selection of 17 of its 240 pages, which illustrate many of the key features.

Roger Prior, author and publisher

Biology Study Guides
Prior Educational Resources Ltd.

Between the Covers:

Table of Contents that indexes all the units and subunits and matches the revised curriculum.

11 Units – each one has:

Colour coding and "**thumb tabs**" for ease of reference

Learning outcomes and a representative photograph to start each unit

A Short **Introduction** to help provide a focused approach to the topic

Content broken into **subunits** and presented in an easy-to-read manner with key words highlighted when they are introduced. All key words (over 900 of them!) are defined in the **Glossary** at the back.

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- **Check Your Knowledge of Concepts** – a set of 25 multiple choice questions at the end of every unit.
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Answers to all of the Concept Check-up Questions, Check Your Knowledge of Diagrams, and Check Your Knowledge of Concepts are provided in the book

Appendices with other useful information, such as histology, the endocrine system, cellular metabolism and the structure of the amino acids

Price: $22.00 each

Roger Prior began his teaching career in SD #35 (Langley) in 1974. In 1978 he began teaching Senior Biology in Trail, BC. In the late 1990s he recognized a need for student resources for biology and set about to write his first biology study guide, which he published in 1999. Roger retired in 2012.

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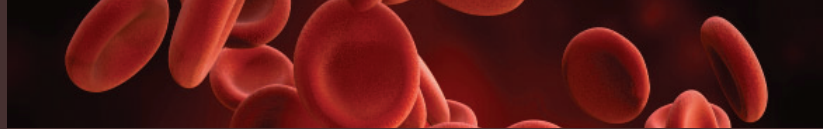

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INTRODUCTION

As much as ***Anatomy and Physiology 12*** is remarkably similar to its predecessor, ***Biology 12 Study Guide,*** it is just as different. Both student resources were prepared as study guides with students in mind—rich with information, questions and answers, supporting pictures, and complete glossaries. In order to keep pace with the curriculum as well as current research, ***Anatomy and Physiology 12*** has some different themes and new features. As with its associated resource for Grade 11, ***Life Sciences 11***, this book has a carefully expanded design. Coloured illustrations with explanatory captions enhance the text, QR codes enable students to go beyond the core topics and see related articles to enrich their learning experiences.

Cellular processes and functions are the focus of the first five units. A great deal of cell research is ongoing. The scientific community will continue to grow and unravel more mysteries of life. For example, it knows which cellular deficiency causes progeria, the aging disease, as well as many other rare afflictions, which were previously mysteries. Armed with this knowledge and having access to the human genome, it may be possible to, literally, fix these disorders. It is crucial that advancement of knowledge about cells and cell functions continue.

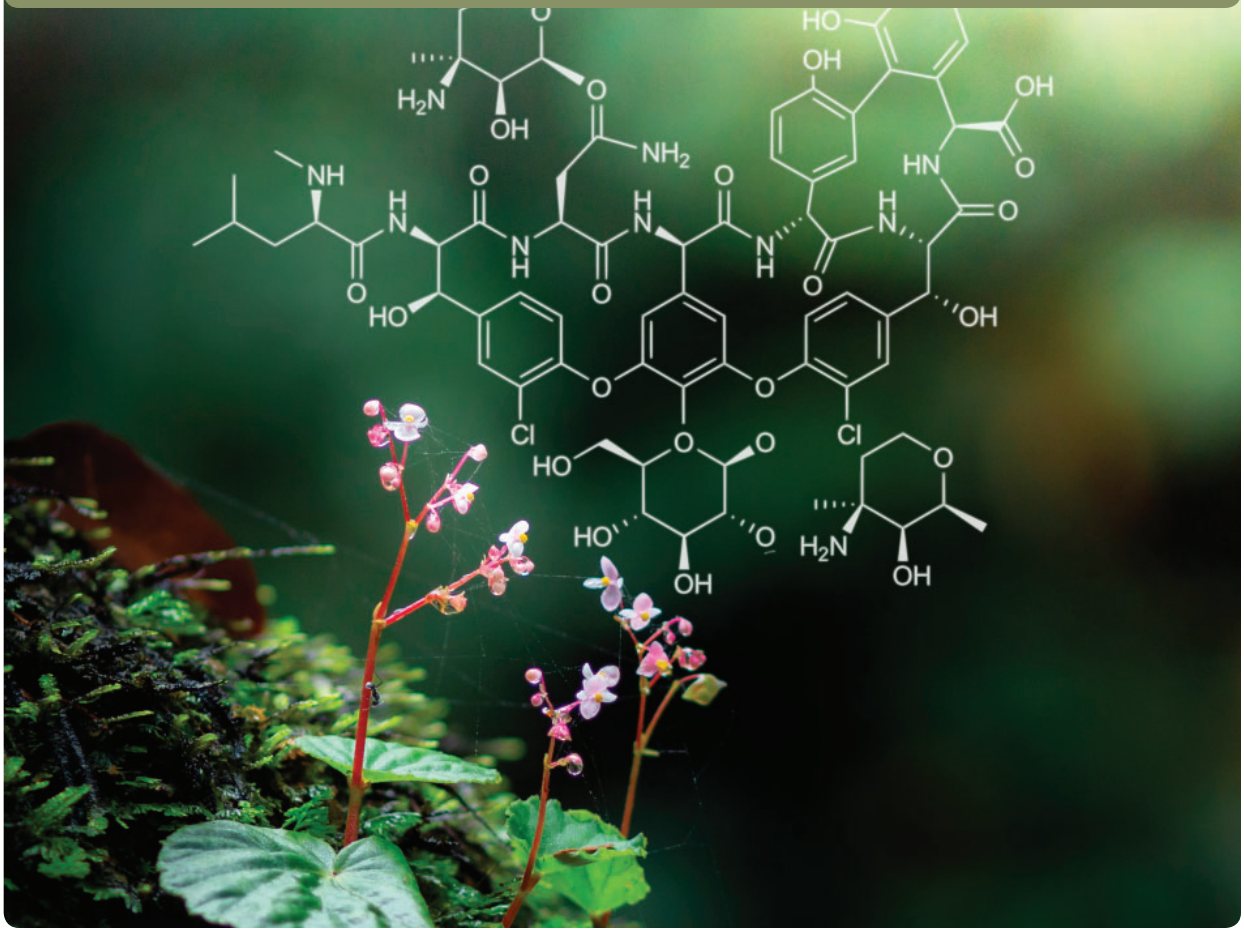
With a solid understanding of biological molecules, membranous structures and functions, enzymes and metabolic pathways, DNA and cell genetics, students will be well equipped for the final six units, which deal specifically with human anatomy and physiology. The cardiovascular system encompasses lymphatics and immunity. Every one of these units includes relevant health topics emphasizing homeostasis and lifestyle choices. Opportunities exist to extend the content to consider First Nations' holistic approach to health.

Extension topics complement the presentation of the structures and functions of the six systems. "Appendix A. Human Tissues" supports the integration of histological terms. "Appendix B. Hormones—Chemical Messengers of the Body" enhances the inclusion of many hormones throughout the text. Finally, Appendices C and D provide reference material for cellular respiration and amino acid structures.

CELLULAR COMPOUNDS AND BIOLOGICAL MOLECULES

This unit will enable you to:

- Differentiate between ionic, covalent and polar covalent bonds
- Describe the formation and effect of positive and negative dipoles
- List six characteristics of water and explain their significance to organisms
- Contrast acids and bases in terms of pH and chemical properties; explain the role of buffers
- Assess a molecular structure or formula as organic or inorganic
- Evaluate carbon as an essential component of biochemicals
- Use examples to demonstrate an understanding of the participation of water in hydrolysis and synthesis reactions
- Recognize a variety of monomers and combinations of monomers
- Explain the structures, key features and uses of a large variety of carbohydrates, lipids, proteins and nucleic acids
- Explain the role of ATP as "energy currency"



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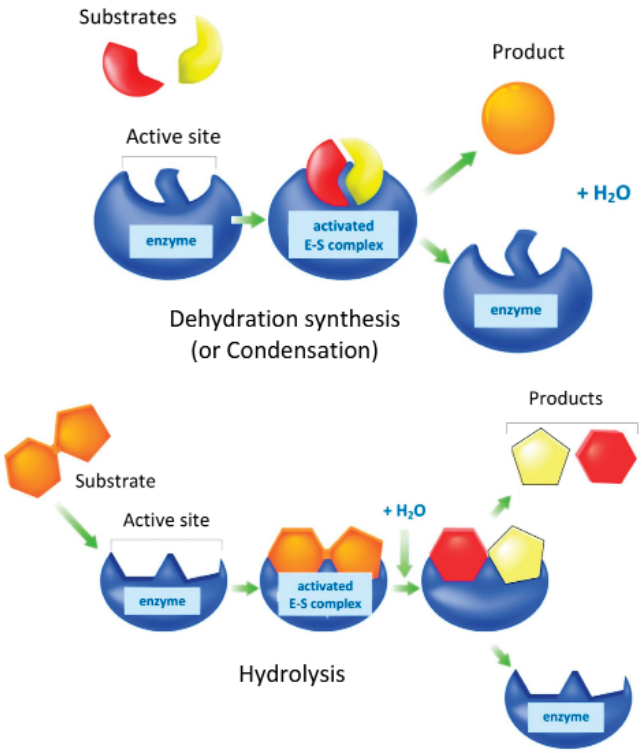
B.2 MODELS OF ENZYME ACTIVITY

Enzymes are very large molecules—usually comprised of well over a hundred amino acids. Human maltase for example, which can be extracted from liver cells, has over nine hundred amino acids coupled together by peptide bonds to form its intricate three-dimensional structure. Using the modern techniques of X-ray diffraction, researchers are able to see the shapes of enzymes like these, and can tag the substrates so they can view the molecular combinations. As precise as this is, the exact behaviour of the E-S complexes during a reaction cannot be viewed. Models have been developed and are used to illustrate and help one visualize the structure of enzymes and how they are believed to function.

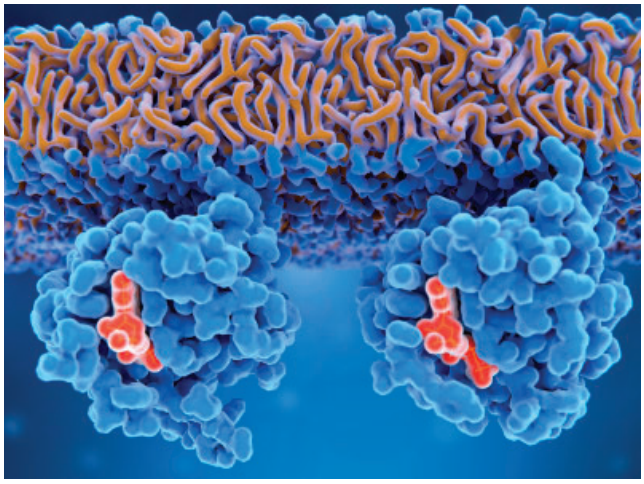
In 1894 Emil Fischer, a German chemist proposed the analogy of a lock and a key to help explain the physical relationship between an enzyme and its substrate. This analogy, which has since become known as the **Lock and Key Model**, states that a substrate and an enzyme fit together like a key fits into a lock. The visual this creates is useful because it emphasizes that each component in the reaction must have the correct shape and fit together perfectly for a reaction to occur (i.e., for a lock to be unlocked). The result of an enzymatic reaction is to change the substrate, but the enzyme (lock) remains intact and may be used repeatedly. To take this comparison one step further, the size and shape of the key hole is significant as not all keys will fit into a given lock—and even if a key will fit through a key hole, it may still not unlock the lock because it is not the right shape to match the mechanism inside the lock.

In enzyme language, the particular location where the substrate joins the enzyme is called the **active site**. The combination of specific amino acids in this region determines its exact shape and chemical nature. Not only must a molecule have the right shape and size to match an active site in order to unite with it and form an E-S complex, it must also match it chemically if the reaction is going to take place. When this happens, the combined arrangement is referred to as an **activated E-S complex**.

The lock and key analogy has the short-coming of presenting enzymes and substrates as being solid, rigid structures, where it is believed that the nature of



The Lock and Key Model. This model helps one visualize how enzymes function. The three-dimensional shape of the enzyme provides a place, called an active site, for the substrates to fit into forming the activated enzyme-substrate complex. This association puts stress on the bonds in the substrates, which results in the reaction. *(Illustration credit: www.Shutterstock #615682358, 643324852)*



The Importance of Shape. This 3-D rendering of a receptor protein on a cell's surface shows the protein's shape changing slightly as its receptor site combines with another molecule, an interaction that causes a change in the cell. The Induced Fit Hypothesis applies this feature to enzyme activity. *(Illustration credit: www.Shutterstock #1035491281)*

phenomenon called the **Law of Diffusion**. A smell, for example will diffuse through the air until the molecules that create the odour are so spread out that it can no longer be detected.

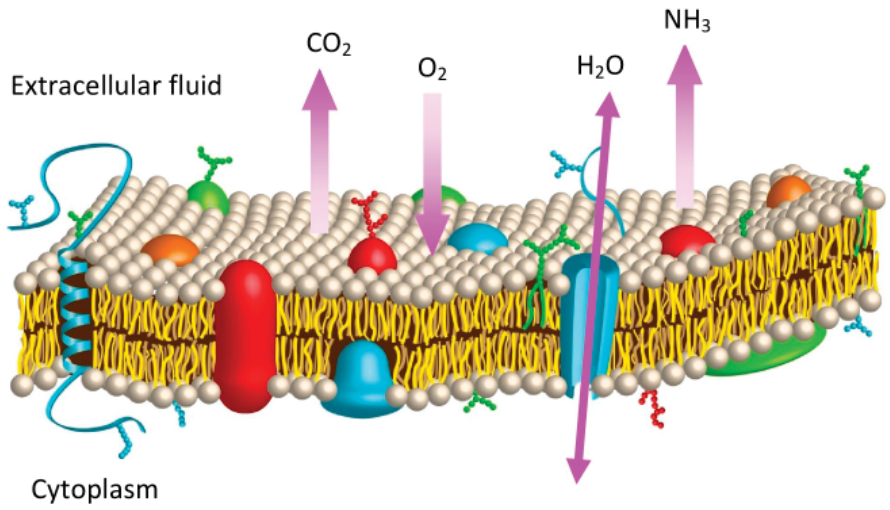
Differences in concentration that give rise to diffusion are known as **gradients**. If the solute particles are ionic or dissolved solids, this difference is a **concentration gradient**. For gaseous solutes such as oxygen or carbon dioxide, such differences are referred to as **pressure gradients**. The greater the difference (i.e., the steeper the gradient), the faster the movement of particles.

Diffusion is a **passive process**, meaning energy (ATP) is not required. In organisms, some small substances diffuse through membranes moving in or out of cells as if the membrane wasn't even there. O_2, CO_2 and NH_3 are examples of molecules that have this freedom of movement. As well, the particular arrangement of phospholipids allows some lipids to pass through because they are nonpolar and able to slip past the hydrophilic heads to mix with the interior before slipping through to the other side of the membrane.

A number of factors affect the rate of diffusion. Increasing the temperature of a solution, for example, increases the kinetic energy of its particles allowing them to move more quickly. This increased motion increases diffusion. The shape and size of the particles also plays a role. Smaller, more streamlined substances diffuse more rapidly because they encounter fewer collisions with other substances. Particle size is a critical factor when considering cells. Many substances are unable to cross membranes readily to enter or leave cells because they are too large, therefore, cells rely on other strategies to transport them.

If the particles are ions, their charge means they are either attracted or repelled in particular directions by the presence of other ions or features of the solution, such as a magnetic field. This movement can either assist or hinder diffusion. Nerve impulses travel along nerve cells because of the movement of sodium and potassium ions across nerve cell membranes. This movement results from concentration gradients as well as ionic charge.

Still another feature of solutions affecting the rate of diffusion is the **viscosity** (fluid density) of the solution. The lower the viscosity of a solution, the more quickly particles can move through it. By way of example, the viscosity of water is much less than that of syrup. Diffusion in water occurs more quickly than



Diffusion through a Membrane. Small gas molecules and water will diffuse through membranes. As cells use up oxygen, it will diffuse in. Carbon dioxide and ammonia are produced in cells, so they diffuse out. Because of the polar nature of water, it requires the presence of protein channels to avoid the hydrophobic interior of the membrane. *(Illustration credit: www.Shutterstock #356996297)*

parent population. These **transgenic** or **genetically modified organisms** (GMOs) are becoming well known. Many of the food crops produced around the world are genetically modified. A little known example is the existence of genetically modified goats that produce spider silk as a component of their own milk. These strong fibres are harvested and used in various ways. Another example is the production of "edible vaccines" in the form of foods such as bananas, so being vaccinated in the future may become a matter of eating the correct food. Scientists have developed golden rice, which produces beta-carotenes needed for making vitamin A. This has the potential to resolve a common vitamin deficiency.

Cloning is also part of this topic. The collection of **gametes** by animal breeders has been going on for decades. The agricultural community has used **artificial insemination** to raise animals that have the greatest potential for maximizing economic gain. With genetic modification, it is very easy to select and alter specific gametes to produce genetically identical organisms. At a research level, these **clones** are useful because organisms with the same genetic make-up can be used in studies of differential gene expression, thereby advancing the understanding of genetic variations, including those associated with disease. Cloned organisms also have the potential to play a huge role in food and resource production.

The development and use of this type of research has not and is not done without objection. There are some ethical issues and public paranoia associated with it. These techniques give researchers the ability to design organisms, to create new species of organisms on earth. Additionally, there are some public advocates against the consumption of genetically altered or enhanced food. Other advocates speak out about the rights of animals and are appalled by the production of laboratory clones.

E.6 CONCEPT CHECK-UP QUESTIONS

1. Define recombinant DNA.
2. Why can only some hormones be produced by biotechnology? Why not all of them?
3. What are the advantages of using biotechnology to make proteins used for medical treatments?
4. What is the HGP? What was its purpose and when was it completed?
5. Name three advantages of having the database produced by the 1000 Genomes Project.
6. How do the purposes of the 1000 Plants Genomes Project differ from the 1000 Genomes Project?

E.6 DISCUSSION QUESTIONS

1. Before gene therapy techniques were developed for diseases such as sickle-cell anemia, tissue transplants were used. Contrast these two techniques and be prepared to comment on the differences.
2. (Research) In the mid-1970s an international moratorium was imposed on conducting a certain type biotechnological research. Find out why. What were they afraid of?
3. (Research) Recently, scientists have been determining the genetic make-up of species with the intention of improving them. Here are two examples: pine tree (*http://phys.org/news/2014-03-loblolly-immense-genome-conquered.html*) and peanuts (*http://phys.org/news/2014-04-peanut-genome-sequenced.html*). Find a third example and be prepared to present your findings.
4. Do the pros of genetic manipulation outweigh the cons? Take a stance and be prepared to defend your position. How has public opinion changed over the years?

Genetically Modified Rice. Rice is one of the world's most valuable grain crops. Researchers have successfully produced genetically engineered varieties of rice that are higher yielding and more nutritious—an outcome seen as a positive step toward addressing food shortages in the world. *(Illustration credit: www.Shutterstock #1087407698)*

Clones are Genetically Identical. Cloning animals for agricultural purposes may become commonplace in the future. It is a desire of people in the industry to have a herd of high-producing dairy cattle, or a flock of good laying hens. *(Illustration credit: www.Shutterstock #1031996269)*

TAKE A CLOSER LOOK AT:
USING CLONED CRAYFISH FOR CANCER RESEARCH

TAKE A CLOSER LOOK AT:
PLANT GENOME FOR SWEETNESS

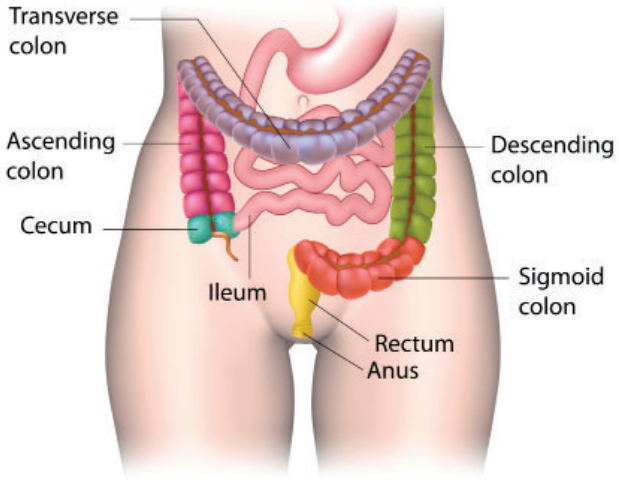
villi. These cells have extensive surface area due to minute cytoplasmic extensions called **microvilli**, creating a "**brush border**" surface. As well, the membranes of these mitochondria-rich cells have specific transport proteins required for moving the various monomers from chyme into the cytoplasm. These cells also contain enzymes that reconstruct the products of fat digestion into neutral fats.

Inside each villus is a bed of loose connective tissue into which extends a capillary bed and an absorptive end of the lymphatic system called a **lacteal**. The newly synthesized fat molecules slip through the cell membranes and enter the lacteals. The rest of the products of digestion are moved through the epithelial cells and across the membrane into the interior of the villi where they enter the blood stream.

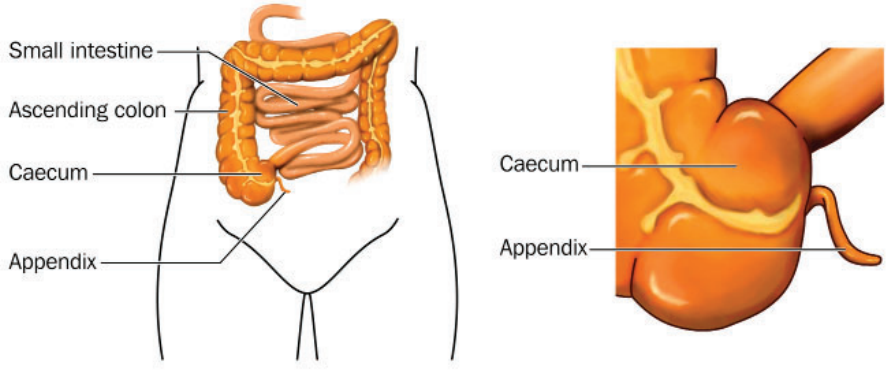
In summary, the small intestine has several functions. First, it receives and produces secretions that further the digestion of food materials. It also has a transport function moving chyme from the stomach to the large intestine. Finally, being equipped with villi and microvilli, it is specialized for absorption.

PREPARATION OF FECES AND DEFECATION

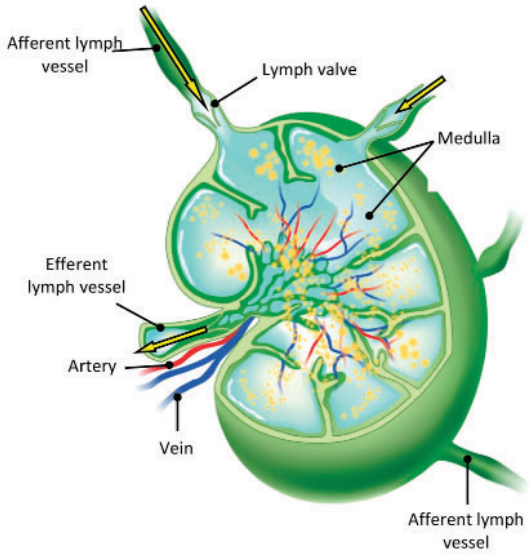
Once the available nutrients from the food are absorbed, the remains (water plus undigestible materials like **cellulose**) pass from the ileum through the **ileo-caecal valve** (another sphincter) into the



Parts of the Colon. The shapes of four major regions of the large intestine or colon provide them with their names. The ascending colon leads to the transverse colon, the descending colon and finally the sigmoid ("s-shaped") colon. Other regions are the caecum and the rectum. *(Illustration credit: www.Shutterstock #228843008)*



The Appendix. Descending from the caecum is a finger-sized projection called the appendix. In other mammals, this structure is specialized into a cellulose-digesting organ. Humans lack the enzymes required to do this, so the appendix is somewhat functionless. Unfortunately, infections of the appendix are common. *(Illustration credit: www.Shutterstock #104901704)*



Lymph Node. Enlargements form at the junction of lymph vessels. These are lymph nodes, which house memory Tcells and macrophages. These immune system cells remove potential pathogens from the lymph before a single efferent lymph vessel conducts it away eventually conducting it to the blood stream. *(Illustration credit: www.Shutterstock #1035495370)*

TAKE A CLOSER LOOK AT:
BACTERIA OF THE BODY

TAKE A CLOSER LOOK AT:
THE FUNCTION OF LYMPH NODES

on valves and skeletal muscle activity. This system is often described as a venous system for this reason.

The hundreds of lymph nodes in the body are home to countless memory T cells. When the lymph harbours foreign antigens, the immune responses of these cells remove them. Lymph nodes can become enlarged, which is a sign that leukocytes are being mass-produced in order to destroy foreign antigens. Persistent enlarged lymph nodes may be a sign of cancer. Health topic: lymphadenitis, lymphoma

Lymphatic vessels also originate in the spleen, which is located above the left kidney. This relatively small organ stores plasma and blood cells and is sensitive to the condition of the blood that flows through it. It can mass-produce lymphocytes when necessary to help ward off disease. The thymus is located in the necks of children—it normally deteriorates in late childhood or early teen years. Like the spleen, it has a blood supply as well as the origins of lymph capillaries. It stores lymphocytes and has an active role in their maturation into Tcells. An adult's ability to produce new Tcells is limited to the mitosis of the cells that they already have after the thymus is no longer active. Tonsils, located in the pharynx, also part of the body's first line of defense, help to capture and remove potential pathogens in inhaled air and food. In many respects, they also resemble the thymus as they play a role in Tcell production and the introduction of these cells into the lymphatic ducts they contain. The tonsils can become infected and become greatly inflamed as their stores of white blood cells actively destroy foreign antigens. If infected tonsils pose a health risk, they are often removed. Health topic: tonsillitis

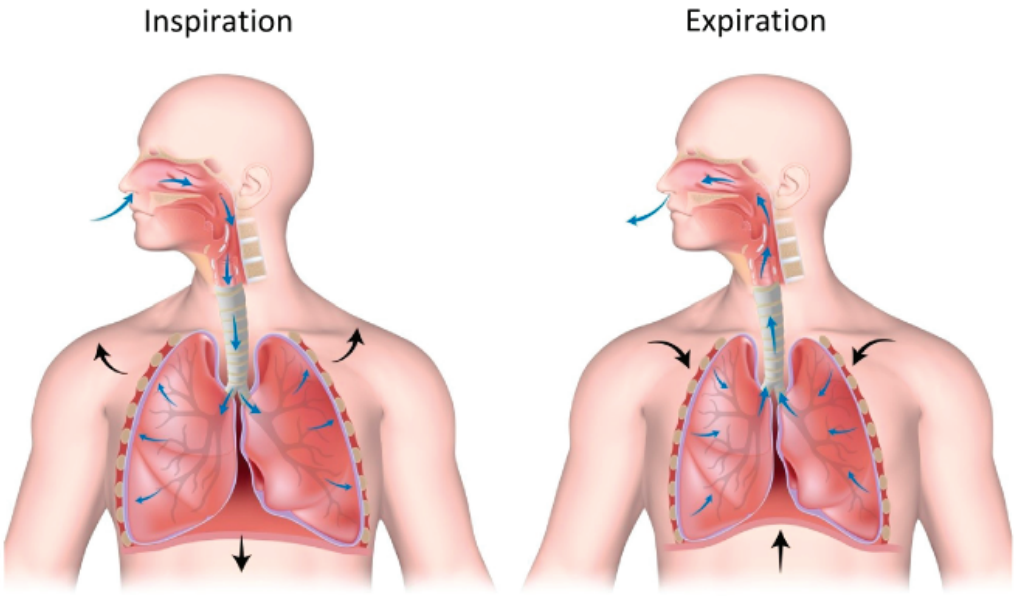
Swollen Lymph Node. Enlarged or swollen lymph nodes can be a sign of a further medical issue, perhaps cancer, known as lymphoma. During metastasis, cancer cells move through the blood stream and lymph vessels. These cells can establish themselves in lymph nodes, starting a secondary cancer. *(Illustration credit: www.Shutterstock #1117938110)*

G.7 CONCEPT CHECK-UP QUESTIONS

1. In general terms, describe the role of the lymphatic system.
2. Describe the role of lymph capillaries in each of the following:
   a. villi
   b. capillary-tissue fluid exchange
   c. inflammatory response
3. How are the functions of lymph nodes, spleen, tonsils and thymus related? How are they different?
4. Describe a condition that will prevent the lymphatic system from functioning.

G.7 DISCUSSION QUESTIONS

1. What is lymphoma? What does having lymphoma mean to one's overall health?
2. What causes elephantiasis? Describe a treatment for it.
3. (Research) What becomes of one's tonsils?
4. (Research) What are immune-suppressant drugs and how do they work?

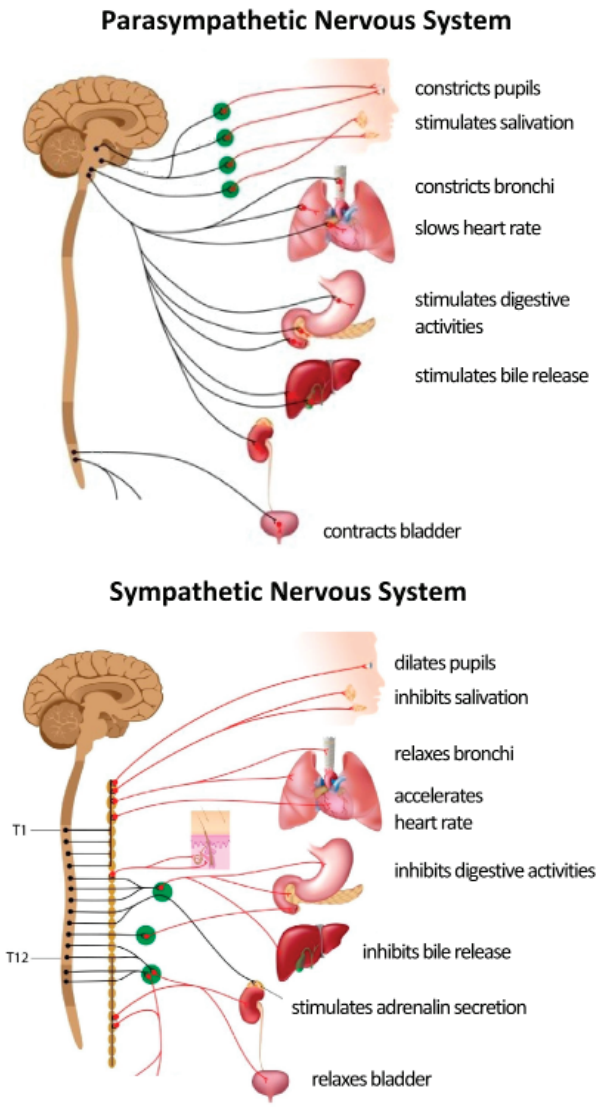


Inspiration and Expiration. Inhaling (inspiration) requires the coordinated muscle contractions of the diaphragm and the intercostal muscles between the ribs. This action creates a vacuum effect in the thoracic cavity, which draws air in, cleaning and conditioning it as it moves. Exhaling occurs when these muscles relax. *(Illustration credit: www.Shutterstock #228844606)*

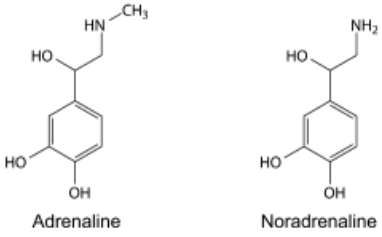
H.2 MECHANICS OF BREATHING

The **respiratory centre**, which is in the **medulla oblongata**, subconsciously controls breathing. This part of the brain stem at the top of the spinal cord contains nerve receptors that are sensitive to the concentrations of carbon dioxide and hydrogen ions in blood plasma. Both of these are toxins that result from cell metabolism and both need to be excreted. When their concentrations get to a critical level, the medulla oblongata sends nerve impulses to the **diaphragm** and the **intercostal muscles** (muscles between the ribs), causing them to contract. The diaphragm, which is bowed up when relaxed, flattens downward when it contracts. When the intercostal muscles contract, they pivot the rib cage upward and outward from its dorsal attachments to the vertebral column. The combined effect of these motions increases the volume of the **thoracic cavity**. This creates negative pressure in the cavity (vacuum effect) and air is drawn in through the trachea. This is inhalation, an active process requiring ATP for the contraction of the muscles.

The **serosa** (tissue lining) of the thoracic cavity, as well as that of the lungs, are thin, delicate coverings called the **pleural membranes**. The **interpleural space** between these two surfaces normally has negligible volume and contains a thin layer of fluid that acts as a lubricant. During inhalation, muscles move the rib cage up and out. The outer pleural membrane, which lines the rib cage, moves as well and, because of the cohesive nature it has with the inner membrane, it pulls on the surface of the lungs, which facilitates their expansion and aids inhalation. This arrangement of membrane-fluid-membrane also allows the surfaces of the lungs to slide smoothly and easily against the inner walls of the thoracic cavity during breathing. In addition, the membranes seal off the thoracic cavity so the only entry point for air is through the trachea. A puncture wound to the chest wall, piercing the outer pleural membrane (even



Autonomic Nervous System. Many body functions and actions increase and decrease autonomically, without thought processes. The heart rate is a good example. It follows that the autonomic nervous system (ANS) that controls this has two subdivisions, the parasympathetic and the sympathetic systems, which use different neurotransmitters and have antagonistic effects on the various organs. Notice other distinctions, such as where and how they connect to the CNS. *(Illustration credit: www.Shutterstock #106263590, 106263593)*



Adrenaline and Noradrenalin. Adrenalin is a hormone released from the adrenal medulla in times of stress. It causes several body responses, such as increases to the heart and breathing rates. Noradrenalin, the neurotransmitter of the sympathetic nervous system, has the same effects. Note the chemical similarity between these two molecules. Noradrenalin secretion at the adrenal medulla promotes its adrenalin release. *(Illustration credit: www.Shutterstock #283257797)*

I.4 AUTONOMIC NERVOUS SYSTEM

Impulse transmission (saltatory and synaptic) occurs in the same way in both the somatic nervous system, for reflexive actions and conscious body control, as well as the autonomic nervous system, regulating our internal functions including heart rate, breathing rate, peristalsis, etc. The ANS deserves a closer look because of additional complexities of its structures and functions.

If one considers the heart, the rate at which it beats increases during times of activity to boost the circulation of gases and nutrients. The muscles are working harder; they are consuming more nutrients and oxygen as well as generating more wastes. When resting, the rate returns to normal. At any given time, the rate the heart contracts results from the combined effect of the two subdivisions of the autonomic nervous system. The **sympathetic** part promotes active body functions (such as increasing heart rate and breathing rate) while the **parasympathetic** part controls the opposite, often termed vegetative (such as slowing heart rate, promoting sleeping and digesting food). These subdivisions are antagonistic in their activity. Together, they help the body maintain homeostasis.

Keeping with the example of heart rate, if the two subdivisions of the ANS alter the rate in different ways, yet the impulses traveling along each type of neuron are the same, it follows that the sympathetic neurons and the parasympathetic neurons must release different neurotransmitters. By extension, different enzymes must also be present in the corresponding synaptic regions to destroy the enzymes so the same neural pathways can be used again. The neurotransmitter produced by sympathetic neurons is **noradrenaline** (AKA **norepinephrine**). It is destroyed by the enzyme **monoamine oxidase**. The antagonistic neurotransmitter is **acetylcholine** (Ach). It is destroyed by the enzyme **acetylcholinesterase** (AchE). Saying it another way, Noradrenaline (sympathetic) promotes active body functions such as increasing heart rate and breathing. Acetylcholine (parasympathetic) promotes vegetative activity.

There are other distinctions between the sympathetic and parasympathetic parts of the autonomic nervous system. The ANS is an effector system only meaning that there is no sensory component to it. Structurally, two motor neurons are required to

REVIEW QUESTIONS

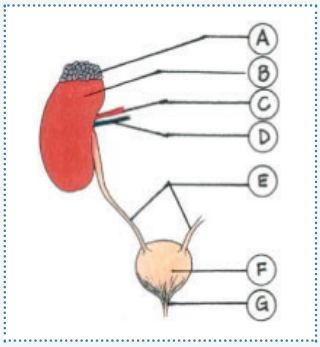
Check your knowledge of diagrams

1. **Name the structures indicated by letters A to G in diagram 1 and describe ONE function of each.**

2. **Name the parts of the circulatory system indicated by letters H to L in diagram 2.**

3. **Name the nephron structures indicated by letters M to Q in diagram 2 and describe the contribution to urine production that occurs at each one.**

1.



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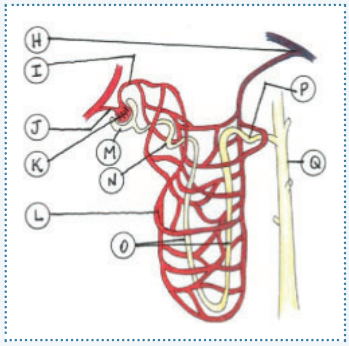


Check your understanding of concepts

1. **Which sequence of structures does urine flow through?**
   A. Renal pelvis, ureters, urethra
   B. Renal pelvis, urethra, ureters
   C. Ureters, renal pelvis, urethra
   D. Urethra, renal pelvis, ureters

2. **Which is the correct sequence of these blood vessels after blood leaves the renal artery?**
   1. Glomerulus
   2. Efferent arteriole
   3. Afferent arteriole
   4. Peritubular capillaries
   A. 3, 2, 1, 4
   B. 2, 4, 1, 3
   C. 3, 1, 2, 4
   D. 1, 2, 3, 4

3. **The respiratory system and an alveolus correspond to each other in the same way as the urinary system corresponds to a**
   A. nephron.
   B. glomerulus.
   C. collecting duct.
   D. urinary bladder.

4. **Which is the correct sequence of regions of a nephron that forming urine encounters?**
   A. Proximal tubule, distal tubule, loop of Henle
   B. Proximal tubule, loop of Henle, distal tubule
   C. Distal tubule, loop of Henle, proximal tubule
   D. Distal tubule, proximal tubule, loop of Henle

5. **Urea is produced by the**
   A. liver.
   B. kidneys.
   C. nephrons.
   D. body cells.

6. **Which description is MOST applicable to blood entering a glomerulus?**
   A. Low blood pressure and velocity, oxygenated, low urea content
   B. Low blood pressure and velocity, oxygenated, high urea content
   C. High blood pressure and velocity, deoxygenated, low urea content
   D. High blood pressure and velocity, deoxygenated, high urea content

7. **The process that occurs between the glomerulus and Bowman's capsule is**
   A. selective and passive.
   B. non-selective and passive.
   C. selective and requires ATP.
   D. non-selective and requires ATP.

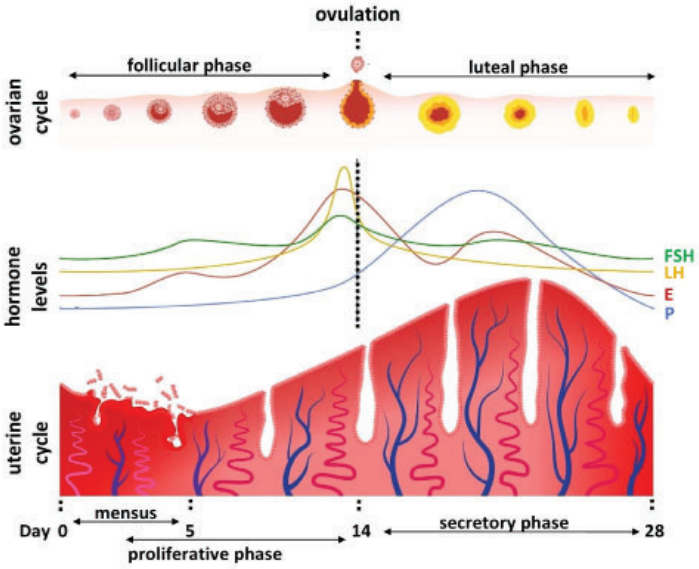
8. **Which blood component becomes more concentrated as a result of pressure filtration?**
   A. Water
   B. Nutrients
   C. Globulins
   D. Nitrogenous wastes

9. **How many of the following substances normally enter filtrate?**
   • Ions • Urea • Protein
   • Oxygen • Glucose • Blood cells
   • Amino acids
   A. Three only
   B. Four only
   C. Five only
   D. Six only

10. **The cells that line the proximal convoluted tubule are specialized for**
    A. filtration.
    B. transport.
    C. secretion.
    D. contraction.

11. **How does the blood in an efferent arteriole compare to the extracellular fluid in the cortical region of a kidney?**
    A. Hypotonic and higher pH
    B. Hypertonic and higher pH
    C. Hypotonic and the same pH
    D. Hypertonic and the same pH

12. **What feature is present in cells of the descending part of the loop of Henle that is absent in the ascending side?**
    A. cilia
    B. Na/K pumps
    C. protein channels
    D. hormone receptor sites



Menstrual Cycle. The menstrual cycle combines the ovarian cycle and uterine cycle and all the changes occurring over the 28-day period including hormonal changes. Initially, all four hormone levels are low. During this time, menstruation occurs and the hormone levels begin to increase. The LH surge causes ovulation. During the secretory phase, the endometrium becomes mature and, should fertilization occur, it is ready for implantation. *(Illustration credit: www.Shutterstock #433022800)*

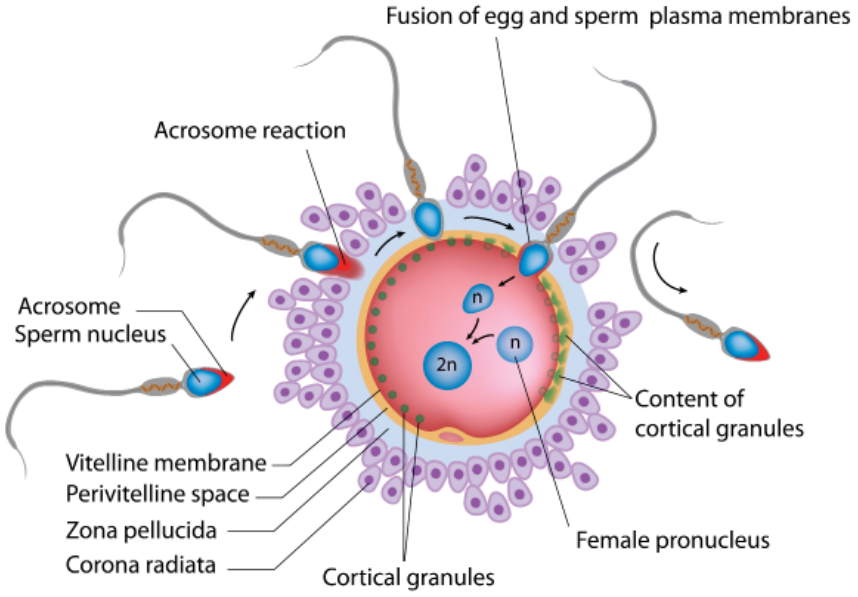
TAKE A CLOSER LOOK AT:
MENOPAUSE

K.4 CONCEPT CHECK-UP QUESTIONS

1. What triggers the release of GnRH in adult females?
2. At what stage during öogenesis does the chromosome number go from 46 to 23?
3. a. Why is the production of polar bodies an advantage?
   b. Compare and contrast an ovum and a sperm.
4. a. What is a Graafian follicle?
   b. What becomes of the follicular tissue of the Graafian follicle following ovulation?
5. Explore the notion of the corpus luteum being a temporaty "scar" tissue remaining from a follicle that burst. How valid is this similarity?
6. a. What happens to ova that are not fertilized?
   b. List the sequence of structures through which an unfertilized ovum passes.
7. How does an ovum get into the oviduct?
8. Describe one example of negative feedback and one example of positive feedback in the female reproductive system.
9. a. Describe the physical events of the phases of the uterine cycle.
   b. How do the ovarian hormones affect the uterine cycle?

K.4 DISCUSSION QUESTIONS

1. Describe the similarity in the roles of LH and FSH in males and females. How are these roles different?
2. Develop a hypothesis to explain a constant supply of fluid that can be swept along the oviducts.
3. Is there a relationship between menopause and a shortage of ova?
4. Do ovaries take turns ovulating or are two ova released during each cycle? Explain.
5. What is the source of testosterone in females? What is its effect on them?
6. What is in "the pill"? How does it affect the menstrual cycle?
7. (Research) What recent discoveries have been made about the genetics of polar bodies?



Fertilization. Fertilization is the union of the genetic material from the ovum and sperm. An ovum is only viable for fertilization for a matter of hours after ovulation. Sperm may live for several days. If they encounter each other while both are viable, the acrosome will allow the sperm's nuclear material into the ovum, which immediately changes the permeability of the ovum, disallowing the entry of any other sperm nuclei. The union of the two sets of chromosomes forms a zygote. *(Illustration credit: www.Shutterstock #166170182)*

blood vessel – tubular structure through which blood is transported. Generally, there are considered to be three types of blood vessels: arteries, capillaries and veins. Related vocabulary: "artery", "capillary", "vein"

bolus – ball of food prepared by the tongue for swallowing. A bolus carries with it some salivary juice, which lubricates its movement down the esophagus and begins the hydrolysis of starch into maltose molecules

Bowman's capsule – specialized beginning of a nephron tubule. Each Bowman's capsule has a porous inner surface that envelops a glomerulus and is the recipient of the fluid material that is forced by blood pressure out of the plasma during pressure filtration. The separated solution is called the filtrate. The composition of the filtrate is progressively modified to form urine. Related vocabulary: "pressure filtration", "glomerulus"

brachial arteries/veins – branches of the subclavian arteries and veins that serve the arms. The brachial artery is significant because it is most often used to measure blood pressure

brain – major organ of the nervous system. It is a mass of nerve cells and support cells with specialized regions that provide an organism with specific abilities. These regions include the cerebrum, cerebellum, hypothalamus etc. The brain associates with the rest of the body through 12 pairs of cranial nerves and the spinal cord. It, like the rest of the central nervous system, is protected from surrounding bone by the meninges. Related vocabulary: "meninges", "central nervous system", "spinal cord"

breathing – the mechanical movements of inhaling and exhaling. Related vocabulary: "inhaling", "exhaling"

bronchi – branches of the trachea that conduct air to and from the lungs. Like the trachea, they are protected from collapse by cartilaginous rings. Additionally, their ciliated mucus lining serves to help condition inhaled air by providing moisture, establishing body temperature, and catching debris. Related vocabulary: "trachea"

bronchiole tree – branching network of bronchioles that conducts air between the bronchi and the alveoli

bronchioles – branches of the bronchi. The bronchioles continue to branch into smaller and smaller passageways finally ending at the air sacs called alveoli. The largest of the bronchioles have cartilaginous walls for support, but, as they get smaller and smaller, they lose their cartilage and rely elastic fibres to maintain their during inhalation. There are millions of bronchiole endings and (therefore) millions of alveoli. The entire air passageway (trachea, bronchi, and bronchioles) is called the bronchial tree. Related vocabulary: "alveoli"

brush border – highly absorptive surface of cells, such as those that line the lumen of the ileum. The surface is created by the invagination of villi creating microvilli, which resemble the hairs of a brush when viewed through an electron microscope. Related vocabulary: "villi", "microvilli"

buffer – substance that resists pH changes through its ionic interactions. For example, a buffer will prevent the pH from dropping by neutralizing excess H^{1+}. Similarly a buffer could prevent a rise in pH by donating H^{1+} to the solution. Bicarbonate ions (HCO_3^{1-}) are significant buffers in the body. Relate d vocabulary: "bicarbonate ion"

caecum – the first lobe of the colon (large intestine) immediately following the ileo-caecal valve. The appendix extends from the caecum. In some mammals, the caecum is specialized and accommodates cellulose-digesting bacteria. In humans, it is not specialized and does not function any differently than the rest of the colon. Related vocabulary: "appendix"

calcium gates – specific type of integral protein that is sensitive to electrical changes (millivolts). The calcium gates in axon termini open to permit the entry of calcium ions as part of synaptic transmission. Related vocabulary: "synaptic transmission"

calcium ion (Ca^{2+}) – significant cofactor (mineral ion) in the body. Included in its functions are: the role it plays in the conversion of prothrombin to thrombin during the formation of a blood clot; the hardening of bone tissue (calcification); triggering the exocytosis of neurotransmitters during synaptic transmission. Related vocabulary: "blood clotting", "synaptic transmission"

Calvin Cycle – metabolic pathway in plant cells that generates glucose. This series of reactions utilizes ATP and hydrogen ions (carried by NAD) that are generated by photophosphorylation as well as CO_2. Related vocabulary: "photosynthesis", "photophosphorylation"

cancer – uncontrolled mitosis of cells. Normally, cell division is metabolically and genetically controlled, but these processes can be disrupted and cell division can occur unchecked. The daughter cells lack normal cell characteristics, are not fully functional and can grow into tumours and/or move, causing damage to other tissues and organs. Related vocabulary: "tumour", "metastasis", "oncogene"

capillaries – smallest type of blood vessel. The walls of capillaries are only one cell thick, thus facilitating capillary-tissue fluid exchange. The array of capillaries between an arteriole and a venule is known as a capillary bed. Sphincter muscles in the arterioles regulate the amount of blood flowing through a capillary bed. Related vocabulary: "arteriole", "capillary-tissue fluid exchange"

capillary bed – branching network of capillaries in a tissue. Capillary-tissue fluid exchange occurs at capillary beds. Related vocabulary: "capillary-tissue fluid exchange", "capillary"

capillary-tissue fluid exchange – exchange of fluid materials between blood in a capillary and extracellular fluids in tissues as the blood travels through a capillary bed. At the arteriole side of the capillary bed, the blood pressure is still sufficiently high (35mm Hg) to force water and some small substances out of the capillaries into the tissue spaces. Oxygen and nutrients readily move down their respective concentration gradients into the cells. Meanwhile, this movement creates an osmotic gradient that draws water back into a capillary at its venule end. The water that is returned now transports substances that are found in abundance in the extracellular fluids, namely CO_2 and NH_3. Under normal circumstances, there is no net change in the fluid volume of blood

carbaminohemoglobin ($HgCO_2$) – combination of carbon dioxide and hemoglobin. This is the second most common way that carbon dioxide is transported safely in plasma from systemic tissues to the pulmonary capillaries where it is exhaled. Related vocabulary: "carbon dioxide", "carbonic anhydrase"

carbohydrate – one of four classes of biomolecules that form macromolecules. Carbohydrates include sugars (such as glucose, ribose, maltose, etc.) and polymers such as starch, cellulose and glycogen. Carbohydrates have the empirical formula: CH_2O

carbohydrate metabolism – metabolism of carbohydrates to generate ATP. These reactions include glycolysis, Krebs Cycle, and the electron transport chain. Carbohydrate metabolism is often considered synonymous with cellular respiration; however, separate pathways exist whereby cells can metabolize fatty acids and proteins into acetate ions that are further used in Krebs Cycle. Related vocabulary: "glycolysis", "Krebs Cycle", "cellular respiration"

carbon dioxide – toxic byproduct of cellular respiration that is removed from the body by the respiratory system. It diffuses into blood during capillary-tissue fluid exchange and gets transported in a variety of ways in blood: mostly as bicarbonate ions produced by the activity of carbonic anhydrase, secondly bonded to hemoglobin producing carbaminohemoglobin, and a little is transported as a dissolved gas. The medulla oblongata is sensitive to the concentration of CO_2 in plasma and initiates breathing when it surpasses a threshold level. Related vocabulary: "carbonic anhydrase", "carbaminohemoglobin", "medulla oblongata"

carbonic anhydrase – enzyme located in the membrane of red blood cells. The enzyme catalyzes the reversible reaction between H_2O and CO_2 forming carbonic acid. Carbonic acid is not very stable in plasma and readily dissociates forming H^{1+} and bicarbonate ions. The pH of blood is prevented from lowering because the H^{1+} bonds to hemoglobin forming reduced hemoglobin (HHb) and the bicarbonate ions act as a buffer. This forward reaction occurs as part of internal respiration. External respiration (at lungs) involves the reverse reaction, which is promoted by the raised oxygen concentration in pulmonary capillaries, a slightly lowered temperature and raised pH. Related vocabulary: "external respiration", "internal respiration"

carboxyl group – functional group of an organic acid consisting of CO_2H. The hydrogen atom tends to dissociate as an ion (H^{1+}), hence making it an acid. Both amino acids and fatty acids have the carboxylic acid group

carboxylic acid – hydrocarbon with a carboxyl group. Related vocabulary: "carboxyl group"

cardiac – refers to the heart

pressure is recorded as two numbers because the pressure is different depending on whether the ventricles are contracting or not. It is higher when they are.
b. An "average" blood pressure is about 120/80 (or "120mmHg over 80mmHg"). (systolic pressure – when the ventricles are contracting "over" diastolic – when the ventricles are not contracting)

6. Factors that can contribute to high blood pressure include diet, smoking, being overweight and fatty build-up or plaques in arteries. Exercise also causes elevated blood pressure temporarily.

7. a. The SA node and the AV node are both involved with the contraction of the heart muscle.
b. The SA node functions to stimulate the contraction of the atria and to trigger the activity of the AV node. The AV node functions through nerve tissue to stimulate the simultaneous contraction of the muscle mass of the ventricles.

8. An ECG is a graph of the electrical changes that occur as a heart contracts. There are three (main) parts as follows: P curve – when the atria contract; QRS curve – when the ventricles contract; and T – when the ventricles recover from their contraction.

9. The cardiac cycle includes the contraction of the atria (opening of AV valves; semi-lunar valves are closed) followed by the contraction of the ventricles (during which the atria relax, the AV valves close and the semi-lunar valves open). This is followed by the recovery and relaxation of the ventricles in preparation for the next cycle.

10. The SA node is called the pacemaker because it directly controls the rate of heart contraction. It is connected to the medulla oblongata (by the vagus nerve), which can adjust the rate as required.

G.2 CONCEPT CHECK-UP QUESTIONS

1. a. The three anterior arteries branching from the aortic arch are: innominate (or brachiocephalic) artery, the left subclavian and left carotid. (The right carotid and the right subclavian are united as the innominate artery at the aortic arch, but separate immediately.)
b. The subclavians conduct blood to the shoulders, where they branch to form the brachials that go to the arms as well as other branch arteries that take blood to the walls of the thoracic cavity. The carotids conduct blood to the head.

2. A pulse can be fairly easily detected in the wrist (branch of the brachial artery called the radial artery), groin area (femoral artery), neck (carotid artery).

3.

	Arteries	Veins
Structure	Thick-walled; equipped with circular muscles and elastic fibres	Thin-walled lacking the muscle and elastic fibre development. Contain valves.
Function	Conduct blood away from the heart and towards capillary beds	Conduct blood away from capillary beds and towards the heart
Location	Usually deep in tissues, along bones	Along surfaces; in skeletal muscles
Blood Pressure	Variable; highest (120/80)	Depends on muscle activity; very low
Blood Velocity	Variable; highest	Depends on muscle activity; very low
Relative surface area	Low as these vessels are the largest	Low; these vessels are large

4. a. There is no pulse in veins because the blood has passed through a capillary bed. Overall, blood pressure in veins is very low and does not pulsate.
b. Blood in veins is returned to the heart by the activity of the skeletal muscles.
c. If valves in veins were to fail, then blood could accumulate in the extremities, a painful condition.

5. Sphincter muscles in the circulatory system control blood flow and pressure into capillary beds. They are located in arterioles before a capillary bed.

G.3 CONCEPT CHECK-UP QUESTIONS

1. Many of the functions of blood are sensitive to pH and temperature changes because they require protein activity. Denaturing these proteins would affect their function.

2. a. Red blood cells – transport; white blood cells – combat infection; and platelets – blood clotting
b. The plasma is the solvent for the particles that are transported as well as the reservoir of water that helps regulate body temperature.

3. a. Red blood cells are specialized for transporting substances in blood. Their specializations include shape (biconcave to squeeze through capillaries) and the presence of hemoglobin in their membranes for transporting O_2. (It also transports CO_2, and/or H^{1+} in venous blood—see respiratory system.)
b. Red blood cells have a short life span because they lack a nucleus and most other organelles, which would otherwise maintain them. The rigorous function of red blood cells wears them out in a few months.

4. Blood clots result from enzymatic reactions in plasma. The reactions are initiated by platelets that are damaged in some way causing them to release the enzyme thromboplastin. Thromboplastin reacts with prothrombin, converting it to thrombin (soluble), which, in turn, reacts with fibrinogen, converting it to fibrin (not soluble). Fibrin forms a network with red blood cells, which is the blood clot.

G.4 CONCEPT CHECK-UP QUESTIONS

1. a. Oxygen is transported to systemic capillaries attached to hemoglobin. (One Hb can transport four oxygen molecules.)
b. Oxygen is released from hemoglobin because the conditions become slightly warmer and slightly more acidic affecting hemoglobin's shape and its ability to transport oxygen.

2. a. Capillaries walls are only one cell thick, so they leak. Blood pressure is high enough at the arteriole end to force the water (and small substances transported by the water or dissolved in it) through the walls and into tissue spaces. Blood cells and large molecules, like proteins (globulins) remain in the plasma, which makes the blood hypertonic. This concentration difference creates osmotic pressure and water is drawn back in on the venule side of the capillary bed. This time the water transports carbon dioxide and ammonia.
b. The globulins help create the osmotic pressure.

G.5 CONCEPT CHECK-UP QUESTIONS

1. The umbilical cord contains a vein and two arteries. The umbilical vein conducts oxygenated blood towards the fetus, while the two umbilical arteries conduct deoxygenated blood towards the placenta (away from the fetus).

2. There are two specializations: the arterial duct conducts blood from the pulmonary trunk to the aortic arch; and the oval opening allows blood to flow from the right atrium to the left atrium.

3. The first breath inflates the lungs, which reduces the resistance to blood flow through the pulmonary tissues. This allows a significant volume of blood to fill the left atrium from the pulmonary veins, which forces the oval opening (valve) closed. The blood now travels through the pulmonary circuit. The arterial duct gradually closes over a period of a few days.

4. The fetal circulatory tissues that are no longer used (such as the internal portions of the umbilical blood vessels) atrophy.

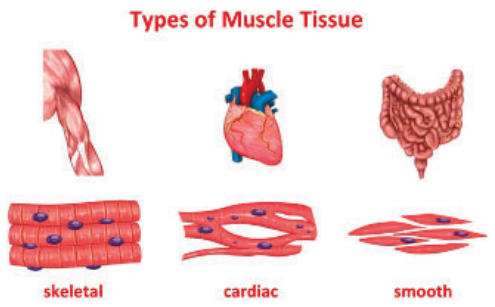
G.6 CONCEPT CHECK-UP QUESTIONS

1. a. Capillary tissue-fluid exchange can contribute to tissue swelling if the capillaries become too leaky and a greater than normal amount of fluid is forced into tissue spaces at the arteriole end (as happens when histamines are present).

APPENDIX A. TISSUE ORGANIZATION OF THE BODY

Table App. A.1 Types of Tissues

TYPE	FUNCTION(S)	LOCATIONS(S)	EXAMPLES(S)
Connective	support; maintain life processes, homeostasis	throughout the body	Blood, cartilage, lymph, bone, fat (adipose) lung...
Nerve	sensory, control, co-ordination, initiate actions and reactions	throughout the body, spinal cord and brain	sensory, motor, & interneurons, Schwann cells, glial cells
Muscle	movement of the body and substances in the body	throughout the body, attached to skeleton, in walls of organs, heart	skeletal, smooth and cardiac
Epithelial	protection, secretion and absorption	surfaces of the body and organs such as the inner lining of the intestine	various types of epithelial (skin) cells



(Illustration credit: www.Shutterstock #110495134)

There are trillions of **cells** in the body. **Tissues** are groups of them that share a function. Generally, combinations of tissues form **organs**, which combine to form **organ-systems**, making up the whole body. There are four primary types of tissues based on their general function. Each of these broad categories includes many specific types of cells.

Connective tissue supports the body and its activities. It includes bones and their associated structures as well as blood and the extracellular fluids that bathe and interact with the cells making up all the tissues and organs in the body. **Adipose** (fat) tissue is another type of connective tissue. It supports the body by storing nutrients as well as providing cushioning and insulation.

The nervous system is one of two communication networks in the body. **Nerve tissue** and nerve cells are located all over the body where they detect changes (**stimuli**) in both internal and external environments and relay this information electrically to the **central nervous system** for processing. Appropriate adjustments (**actions**) follow when necessary. In this manner, nerve tissue influences the entire body.

There are three major types of **muscle tissue**. When stimulated, the cells making up these tissues contract by increasing the overlap of the protein filaments in them. By doing so, the muscle mass shortens, causing the movement of the body part they are associated with. **Cardiac muscle** makes up the muscle of the heart. Its contraction forces blood around the body through blood vessels. Contractions of **skeletal muscle** maneuvre parts of the body, including the face. Finally, **smooth muscle**, which is not under conscious control, causes contractions of the internal organs such as the stomach, intestines and even blood vessels. The circular and longitudinal muscles in the walls of these organs are smooth muscles. When viewed microscopically, both skeletal and cardiac muscle appear as "banded", or **striated**, an effect caused by the regular arrangement of protein filaments in their cells.

The final tissue type, **epithelial tissue**, is very diverse and exists in many forms throughout the body. It forms the coverings of the body as well as the internal organs and all the inner surfaces. In these positions, it forms the interface between various internal and external environments. The cells of the epithelial tissue protect the body and its organs as well as interact by secreting and or absorbing substances. Cell shape and microscopic appearance provide the criteria used to classify the cells of these "skins".

Squamous epithelial tissue has flat cells that permit the passage of materials across them. Blood **capillaries** and the alveoli of the lungs are examples of thin structures made out of these types of cells. **Cuboidal epithelial tissue** comprises many of the glands and organs of the body such as those parts of the **kidneys** that are specialized to produce, secrete, and in some cases absorb substances.

Some epithelial cells are elongated and form **simple columnar epithelial tissue** such as that which lines the inside surface, or **lumen**, of some tubes of the body like the **small intestines** and **fallopian tubes**. The action of **cilia**, present on the exposed surfaces of these cells, moves fluid along, or through the tubes. Sometimes these liquids contain substances that are absorbed by the tissue lining of the tubes. In other cases, the epithelial cells secrete substances into the lumen.

All three of these types of epithelial cells also form layers; there is a stratified version of each of them. Typically these thicker layers of cells offer protection, but may also have additional functions such as secretion. Another variation of the columnar arrangement is **pseudostratified columnar epithelial tissue**. Because