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BASIC BIOMEDICAL SCIENCE

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UU No 28 tahun 2014 tentang Hak Cipta

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Cerdas, Bahagia, Mulia, Lintas Generasi.

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Editor:
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Desain Cover :
Dwi Novidiantoko

Sumber :
www.shutterstock.com

Tata Letak :
Joko Waluyo

Proofreader :
Agista Rinaningtyas Susti

Ukuran :
viii, 341 hlm, Uk: 15.5x23 cm

ISBN :
978-623-02-7313-1

Cetakan Pertama :
Oktober 2023

PENERBIT DEEPUBLISH
(Grup Penerbitan CV BUDI UTAMA)
Anggota IKAPI (076/DIY/2012)

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FOREWORD

Praise and gratitude the authors pray to the presence of God Almighty for His abundance of grace, so that the authors can complete the "Basic Biomedical Sciences Module" for nursing students. This teaching materials summarizes learning material on the application of physics in nursing, basic principles of biology in nursing, basics of anatomy and physiology of the human body, tissues and systems of the human body, metabolism and temperature regulation, respiratory system, cardiovascular system, lymphatic and immune system, digestive system, endocrine system, urinary system, respiratory system, musculoskeletal system, integumentary system, and sensory system.

The Basic Biomedical Science Teaching materials is a learning medium for early semester nursing students to understand and explain various physiological systems in humans. Through a good understanding of human physiology, it is hoped that students will be able to integrate it into clinical nursing science such as medical surgical nursing, emergency nursing, maternity nursing, paediatric nursing and gerontic nursing.

The author hopes that this teaching materials can be read, then the knowledge in it can be understood and can be integrated into clinical nursing courses in the following semester. So that in the end it can provide maximum benefits for the development of nursing.

Finally, the author wishes you a happy reading and understanding of the material in this module. Hopefully the explanation in this teaching materials will be of great benefit to lecturers in charge of the subject and students.

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COURSE OVERVIEW

You are currently pursuing the Basic Biomedical Science Module. Basic Biomedical Sciences is one of the courses that is anticipated to contribute to your attainment of competence as a Diploma IV candidate in professional nursing. You are expected to receive a learning experience that facilitates the achievement of learning objectives globally and comprehensively, including through the fundamental biomedical sciences. The Basic Biomedical Science course consists of 3 credits of theory and 1 credit of laboratory, for a total of 4 credits. On this teaching material only give explanation of the basic biomedical science material, while practical teaching materials will be given in different books.

This teaching materials studies the structure and function of the human body in a healthy state. The contents of this course cover the organisation that occurs in the human body, from the level of cells, tissues, and organs to the organ systems of the human body. This course will discuss the human body from the perspectives of biology, physics, biochemistry, anatomy, and physiology. The expected competence is that after participating in this course, students will be able to use the principles of biomedical science to identify normal parameters in the human body. The basic biomedical sciences course is described in detail in sixteen chapters: physics basic principle in nursing, biology basic principles in nursing, biochemistry basic principles in nursing, fundamentals of anatomy and physiology of the human body, cardiovascular system, lymphatic and immune systems, endocrine system, urinary system, nervous system, musculoskeletal system, integumentary system, sensory system, reproductive system.

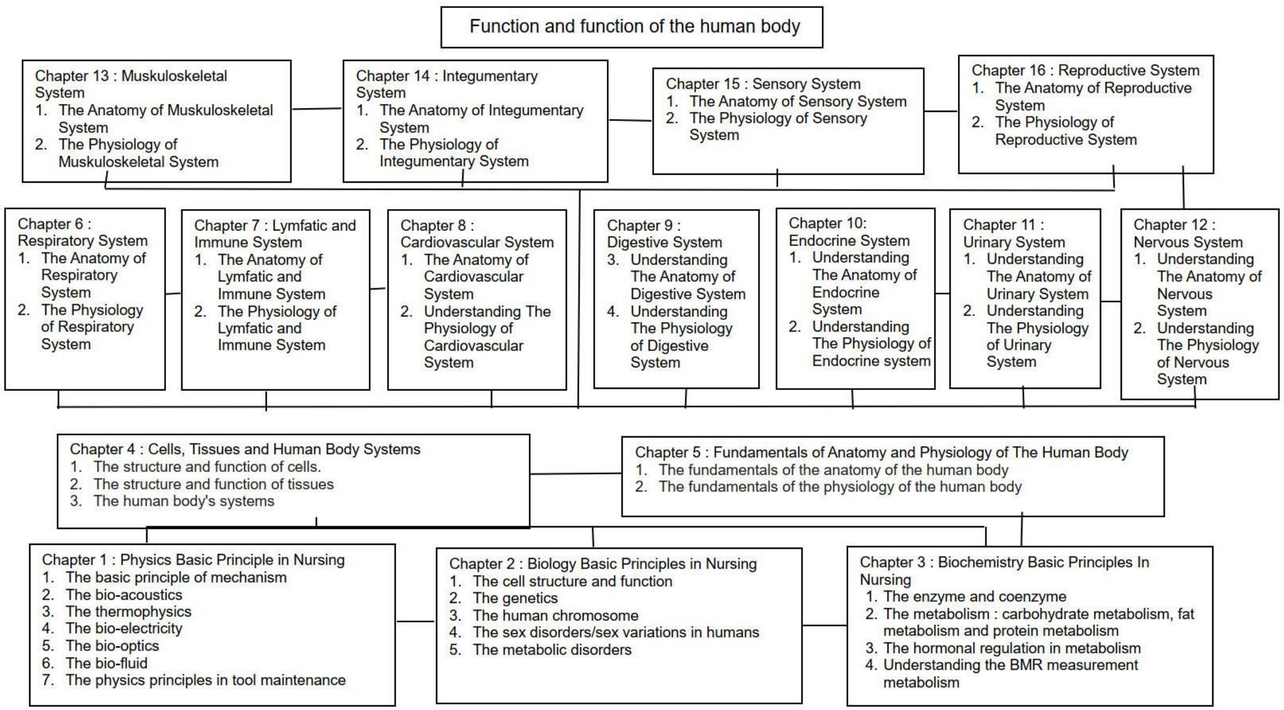
In this subject, you will understand the basic physics principles in nursing to be able to understand the functions and work of the body. The scope of physics basic principles in nursing, such as the basic principle of mechanism, bio-acoustics, thermophysics, bio-electricity, bio-optics, bio-fluid, and physics principles in tool maintenance. In addition, students will also learn about biology's basic principles in nursing with sub-chapters such as cell structure and function, genetics, the human chromosome, sex disorders and sex variations in humans, and metabolic disorders. In biochemistry basic principles in nursing material, the students will learn about enzymes and coenzymes, metabolism (carbohydrate metabolism, fat metabolism, and protein metabolism), hormonal regulation in metabolism, and BMR measurement metabolism. The students will also learn the fundamentals of the anatomy and physiology of the human body. After they learn this chapter, they will be able to understand the fundamentals of the anatomy and physiology of the human body. Learning cells, tissues and human body systems consists of structure and function of cells and tissues, human body's systems. Students will learn anatomy and physiology of Respiratory System, Cardiovascular System, Lymphatic and Immune Systems, Digestive System, Endocrine System, Urinary System, Nervous System, Musculoskeletal System, Integumentary System, Sensory System, and Reproductive System.

Learning is designed to provide opportunities for students to complete learning outcomes through lectures and discussions. To make it simpler for you to follow the learning process in this module, the following learning steps have been outlined.

1. Examine the theory teaching materials in order
2. Read the information displayed in each learning activity with care
3. During face-to-face activities, engage in relevant exercises and discuss them with your peers, the facilitator, or a tutor
4. Create a summary of the discussed material to help you remember it
5. Perform a formative assessment as an evaluation of the learning process for each discussed topic, and match your answers to the provided answer keys.

If you are having difficulty, consult with your peers and the facilitator. The success of your learning process as you study the material in this teaching materials is contingent on your sincerity in completing the exercises. Study and practise independently or with colleagues for this purpose. We trust you can follow all of the modules and learning activities in this module. Basic Biomedical Science is an introduction to the study of abnormal conditions in pathology courses. These courses also serve as the basis for special courses in nursing, such as Medical Surgical Nursing, Emergency Nursing, Paediatric Nursing and so on.

EPITOME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1. The Anatomy of Integumentary System
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CHAPTER 1
APPLICATION OF PHYSICS BASIC PRINCIPLE IN NURSING

Learning Objectives:

1. Understanding the basic principle of body mechanism
2. Understanding the bio-acoustics
3. Understanding the thermophysics
4. Understanding the bio-electricity
5. Understanding the bio-optics
6. Understanding the bio-fluid
7. Understanding the physics principles in tool maintenance

Introduction:

This course provides knowledge and application of the physical sciences in nursing. The students understand and exemplify the importance of physics in human life so that they can apply the concept of physics to health. With the ability to think critically about physics in the health sector, present and discuss physics problems in the health sector, and be able to search for and choose physics concepts according to the problems that occur, you will have a great opportunity to find effective steps in solving problems in nursing care.

This chapter, entitled Introduction to Physics, discusses the concepts of biomechanics, bioelectricity, and bioacoustics. This chapter is packaged into some topics arranged in the following order: They are the basic principles of the mechanism. Bio-acoustics, thermophysics, bio-electricity, bio-optics, bio-fluid, and physics principles in tool maintenance.

After studying this topic, students are expected to be able to explain units of measurement, the basic laws of biomechanics, forces on bodies, force analysis and clinical use, and sports physics. Be able to explain the concept of electricity in the activity of the nervous and cardiovascular organ systems. Able to explain the concepts of sound, sound wave, sound source, sound frequency distribution, sound intensity, sound loudness, doppler principle, ultrasonics in medicine, hearing aids, noise, and vibration.

Topic 1: The Basic Principle of the Mechanism

Did you know why we should know the basic principle of the body mechanism? Someone in motion needs to base mechanical performance so that the movements carried out are energy efficient so they don't get tired quickly but the results obtained are more optimal. Some basic principles that can be used as a guide for someone in making movements.

There are four basic principles of body mechanics (Wahyuni, 2021), among others: *Gravity*. The first principle that must be considered in doing body mechanics correctly is viewing gravity as an axis in the movement of the body. There are three factors to consider in gravity: the centre of gravity is a point that is in the middle of the body; the line of gravity (line of gravity) is a vertical imaginary line through the centre of gravity; and the base of support (base of support) is the basis on which a person is at rest to support or hold the body. *Balance*: Balance in the use of body mechanics is achieved by maintaining the position of the line of gravity between the centre of gravity and the pedestal. *Weight*. When using body mechanics, what matters most is the weight of the object to be lifted, because the weight of the object will affect the mechanics of the body. *Basic Movements in Body Mechanics*: Body mechanics and ambulation are part of the needs of human activity.

Potter & Perry (2005) explain that before doing body mechanics, there are some basic movements that must be need attention, they are:

1. Movement (ambulating): correct movement can help balance the body. For example, the balance when people stand and when people walk is different. A standing person will be more stable than a walking person, because in the walking position there is a displacement of the base of support from one side to the other and the centre of gravity always changes in the position of the feet. When walking, there are two phases, namely the weight-bearing phase and the swinging phase, which will produce smooth and rhythmic movements.
2. Holding (squatting): in making changes position, the holding position is always changing. For example, the position of a person sitting will be different from someone who is squatting and of course also different from a bent position. Gravity is something that needs to be considered to provide the right position in holding. In holding it is very necessary to have the right foundation to prevent body abnormalities and make it easier for the movement to be carried out.
3. Interesting (pulling): pulling correctly will make it easier to move objects. There are several things that need to be considered in pulling objects, including height, location of objects (preferably in front of the person who will pull), the position of the legs and body in pulling (such as leaning forward from the pelvis), thrusting the palms of the hands and upper arms under the centre patient's gravity, upper arms and elbows are placed on the surface of the bed, hips, knees and ankles are bent then do withdrawal.
4. Lifting: lifting is a way of moving traction. Use the large muscles of your heels, upper thighs, lower legs, stomach and hips to relieve back pain.
5. Rotate (pivoting): rotating is a movement to rotate the limbs and rest on the spine. Good circular motion takes into account

all three elements of gravity in the movement so as not to adversely affect body posture.

After understanding how biomechanics is in our body, a nurse must actually understand and apply these biomechanics to protect herself while working (ergonomic position) and be able to work more effectively and efficiently. The application of biomechanics in nursing can be seen in meeting the needs of patient mobilization, ergonomics, balanced positioning, force analysis, traction on bones, lever systems and others.

Topic 2: Bio-Acoustic

Bio-acoustics is a science that studies the process of hearing reception produced by living things (Purnawinadi, 2012). Bioacoustics is a field of science that studies sound characteristics, sound physiology, voice organs, voice functions, sound analysis, and the benefits of sound for living things. Bio-acoustic analysis means a study that unravels the relationship between sound, sound waves, vibrations, and sound sources (Rusfidra, 2006).

Bioacoustics in the world of health has many benefits, both for diagnosis and for continuous treatment. Bio-acoustic analysis as a marker and characteristic, as well as early detection of various sounds that may originate from humans.

Definition of sound. Sound in physics is a longitudinal wave that propagates through a certain medium. Sound occurs because of a vibration so as to create a sound method that makes the sound audible to the human sense of hearing. According to the Big Indonesian Dictionary, "sound" means something that is heard or heard by hearing aids (Kustaman, 2018). Each sound has certain characteristics in terms of frequency, amplitude, speed, reverberation time, and so on. Every cell in the body of every person, stone, and tree also has a natural resonant frequency that is ideally in harmony with all its units. Every sound, from as soft as pure musical notes to as harsh as a gunshot, elicits a surge of energy (Trever, 2014).

Sound Intensity Heard by Humans. The normal human ear's sensitivity to sound intensity has two thresholds, namely the hearing threshold and the pain threshold. Sounds with an intensity below the threshold of hearing cannot be heard. The intensity of the hearing threshold depends on the frequency emitted by the sound source. The frequency that can be heard by normal human ears is between 20Hz to 20KHz. Beyond that frequency limit, you can't hear it (Barsasella & Diana, 2015).

Noise is defined as "unwanted sound, for example, that which hinders the hearing of voices, music, etc., or which causes pain or interferes with lifestyles. Noise is an unwanted sound from business or activity. Darlani & Sugiharto (2017), in their research on noise thresholds or noise in the work environment, found that noise above 80 dB can cause anxiety, feeling unwell, hearing fatigue, stomach pain, and blood circulation problems. Excessive and prolonged noise is seen in disorders such as heart disease, high blood pressure, and stomach ulcers.

Noise Type. Several sources describe several types of noise such as, (1) Continuous noise with a wide frequency spectrum. This associated noise remains within the limits of less than 5 dB for 0.5 consecutive periods. For example, machines, fans, incandescent kitchens. (2) Continuous noise with a narrow frequency spectrum. This noise is also relatively constant, but it only has certain frequencies (at frequencies of 500,1000 and 4000 Hz), for example gas valve secular saws. (3) Intermittent noise (intermittent). Noise here occurs continuously. But there are periods of relative calm, for example the sound of traffic, noise on airplanes. (4) Impulsive noise, this type of noise has a change in sound pressure exceeding 40 dB in a very fast time and usually shocks the hearing. For example, gunshots, fireworks explosions, cannons. (5) Repetitive impulsive noise, the same as impulsive noise except that it occurs repeatedly, for example forging machines.

Sound Waves. Wave is a phenomenon of disturbance (energy) propagation. Waves are disturbances of the physical properties of a medium that propagate according to place and time, where the medium is not moving. In its propagation requires a material called a medium. Based on the direction of propagation, waves are divided into: (1) Longitudinal Waves. Waves whose direction of vibration is parallel to the direction of propagation. Example: sound gel, spring gel. (2) Transverse Waves. Waves whose direction of vibration is perpendicular to the direction of propagation. Example: rope gel, water surface gel. Based on the mechanism, waves are divided into: 1) Mechanical waves are waves whose propagation speed depends on mechanical quantities. 2) Elastic waves are waving whose propagation speed depends on the magnitudes of elasticity. 3) Surface waves in liquids are waves whose propagation speed depends on the surface area of the liquid. 4) Electromagnetic waves are waves that have propagation speed depending on electric and magnetic quantities.

Frequency, sound intensity. Sound waves or voices are divided into three regions, such as infrasonic, sonic and ultrasonic. Infrasonic has a frequency below 20 Hz. (Ground shaking, earthquake). Sonic sound that can be heard by normal humans, has a frequency between 20 Hz to 20 kHz and Ultrasonic is sound that have frequencies above 20 kHz. Ultrasonic waves are sound waves emitted by bats as radar.

The intensity of the wave is the amount of energy carried by the wave per unit time per unit area. Sound intensity is the amount of sound energy that penetrates perpendicular to the plane area of one unit area per second. $I = P/A$. I = sound intensity (watts/m^2 or watts/cm^2). A = surface area (m^2 or cm^2). P = sound power (watts).

Topic 3: Thermophysical

Thermophysical is study of the laws governing the conversion of energy from one form to another, the flow of energy, and the ability to do work. Two terms that are closely related in thermodynamics. (1) System, is the subject matter or focus of attention and (2) Environment refers to: everything outside the system or everything outside the system.

Metabolism as energy conversion. Metabolism is the process of change in an organism (the total number of chemical or physical reactions necessary for life). Metabolic speed of energy conversion in the body. Metabolism includes anabolism and catabolism. Anabolism is exhibits synthetic reactions that lead to energy storage in the body. Catabolism describes tissue damage and use of energy sources (Inayah, 2019).

Laws of Thermodynamics. First law of thermodynamics “The heat added to a system equals the change in energy in the system plus the work done by the system”

$$Q = \Delta U + W$$

Information:

Q = + heat entering the system
= - heat is escaping from the system
U = energy in the system
W = + work done by the system
= - work done on the system

The first law of thermodynamics cannot explain whether a process will occur or not. Therefore, the emergence and codification of the second law of thermodynamics cannot be separated from efforts to find the nature or magnitude of the system as a state function. It turns out that the person who discovered it was Clausius, and that quantity is called entropy. The second law can be stated as follows: "It is impossible for a process in an isolated system to be accompanied by a decrease in entropy. In every process that occurs in an isolated system, the entropy of the system always increases or remains constant (V. Mayer, 1840).

The second law of thermodynamics states that heat flow has a direction. That is, not all processes in nature are reversible (the direction can be reversed). The second law of thermodynamics states that heat flows spontaneously from objects at a higher temperature to objects at a lower temperature, never spontaneously in the opposite direction. For example, if you dip a small cube into a cup of hot coffee water, heat will flow from the hot coffee water to the ice cubes until they are both at the same temperature (V. Mayer, 1840). The second law of thermodynamics places fundamental limits on the efficiency of a machine or generator. The law also sets limits on the minimum input energy required to run a refrigeration system. The second law of thermodynamics can also be expressed in the concept of entropy, which is a quantitative measure of how orderly or random a system is.

The experts concluded from the experimental results that it is impossible to build a heat engine that completely converts heat into work, that is, an engine with 100% thermal efficiency. This impossibility is the basis for the following statement of the second law of thermodynamics: "It is impossible for a system to undergo a process in which the system absorbs heat from a reservoir at a single temperature and completely converts that heat into mechanical work, and the system ends up in the same state as it originally was." This is known as the "machine" statement of the second law of thermodynamics (V. Mayer, 1840).

The basis of the second law of thermodynamics lies in the essential difference between internal energy and macroscopic mechanical energy. In a moving body, there is random motion of the molecules, but most importantly, each molecule moves in a coordinated manner in the direction that corresponds to the velocity of the object. The kinetic and potential energy associated with random motion produces internal energy (V. Mayer, 1840).

If the second law didn’t apply, a person could drive a car or generator by cooling the air around it. Neither of these impossible situations violates the first law of thermodynamics. Therefore, the second law of thermodynamics is not a corollary of the first law but exists independently as an independent law of nature. The first law ignores the possibility of energy being created or destroyed. At the same time, the second law of thermodynamics limits the availability of energy and how it is used and transformed. Heat flows spontaneously from more warm matter to colder objects, not vice versa.

Second law of thermodynamics the equation: $\eta = \frac{P}{Q1} \times 100\ \%$

Because W = Q1 – Q2, then:

$$\eta = \frac{Q1 - Q2}{Q1} \times 100\ \%$$

Heat Transfer. According to the law of "Vantt Hoff," a chemical reaction in the body decreases with decreasing body temperature. Chemical reactions in the body depend on body temperature. Under very cold conditions, "homeostatic mechanisms" cause hypothermia. Hypothermia is used during cardiac surgery as metabolic protection against hypoxia because tissues require very little oxygen. The function of temperature regulation lies mainly in biochemical reactions, thermal reactions, and metabolites of the organisms themselves, as well as heat loss through the environment. There are four ways heat energy is lost through the skin or enters the body: conduction, convection, radiation, and evaporation.

Thermal Mechanism. Thermal energy first penetrates the skin tissue in the form of light (radiative or conductive) and is then dissipated as heat into deeper tissue areas. Heat is transferred to the tissues by convection, which flows through the body. Methods used in medicine for energy transfer are transmission methods, radiation methods, electromagnetic methods, and ultrasonic methods.

Heat balance. Body temperature regulation is an organism's self-regulating homeostatic system. The hypothalamus is divided into two parts. (1) Hypothalamus anterior: regulates heat dissipation by dilating blood vessels on the surface of the skin, increasing breathing, sweating, and anorexia. (2) Posterior hypothalamus:

regulates hypothermia through shivering, skin surface vasoconstriction, and hunger, which regulates heat generation.

Feedback mechanism for the regulation of body temperature. Cold exposure mechanisms are hunger shivers, increased striated muscle activity, increased secretion of no methamphetamine and epinephrine, narrowing of the blood vessels, contraction of the skin, increased heat production, and decreased heat loss. Mechanisms of thermal activity include skin vasodilation and sweating. Increased breathing, decreased appetite, lethargy, increased heat loss, and decreased heat production.

Diagnostic tool that uses heat energy (close to skin surface temperature) to produce temperature images. The surface temperature of the skin is affected by heat-producing processes in the subcutaneous tissue, including inflammation, circulation disorders, and active tumours. In principle, there are two types of thermal imaging: heat balance thermal imaging and infrared photoelectric thermal imaging. Thermal imaging follows the principle of thermal equilibrium. Made of nitrocellulose sheet coated with heat-absorbing oil. A skin surface that reaches a certain image (colour) of thermal equilibrium at a certain temperature Example: A normal skin surface is green. As the temperature increases, the colour of the cellulose membrane changes from brown to reddish.

Principle of thermal imaging of the photoconductive material using an infrared camera the heat emitted by the skin surface in the form of infrared radiation falls on the infrared detector via an optical array and is intermittently converted into electrical pulses by the infrared transducer, which are then amplified by an amplifier and displayed on the image (Utami, 2016).

Topic 4: Bio-Electricity

Voltage occurs when there is a potential difference—a difference in the quantity of electrons from one side to the other—resulting in the movement of electrons to achieve stability. The process of moving electrons, which actually results in differences in numbers, results in an electric field that is always active. Likewise, an electric current will always appear in your body. In order to keep the voltage and current in a state of homeostasis, you must consume electrolytes in a balanced way. Electrolytes that play a very important role in your body are Na+, K+, and Ca+. The electrolytes Na+ and K+ are needed by nerve cells so that they can transmit signals. With this signal transduction, the sensory nerves (receivers of stimuli) and motor nerves work in harmony, both synergistically and antagonistically.

Before studying physics in nursing further, at the beginning of this topic we will discuss the meaning of physics, derived from the Greek word physics, which means talking about nature and its phenomena. Physics can be said to be the science of understanding the universe. A number of concepts, such as "position", "time", "mass", "force", "electron", "temperature", etc., and the observable relationships between the various concepts

These relationships are called "principles". When someone observes that the surrounding objects change places. So, in describing the event, it was agreed that there is a concept (understanding) of "position", which changes with "time", so that derivatives named "speed" and "acceleration" are obtained. In the scientific process, observations of natural events and experiments are carried out. To compile experiments, a model of real events is needed. To help understand the physical aspects of the human body, an analogy is needed, namely an example or a simple approach.

Bioelectricity is the science that studies the electric potential in the organs of the body. In bioelectricity, there are two aspects that play an important role: the electricity and magnetism that arise in the human body, as well as the use of electricity and magnetism on the surface of the human body. The activities of organs and various systems in the human body are not only closely related to each other but also work together in response to changes in the environment, both the internal and external environment of the body. In the human body, there is a coordination system that includes the nervous system, which functions to control activity and work in harmony between organ systems.

In the history of the development of bioelectricity, Galavani (1780) began to study electricity in the animal body and, in 1786, reported the results of his experiments that both frog legs lifted when given an electric current through a conductor. In 1856, Caldani demonstrated electricity in the muscles of dead frogs, and in 1928, he reported on the treatment of patients using short waves. Bioelectricity is the energy contained in the bodies of living things that comes from ATP (adenosine triphosphate), which is produced by one part of the cell, namely the mitochondria, in the respiration process. In other words, bioelectricity is everything related to electricity produced by living bodies. The electricity in question is everything related to charges and ions contained in the body, the electric field produced by these ions and charges, and the resulting voltage.

Electrical voltage, often called electric potential," can be generated by body cells. The resulting voltage is referred to as bio-voltage or biopotential. The greatest tension is generated by nerve cells (nerve) and muscle cells (muscle). The voltages that occur in the cell (hereinafter referred to as cell voltages or cell potentials) are constantly maintained, and to maintain them, large amounts of energy are required. So, as much as 25% of the energy supplied to the body is used to maintain the presence of tension in the cells.

Bio-electricity is the energy that every human has that comes from ATP (adenosine triphosphate), which is produced by one of the energies called mitochondria through the process of cellular respiration. Bioelectricity is also a cell phenomenon. Cells are capable of generating an electric potential, which is a thin layer of positive charge on the outer surface and a thin layer of negative charge on the inner surface of the boundary or membrane. The ability of nerve cells (neurons) to transmit bioelectrical signals is very important. Bioelectric signal transmission (TSB) has a tool called dendrites, which function to transmit signals from sensors to neurons. Stimuli for Meiningen neurons can be pressure, temperature changes, or electrical signals from other neurons. Bio-electricity activation in a muscle can spread throughout the body like waves on the surface of water. Observation of these electrical pulses can be done by placing several electrodes on the surface of the skin. The results of the recording of electrical signals from the heart (electrocardiogram, or ECG) are substituted for health diagnoses. As with the ECG, brain activity can be monitored by placing several electrodes in certain positions. The resulting electrical signals can be used to diagnose symptoms of epilepsy, tumours, concussions, and other brain disorders.

Electricity and magnetism in the human body (1) The nervous system and neurons: the nervous system is divided into two parts, namely the central and autonomic nervous systems. The central nervous system consists of the brain, spinal cord, and periphery. These peripheral nerves are the nerves that send sensory information to the brain or to the spinal cord, called afferent nerves, while the nerve fibres that carry information from the brain or spinal cord to muscles and glands are called the efferent nervous system, while the autonomic nervous system regulates organs in the body such as the heart, intestines, and glands, so that the control of this system is carried out subconsciously, namely working independently. (2) The concentration of ions inside and outside the cell This is a resting potential model at time = 0 where K ions will diffuse from a high concentration to a low concentration so that at a certain moment a dipole membrane or a two-pole membrane will occur where a solution with a previously low concentration will have an excess of positive ions, in contrast to a solution with a high concentration that will experience a lack of ions, so it becomes more negative. (3) Electrical nerves in the field of neurotomy, the speed of nerve fibre impulses will be discussed. Nerve fibres with a large diameter have the ability to conduct impulses faster than nerve fibres that have a small diameter. Fibres can be grouped into three parts, including A, B, and C. Using an electron microscope, nerve fibres are divided into two types: myelinated and unmyelinated nerves. (4) action potential propagation. An action potential can occur when an area of the nerve or muscle membrane reaches a threshold value. The action potential itself has the ability to stimulate the blood around the cell membrane to reach a threshold value. The propagation of the action potential can occur.

Heart Muscle Electrical Cardiac muscle membrane cells are very different from those of nerves and striated muscles. In nerves and striated muscles, when a state of resting membrane potential stimulation is carried out, Na+ ions will enter the cell, and after reaching a threshold value, depolarization will occur, while in cardiac muscle cells, Na+ ions easily leak, resulting in complete repolarization. Na+ ions will slowly re-enter the cell, with the result that symptoms of spontaneous depolarization occur until it reaches a threshold value and an action potential occurs without the need for external stimulation.

Topic 5: Bio-Optic

Bio-optics, composed of the word's bio and optics," Bio relates to living things, living substances, or certain parts of living things, while optics is known as the part of physics that deals with light or beams of light. Specifically, there is a classification of geometrical optics and physical optics. The main focus of the bio-optics is related to the human sense of sight, namely the eyes. The eye becomes the most important optical instrument in humans or other living things.

Geometric Optical. The journey of light begins in a straight line; the rays of light are called light lines and are drawn in a straight line. In this way, mirrors and lenses can be described in mathematical terms. For example, for the mirror and lens formula, $1/f = 1/s + 1/s'$ (f = focus focal point, s = object distance, s' = image distance)

Physical Optical. Quantum theory (Plank, 1858–1947) explains that light is made up of quanta, or photons, similar to the old Newtonian theory. Max Plank's theory is used to explain why objects get hot when exposed to light. Huygens (1690) describes light as a wave phenomenon from a light source that transmits vibrations in all directions. Each point in space that vibrates can be considered a new wave centre. This is Huygens' principle, which cannot explain the passage of light from one medium to another.

Various shapes of lenses Based on the shape of the surface, lenses that have a spherical surface are divided into three types: convex/convergent/positive lenses, concave/divergent/negative lenses, and lenses with a cylindrical surface. Convex, convergent, or positive A positive or collecting lens is one that is thicker in the centre than at the edges. Parallel light incident on a positive lens is focused at the second focal point, which is on the transmission side of the lens. A concave, divergent, or negative lens is one that is thicker at the edges than the centre. Parallel light incident on a negative lens emanates as if from the second focal point, which is on the incident side of the lens. A cylindrical surface lens is a lens that has a cylinder. This lens has a positive focus, and some have a negative focal length.

Lens Aberration. Based on the equations related to object distance, image distance, focus distance, lens curvature radius, and paraxial incoming rays, there is a possibility of lens aberration (lens aberration). There are various types of aberrations. (1) Spherical aberration (caused by the convexity of the lens). Paraxial rays or rays from the edge of the lens form an image at P'. This aberration can be eliminated by using a diaphragm placed in front of the lens or by using an aplanatic compound lens consisting of two lenses of different glass types. (2) Coma. This aberration occurs due to the inability of the lens to form an image from the rays in the middle and the rays on the periphery. In contrast to spherical aberration, in coma aberration, an object point will form an image like a tailed star; this coma symptom cannot be corrected with a diaphragm. (3) Astigmatism. It is a lens aberration caused by the point of the object forming a large angle with the axis, so that there are two images formed, namely primary and secondary. If the angle between the axis and the object point is relatively small, it will most likely be in the form of a comma. (4) Field curvature the image formed by the lens on the layer is not in a flat plane but in a curved plane. This event is called field curvature or shadow plane curvature. (5) Distortion. Distortion or symptom of the formation of a false image. The occurrence of this false image occurs because in front or behind the lens is placed a diaphragm or a blemish. A lattice-shaped object will appear as a barrel-shaped or pillow-shaped shadow. Symptoms of this distortion can be removed by installing a gap between the two lenses. (6) Chromatic Aberration The basic principle of chromatic aberration is that the lens focus is different for each colour. As a result, the image formed will appear at various distances from the lens. Aberration Blurring the image of a single object is known as an aberration. Spherical aberration results from the fact that curved surfaces only focus paraxial rays (rays traveling near the principal axis) at a single point. Nonparaxial rays at a near point depend on the angle they make with the principal axis. Rays that strike the lens far from the principal axis are deflected more than rays near the principal axis, with the result that not all rays are focused at a single point. Instead, the image appears as a circular disc. The circle with the least clutter is at the point where the diameter is the minimum.

Topic 6: Bio-Fluids

Bio-fluids are liquids found in the bodies of living organisms, such as humans and animals. Bio-fluids play an important role in carrying out vital functions in the body, including transport of nutrients, transport of wastes, temperature regulation and lubrication (Ghista, 2017**).**

Bio-fluid mechanism. Tortora & Derrickson (2017) explained about Bio-fluid mechanism (1) Blood. Blood is the most famous and very important Bio-fluid. It contains blood cells (such as erythrocytes, leukocytes, and platelets) circulating in the plasma. Blood transports oxygen, nutrients, hormones, and metabolic wastes throughout the body (Silverthorn, 2015). (2) Lymph. Lymph is a Bio-fluid found in the lymph system. It plays a role in the immune system by transporting immune cells, as well as removing excess fluid and waste from tissues (Abbas, Lichtman & Pillai, 2017). (3) Cerebrospinal fluid (CSF). CSF is found around the brain and spinal cord. Its function is to protect and provide nutrition to the central nervous system. CSF also plays a role in transporting chemical substances and eliminating metabolic waste from the central nervous system. (4) Synovial fluid: Synovial fluid is found in the joints of the body. It plays a role in lubricating joints, reducing friction between bones and relieving pressure on joints.

Based on the fluid's movement, fluids are divided into static fluids and dynamic fluids. Static fluids are fluids that are not moving, while dynamic fluids are fluids that are in motion. *Static fluid*. Static fluid is a fluid that is in a stationary phase or a fluid in a state of motion but there is no difference in velocity between the fluid particles. It can also be said that the fluid particles move at a uniform speed. Does not cause such thing as a shear force. Examples such as water in a glass that is not given a force will be still or river water that flows at a constant speed. *Dynamics Fluid*. Dynamic Fluid Properties is steady flow (flow velocity at a point is constant with time). If the velocity v at a point is constant, then the fluid flow can be said to be steady. An example of steady flow is a steady stream of water (low flow rate). It is an incompressible flow, meaning that the flowing fluid does not change in volume or density when pressed. If the flowing fluid does not change in volume or density when pressed, then the fluid flow can be said to be incompressible. Dynamic Fluid Properties is a non-viscous flow also. The fluid will not experience friction between one fluid layer and another fluid layer. In fact, fluid fluids also do not experience friction with the channel walls as a result of viscosity symptoms. Flow has a current line and is not turbulent, meaning that each fluid particle will pass through the same trajectory point and head in the same direction. Even though there is no absolutely ideal fluid, the fluid closest to the ideal fluid properties is water. So that research on fluids often uses water.

Heart Working Mechanism. The amount of blood in an adult is 4.5 litters. In a normal adult, each contraction of the heart muscle pumps about 80 ml of blood, and every one minute a complete red blood cell circulates one cycle in the body. In this process the heart does work. The pressure in the two cardiac pumps is not the same. In the pulmonary system the pressure is low (maximum/systolic pressure = 25 mmHg). In the systemic circulation, the peak/systolic pressure is about 120 mmHg. In the resting phase (diastole) the pressure is about 80 mmHg. The muscle that powers the left ventricle is about three times thicker than that of the right ventricle. When we work hard or exercise, blood pressure can increase by 50% and the volume of blood pumped can increase 5 times so that there is an increase in the energy released by the heart. Rev. Stephen Hales (1733) first used a glass tube to measure blood pressure, connected directly to the horse's arteries by the goose's trackage. In the pipe, blood will rise and reach a height of approximately 1.3 m from the position of the heart. This height can be found using the average value of blood pressure in the heart of 100 mmHg, the density (density) of blood is 1040 kg/m^3. At a location near the soles of the feet, blood pressure becomes 200 mmHg or the equivalent of 2.6 meters of blood. The high pressure on the feet is caused by the weight of the blood between the heart and the feet pressing down (the distance of the heart from the soles of the feet is about 1.3 meters). With a little calculation can be understood that an increase in blood pressure by 10 mm Hg causes an increase in blood column height of 131 mm. Blood pressure of 150 means the height of the blood column in the pipe (calculated from the soles of the feet) is 1.95 m.

In practice, blood pressure is usually measured with a device called a sphygmomanometer. This tool consists of: pads/bracelets; in this bandage there is a cavity that can be pressured by a manometer connected to the pad to measure the pressure. In its original form, the mercury manometer and stethoscope were used. Blood flow usually flows in a laminar/streamline, but in some places, turbulence occurs, for example in the heart valves (heart valves). By using a sphygmomanometer and a bandage wrapped around the upper arm, the blood flow will be turbulent and produce vibrations so that heart sounds can be heard using a stethoscope. Laminar flow can be converted to turbulence if the vessel is gradually reduced in radius and the flow velocity is gradually increased until it reaches a critical velocity.

The way blood pressure measurement works is that a bandage is first wrapped around the upper arm and the pressure is increased rapidly with the help of a hand pump until the pressure can stop blood flow. Then by slightly opening the valve on the pump, the pressure is lowered rather slowly. At the same time, sounds in the veins of the forearm are listened to with a stethoscope and the readings on the manometer are observed.

When the pad pressure is still higher than the systolic pressure, blood is unable to penetrate the bandage clamp so no sound can be heard through the stethoscope. When the pressure of the pads drops below the systolic pressure, there is a turbulent flow of blood that sprays through the arteries. The pressure of blood flowing through the bandage clamp towards the forearm causes sound vibrations which are detected with a stethoscope. These sounds are called Korotkoff or K sounds. The pressure at which the K sound is first heard indicates the systolic pressure. As the pressure decreases, the K sound gets louder and then subsides.

If the pad pressure is lower than the diastolic pressure, the sound will change or disappear. When the K sound disappears or changes, it indicates the diastolic pressure. Blood pressure is recorded as the indicated pressure by the manometer when the sound appears due to the pressure of blood flow (systolic pressure) and when the sound changes or disappears again (diastolic pressure).

At this time there are blood pressure gauges that work electronically, but are still based on the sphygmomanometer principle. The pressurized pads are still used, while the sound appears (systolic pressure) and the sound changes/disappears (diastolic pressure) are detected electronically. The measurement results are immediately displayed on the digital display. Often it also displays the number of heart beats per minute.

An average pair of lungs can store about 6 litters of air but only a small portion of this capacity is used during normal breathing. A person's lung volume depends on differences in the physical size of the lungs, also related to conditions during inspiration and expiration. Lung volume values depend on the person's age and height and weight. In calculating lung capacity, we know there are several terminologies as follows: Total Lung Capacity (TLC) is 6 litters. Volume of air stored in the lungs at the end of maximum inspiration. Vital Capacity (VC) is 4.8 litters. Amount of air that can be expelled from the lungs after maximum inspiration. Tidal Volume (TV) is 500 ml. The amount of air inhaled and exhaled during normal exhalation. Residual Volume (RV) is 1.2 litters. Amount of air in the lungs after maximal expiration. Expiratory Reserve Volume (ERV) is 1.2 litters. The additional amount of air that can be exhaled after a normal expiration. At the end of a normal exhalation, the lungs contain a residual volume plus the expiratory reserve volume, or approximately 2.4 litters. If one could expel as much air as possible then only a residual volume of 1.2 litters would remain. Inspiratory Reserve Volume (IRV) is 3,6 litters. The additional air that can be inhaled after the tidal volume enters the lungs. Functional Residual Capacity (ERV + RV) is 2.4 litters. Amount of air in the lungs after the tidal volume is exhausted. And Inspiratory capacity (IC) is amount of air that can be inhaled after the tidal volume has been removed. Anatomical dead volume (or dead space) is 150 ml. The volume of the conducting airways.

The mechanism of breathing in humans is called tidal respiration. Tidal breathing means that air enters and leaves the lungs in the same way. Total lung capacity depends on a person's age, weight, sex and physical activity. For example, women have a lower lung capacity of 20–25% than men. Heavy smokers have lower lung capacities than non-smokers. Lung capacity also depends on altitude. Someone born and living in the lowlands has a smaller capacity than people who live in the highlands.

This is because the atmosphere has a low density at high altitudes, so that the same volume of air contains few molecules, including oxygen. The lungs will grow larger in order to process more air. Someone who goes from low altitude to high altitude often experiences “altitude sickness, because the lungs cannot process enough oxygen for the body’s needs. Tidal volume, vital capacity, inspiratory capacity and expiratory reserve volume can be measured with a spirometer. Residual volume determination can be performed by radiographic planimetry, body plethysmography, closed circuit dilution and nitrogen washout.

Topic 7: Principles of Physics in the Maintenance of Medical Devices

As we all know, medical devices are made of various materials, such as metal and raw glass, so in their use and maintenance, nurses need to know the principles of physics in the maintenance of equipment. The principle is explained as follows:

1. Maintenance of Electronic Medical Devices
   Electronic maintenance is very sensitive to shocks, so it is necessary to avoid shocks. Avoid equipment with strong magnetic fields so that the sensitivity of the meter does not change. Electronic devices cannot withstand temperatures above 25°C. To avoid the temperature being too high, the tool needs to be given a fan around the power source. Dust can also affect the work of the tool, so every time the room is cleaned using a vacuum cleaner, Knowledge and skills in using equipment play an important role in equipment maintenance so that the equipment runs properly and avoids damage. This knowledge and skills include: understanding the measurement objectives in advance; preparation of measurement methods, times, and programs; determining whether the condition of the equipment is good or not; and examples of electronic equipment, namely: electrocardiography, electroencephalography, thermography units, ventilators, EKG monitoring units, patient monitors, etc. (Budiyono, 2014).

2. Maintenance of Tools Made from Metal Raw Materials
   Tools made of metals such as iron, copper, and aluminium often rust. To prevent this from happening, these tools must be stored in a place with a high temperature of 37°C and in a dry environment. If necessary, use silicon material as an absorbent for moisture. Before being stored, the tool must be free from dirt, dust, or water adhering, then smeared with oil, brake fluid, or liquid paraffin. Examples of tools made of metal raw materials include extraction forceps, scissors, tweezers, heaving needles, etc. (Budiyono, 2014).
3. Equipment from Glass Raw Materials
   Glass materials are widely used in medical laboratories. There are several advantages and disadvantages to the glass raw material. The advantages: glass material is resistant to chemical reactions, especially Pyrex glass material, is resistant to sudden changes in temperature, has a small expansion coefficient, and has high light translucency. Weaknesses: easily broken by mechanical pressure; easy to grow mould so that it interferes with light penetration; sometimes using a cotton cloth to clean it easily causes scratches.

The things that must be considered "on the advantages and disadvantages of glass materials in terms of nursing are: storage in a room where the temperature is around 27°C–37°C and given an additional 25-watt lamp, the storage room is given silicon material as a hygroscopic substance. Use alcohol, acetone, cotton, a soft brush, and an air pump to clean dust from the surface of the glass. When cleaning the lens, try not to damage the lens coating. When heating the test tube, it should be placed on top of the wire mesh or may be heated directly as long as the glass material is made of Pyrex. The glass to be boiled should not be put directly into the boiling water, but the glass should be put into cold water and then heated slowly. Examples of equipment made from glass raw materials include pipettes, test tubes, burettes, vacuum extractives, etc (Budiyono, 2014).

Summary

The four basic principles of body mechanics are gravity, balance, weight, and basic movements. Balance is achieved by maintaining the position of the line of gravity between the centre of gravity and the pedestal. Weight is the most important factor when using body mechanics, as it affects the mechanics of the body. Basic movements must be taken into account before doing body mechanics. Standing is more stable than walking, as there is a displacement of the base of support from one side to the other and the centre of gravity changes in the position of the feet.

Holding is always changing, and gravity needs to be considered to provide the right position. Pulling is a way of moving objects, lifting is a way of moving traction, and rotating is a movement to rotate the limbs and rest on the spine. Biomechanics is a science that studies the process of hearing reception produced by living things. Bioacoustics is a field of science that studies sound characteristics, sound physiology, voice organs, voice functions, sound analysis, and the benefits of sound for living things. Sound has certain characteristics in terms of frequency, amplitude, speed, reverberation time, and so on.

The normal human ear's sensitivity to sound intensity has two thresholds, namely the hearing threshold and the pain threshold. Noise is unwanted sound that hinders the hearing of voices or causes pain or interferes with lifestyles. Darlani & Sugiharto (2017) found that noise above 80 dB can cause anxiety, feeling unwell, hearing fatigue, stomach pain, and blood circulation problems. Types of noise include continuous noise with a wide frequency spectrum, intermittent noise, impulsive noise, and repetitive impulsive noise. Sound waves are disturbances of the physical properties of a medium that propagate according to place and time, where the medium is not moving.

Waves are divided into longitudinal, transverse, mechanical, elastic, surface, and electromagnetic waves. Frequency and sound intensity are also divided into three regions: infrasonic, sonic, and ultrasonic. Thermophysical is the study of the laws governing the

conversion of energy from one form to another, the flow of energy, and the ability to do work. Two terms that are closely related in thermodynamics are system and environment. Metabolism is the process of change in an organism, including anabolism and catabolism.

The first law of thermodynamics states that the heat added to a system equals the change in energy in the system plus the work done by the system. The second law of thermodynamics is an independent law of nature that states that it is impossible for a process in an isolated system to be accompanied by a decrease in entropy. It states that heat flow has a direction and that heat flows spontaneously from objects at a higher temperature to objects at a lower temperature, never spontaneously in the opposite direction. It places fundamental limits on the efficiency of a machine or generator and sets limits on the minimum input energy required to run a refrigeration system. It also states that it is impossible for a system to undergo a process in which the system absorbs heat from a reservoir at a single temperature and completely converts that heat into mechanical work, and the system ends up in the same state as it originally was.

Review Questions

Understanding the basic principle of mechanism

1. What kind of science that studies motion by paying attention to its causes?
   A. Static
   B. Constant
   C. Dynamic
   D. Friction
   E. Gravity
   Answer: D

2. Physics in health can be used as follows:
   A. Determine the function of the body and the occurrence of disease

B. Determine the mechanism of nerve transduction
C. Determine the body's chemical mechanism
D. Determine the structure of the body
E. Determine the reaction in the body
Answer: B

3. What is an eye disorder caused by an uneven size of the eye lens or cornea, a curvature of the surface of the cornea or lens that is not smooth, which results in the patient seeing a box where the vertical lines appear blurred and the horizontal lines are clearly visible, or vice versa?
A. Night blindness
B. Astigmatism
C. Presbyopia
D. Cataracts
E. Myopia
Answer: B

Understanding the bio-electricity

4. What functions as an insulator in nerve cells is?
A. Axon
B. Myelin
C. Nucleus
D. Synap
E. Cable
Answer: A

5. Which ionic liquid is outside the cell?
A. Potassium
B. Calcium
C. Sodium
D. Phosphate
E. Magnesium
Answer: C

6. Which ionic liquid is inside the cell?
   A. Potassium
   B. Calcium
   C. Sodium
   D. Phosphate
   E. Magnesium
   Answer: B

Understanding the bio-acoustics, the bio-optics and the thermophysics

7. What condition affects the eyes that can result in painless blindness?
   A. Myopia
   B. Cataracts
   C. Astigmatism
   D. Conjunctivitis
   E. Hypermetropia
   Answer: D

8. What is the name of the tool used to measure hearing power is?
   A. X-ray
   B. Doppler
   C. Audiometer
   D. Tuning fork
   E. Ultrasound
   Answer: C

9. What is the heat transfer called when we bask in the sun?
   A. Radiation
   B. Regulation
   C. Conversion
   D. Convection
   E. Conduction
   Answer: E

Understanding the bio-fluid

10. Why the blood pressure in the left arm is different from the blood pressure in the leg?

    Answer Instructions: Look at the first subject of fluids and pressure.

Understanding the physics principles in tool maintenance

11. Why is it necessary to keep medical devices made of aluminium in a room with a high temperature of 37°C and in a dry environment?

    A. To stop moisture from entering the device
    B. To stop damage to the tool
    C. To stop sticking to the tool
    D. To stop damage to the tool
    E. To stop rust on the tool

    Answer: E

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CHAPTER 2
BIOLOGY BASIC PRINCIPLES IN NURSING

Learning Objectives:

1. Understanding the cell structure and function
2. Understanding the genetics
3. Understanding the human chromosome
4. Understanding the sex disorders/sex variations in humans
5. Understanding the metabolic disorders

Introduction:

Biology is the science that studies living things. We can find out about the environment, plants, animals, the human body, and many others by studying biology. A nurse must have the ability, as well as good and sufficient biological knowledge, to support their profession in carrying out their duties. Currently, biology is experiencing rapid development, so many new branches of science are very useful, especially cell biology, molecular biology, and genetics. With advances in this field, the discovery of high-yielding seeds, tissue culture, and improved offspring are of great importance. After learning this chapter, students are able to describe cell structure and function, basic andrology, genetics, the human chromosome, and sex disorders and sex variations in humans.

Topic 1: Cell Structure and Function

Cell definition. Cell Structure Cells are the smallest units of life in living things. The smallest unit includes structural and functional units. Living things made up of a single cell are called unicellular living things. One-celled living things include bacteria, amoeba, Paramecium, Euglena, and blue-green algae. Based on the presence or absence of a nuclear membrane, cells are grouped into two types, namely prokaryotic cells and eukaryotic cells. Prokaryotes are cells that do not have a nuclear membrane, for example, bacterial cells and blue algae. Eukaryotic cells that have a protective membrane core material Living things are composed of a number of cells that group together and are called multicellular living things, in which all the functions of the activity are carried out by special cells. Cells are divided into three main parts, namely the cell membrane (plasma membrane), cytoplasm, and nucleus (nucleus). The plasma that is outside the cell nucleus is called the cytoplasm, while the plasma that is inside the cell nucleus is called the nucleoplasm. Nucleoplasm and cytoplasm are called protoplasm.

Protoplasm is a viscous liquid composed of water, carbohydrates, proteins, fats, mineral salts, and vitamins (Schleiden, 2014). The cell is the fundamental unit of structure and function in life. Some types of organisms, such as amoebae and most bacteria, are single cells. Other organisms, including plants and animals, are multicellular. Some single organisms carry out all the functions of life; multicellular organisms have a division of tasks among specialised cells. The human body is composed of trillions of microscopic cells of various types, such as muscle cells and nerve cells, which are organised into various specialised tissues. For example, muscle tissue consists of bundles of muscle cells (Campbell, 2008).

Cell Structure and Functions Cells have different parts and organelles in shape, size, structure, and function. To study the components of cell organelles and their functions, cytologists use a biochemical approach called cell fractionation to isolate cell components of different sizes. Cell components or organelles contained in eukaryotic cells, namely the cell membrane (cell plasma membrane), nucleus (cell nucleus), and cytoplasm (cytoplasm), are ribosomes, endoplasmic reticulum, Golgi bodies, lysosomes, peroxisomes, mitochondria, chloroplasts, vacuoles, centrosomes, and centrioles, as well as a cell wall that limits the outside.

Cell membrane (plasma membrane). Cells have an outer layer that separates the nucleus from the environment. The outermost layer is called the cell membrane. The main building blocks of cell membranes are lipids and proteins (lipoproteins). The cell membrane consists of a double layer (bilayer) of phospholipids. Phosphate in the head is hydrophilic (loves water), and fat in the tail is hydrophobic or water repellent (Yusa, 2016). The cell membrane is selectively permeable or semipermeable because only certain ions, molecules, and compounds can pass through it. In animal and human cells, the cell membrane is located on the outside, whereas in plants, the cell membrane is surrounded by a cell wall. The plasma membrane is composed of lipid material (phospholipids), proteins, and carbohydrates (Irnaningtias, 2016).

The function of the cell membrane is as follows: (a) to control the entry and exit of substances from or into the cell; (b) to provide protection so that the contents of the cell do not come out; and (c) to act as a receptor (receive stimuli) from outside the cell.

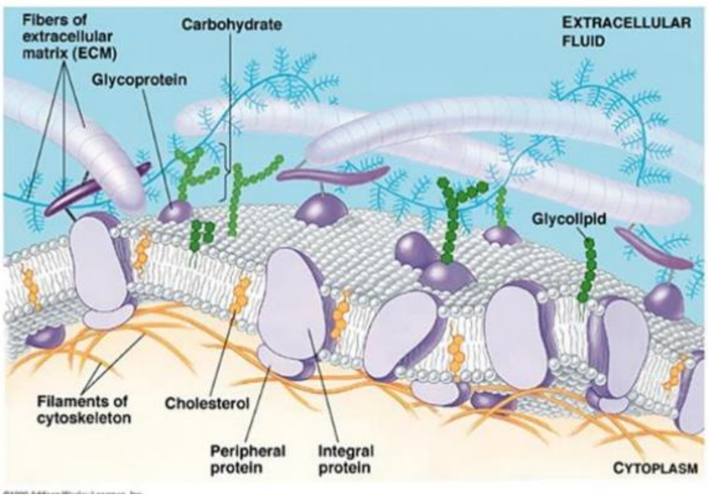

Figure 2.1. Cell Plasma Membrane Structure (Campbell, 2010)

Nucleus (cell nucleus). The nucleus contains most of the genes in eukaryotic cells (most of the genes are located in mitochondria and chloroplasts). The nucleus is generally the most prominent organelle in eukaryotic cells, with a diameter of about 5 m. Within the nucleus, DNA is organised into discrete units called chromosomes, which are structures that carry genetic information. Each chromosome is made of material called chromatin, a complex of protein and DNA. Stained chromatin is usually seen as an indistinct mass, either by light or electron microscopy. But when a cell gets ready to divide, the thin chromatin fibres condense so that they are thick enough to be distinguished as separate structures known to us as chromosomes. Each eukaryote species has a unique number of chromosomes. For example, human cells contain 46 chromosomes in the nucleus, except for sex cells (eggs and sperm), which in humans only contain 23 chromosomes. Most fruit fly cells contain 23 chromosomes, except sex cells, which have 4 chromosomes. The prominent structure in a non-dividing nucleus is the nucleolus (Campbell, 2008).

According to Irnaningtias (2016), the function of the nucleus is as follows: a) controlling protein synthesis by synthesising mRNA according to DNA instructions; b) controlling the process of cell metabolism; c) storing genetic information in the form of DNA; and d) being the place of doubling (replication) of DNA. The next paragraphs will provide an explanation of the many sorts of nucleus.

Cytoplasm. The cytoplasm is the cell fluid that is located inside the cell, outside the cell nucleus and cell organelles. The cytoplasm is in the form of a clear, homogeneous colloidal liquid and contains nutrients, ions, salts, and organic molecules. The function of the cytoplasm is as follows: a) Place the cell organelles and cytoskeleton; b) Allow for the movement of cell organelles by the flow of cytoplasm; c) The place where the cell's metabolic reactions take place; d) To store organic molecules (e.g., carbohydrates, fats, proteins, and enzymes).

Ribosomes. Ribosomes are complexes made of ribosomal RNA and proteins, which are the cellular components that carry out protein synthesis. Cells that have a high rate of protein synthesis have a large number of ribosomes. For example, a human pancreatic cell has several million ribosomes. Ribosomes build proteins at two locations in the cytoplasm. At any time, free ribosomes are scattered in the cytosol, while bound ribosomes are attached to them outside of the endoplasmic reticulum or nuclear envelope. Most of the proteins made on free ribosomes function in the cytosol; for example, the enzymes that catalyse the first step of the breakdown of sugars Bound ribosomes generally make proteins that are normally destined to be inserted into the membrane and packaged in certain organelles, such as lysosomes. Cells specialised for protein secretion, for example, pancreatic cells that secrete digestive enzymes, often have a high percentage of bound ribosomes (Campbel, 2018).

Endoplasmic Reticulum. The endoplasmic reticulum, or ER, is a network of membranes so extensive that it makes up more than half of the total membrane in many eukaryotic cells. (The word endoplasmic means 'inside the cytoplasm', while *reticulum* is the Latin word for 'little net.") The ER consists of a network of tubules and membranous sacs called cisternae (cisterna is from the Latin word for fluid reservoir). The ER membrane separates the internal compartment of the ER, called the ER lumen or cistern space, from the cytosol. Because the ER membrane is connected to the nuclear envelope, the space between the two membranes in the nuclear envelope is connected to the ER lumen (Campbell, 2008). There are two areas of the ER that differ in terms of structure and function, though they are connected. Specifically, smooth RE and rough ER *Smooth ER* functions in a variety of metabolic processes, which vary according to cell type. These processes include lipid synthesis, carbohydrate metabolism, and the detoxification of drugs and poisons. Many cell types secrete proteins that are produced by the ribosome attached to the rough ER. For example, certain pancreatic cells synthesise insulin in the ER and secrete this hormone into the bloodstream. When the chain polypeptide grows from the bound ribosome, the chain is released into the lumen of the ER through a pore formed by a protein complex in the ER membrane. When it enters the lumen of the ER, the new protein folds into its original shape. Most of the secreted proteins are glycoproteins, proteins that are covalently linked to carbohydrates. These carbohydrates are attached to proteins in the ER by specialised molecules present in the ER membrane (Campbell, 2008).

After secretory proteins are formed, the ER membrane keeps them separate from proteins produced by free ribosomes and keeps them in the cytosol. Secretory proteins leave the ER in a membrane-enclosed state of vesicles that sprout like bubbles from a specialised region called the transitional ER. Vesicles that move from one part of the cell to another are called transport vesicles (Campbell, 2008).

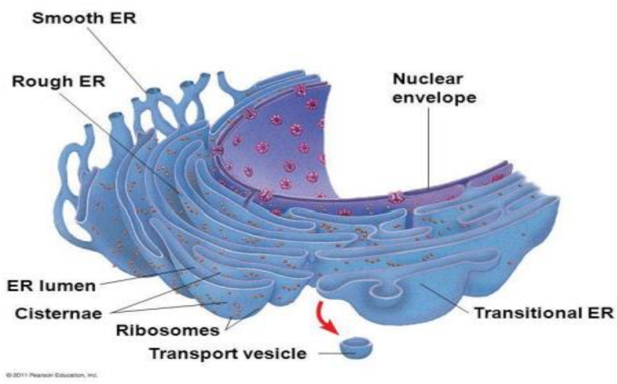

Figure 2.2. Endoplasmic Reticulum (Campbell, 2010)

Golgi apparatus. After leaving the ER, many transport vesicles move to the Golgi apparatus, also known as the Golgi apparatus. We can think of the Golgi apparatus as the centre for manufacturing, warehousing, sorting, and shipping. In this organelle, RE products, such as proteins, are modified and stored and then shipped to various other destinations. The Golgi apparatus consists of flat membranous sacs that look like stacks of flatbread that can be sliced for filling. A cell can have many, even hundreds, of these stacks. The membrane of each cistern in such a stack separates the internal cistern space from the cytosol. Vesicles concentrated near the golgi apparatus are involved in the transfer of materials between golgi divisions and other structures (Campbell, 2008). According to Irnaningtias (2016, p. 20) the function of the golgi body is as follows: a) Play a role in secretion or form vesicles that contain enzymes for secretion; b) Make macromolecules, such as polysaccharides and hyaluronic acid (sticky substances in animal cells); c) Forms the plasma membrane from the released vesicles; and d) Forming the cell wall in plants.

Lysosome. Lysosomes are membrane sacs containing hydrolytic enzymes used by animal cells to digest macromolecules. Lysosomal enzymes work best under the acidic conditions found in lysosomes. If the lysosome ruptures or leaks, the enzymes released are not very active because the cytosol has a neutral pH. However, excessive leakage from many lysosomes can destroy cells through autodigestion (Campbel, 2008). Hydrolytic enzymes and lysosomal membranes are made by the rough ER and then transferred to the Golgi apparatus for further processing. Lysosomes carry out intracellular digestion in a variety of situations. Amoeba and many other protists feed by ingesting smaller organisms or other food particles, a process called phagocytosis, from the Greek word *phagein*, eat, and kytos, receptacle, referring to the cell (Campbel, 2008).

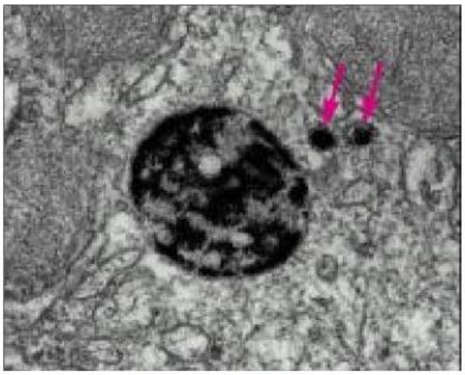

Figure 2.3. Formation and function of lysosomes (Alberts, 2002)

Peroxisomes. Peroxisomes are specialized metabolic compartments bounded by one single membrane. Peroxisomes contain transfer enzymes hydrogen from various substrates to oxygen (O_2), yielding oxygen peroxide (H_2O_2) as a by-product, from which the organelle gets its name. These reactions may have many different functions. Some peroxisomes use oxygen to break down fatty acids into smaller molecules which can then be transported to mitochondria, where these molecules are used as fuel for cellular respiration. Peroxisomes in the liver detoxify alcohol and other harmful compounds by transferring hydrogen from these poisons to oxygen. The H_2O_2 formed by peroxisomes is toxic in itself, but this organelle also contains an enzyme that converts H_2O_2 into water (Campbell, 2008).

Mitochondria. Mitochondria are the site of cellular respiration, a metabolic process that produces ATP by extracting energy from sugar, fat and other fuels with the help of oxygen. Mitochondria are found in almost all eukaryotic cells, including plant, animal, fungal, and most protist cells. Mitochondria are approximately 1-10 µm long. Mitochondria are enclosed by two membranes, each of which is a phospholipid bilayer with a host of protein units embedded within. The outer membrane is smooth in texture, but the inner membrane is pliable, with infoldings called crystals. The inner membrane divides the mitochondria into two internal compartments. The first is the intermembrane space, the narrow area between the inner and outer membranes; the second is the compartment, the mitochondrial matrix covered by the inner membrane. This matrix contains many different enzymes, as well as mitochondrial and ribosomal DNA.

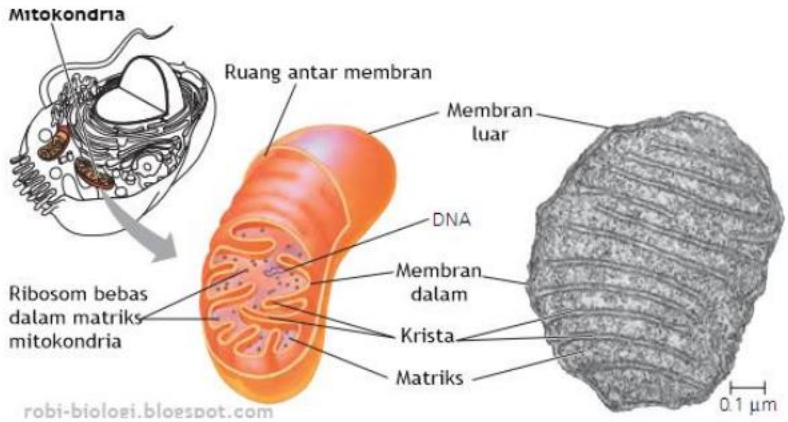

Figure 2.4. Mitochondrial Structure (Campbell, 2010)

Topic 2: Genetics

Have you ever wondered why every living thing, for example, animals, has a different shape, characteristics, and number? Maybe you often ask questions like, "Why did all of this happen?" and "Who is responsible for all of these events?" Humans basically have the ability to pass on the physical traits or characteristics of their bodies to their offspring through marriage. Marriage aims to preserve the species carried by their offspring, and the preservation of the species can be maintained. This is what causes the emergence of some of the questions above, both in humans and in animals. But what is the process of these events? In this teaching material, we will try to study these problems based on the existing literature.

Based on the perception above, we argue that basically all living things, whether humans, animals, or plants, have the same basic ability, which is to pass on the physical traits or characteristics of their bodies to their offspring through mating events with the aim of maintaining the continuity of their kind. The ancients had thought that the part responsible for the inheritance as we discussed above was blood, so how do we explain the mechanism of this inheritance in plants that do not have blood? A human being who has received a blood transfusion should be able to change the characteristics and physical characteristics of his body because he has experienced the mixing of blood. This will be more clearly known based on the findings of scientists who can explain what plays a role in terms of this inheritance associated with an important part of the living body. The science of genetics has experienced many advances since 1978, especially in the field of medical genetics, which briefly applies important matters regarding the basics of genetics, including genes, alleles, and chromosomes. An understanding of divorce about how inheritance is recessive, dominant, or sex-linked So this science needs to be studied to find out the causes of genetic disorders in humans.

Genetics is a branch of biology that tries to explain the similarities and differences in inherited traits in living things (Artadana & Savitri, 2018). In addition, genetics also tries to answer questions related to what is inherited or passed on from parents to their offspring, how the mechanism of genetic material is passed on, and what is the role of this genetic material. Long before genetics was considered as a branch of science, various human activities in order to fulfil their life needs had unknowingly applied genetic principles (Susanto et al., 2022).

The concept of genetics develops from the science that discusses how traits are inherited and becomes more broadly the science that studies genetic material. Genetics broadly discusses: 1) the structure of genetic material, including: genes, chromosomes, DNA, RNA, plasmids, episomes, and transposable elements, 2) reproduction of genetic material, including: cell reproduction, DNA replication, reverse transcription, rolling circle replication, cytoplasmic inheritance, and Mendelian inheritance, 3) work of genetic material, including: scope of genetic material, transcription, post-transcriptional modification, genetic code, translation, concept of one gene one enzyme, interaction of gene work, control of gene work in prokaryotes, control of gene work in eukaryotes, genetic control of the immune response, genetic control of cell division, sex expression, changes in genetic material, 4) changes in genetic material, including: mutation and recombination, 5) genetics in populations, and 6) engineering of genetic material (Nusantara, 2014).

J.G. Mendel was the first to establish a mechanism for decreasing inheritance through experiments in the field of genetics. Mendel's Law is a theory put forward by the father of genetics Gregor Mendel who put forward the principles of inheritance in organisms. That inherited traits are brought about by determining factors (genes) and are determined by half of the male parent (sperm) and half of the female parent (ovum). A monk from Austria, named Gregor Johann Mendel, towards the end of the 19th century did a series crossbreeding trials on pea (Pisumsativum).

Based on this experiment, the theories of the genetic scientists at the time, The Blending Theory of Inheritance, were not true. Prior to Mendel's experiment with the capri plant (Pisum sativum), experts had had the idea of the existence of continuous life, which carries the factor of inheritance from generation to generation. But they did not carry out experiments like Mendel did, and besides that, the scientific tools that could be used to prove their thinking did not exist. Mendel successfully proved that the transfer of nature is rather a predictable pattern. This is the basis of Mendel’s thinking, which is then the basis for obtaining the properties desired by doing hybridization. Based on his work conducting genetic studies by crossing peanuts, Mendel was nicknamed the father of genetics. Genetics is not just about hereditary factors (Oktarisna et al., 2013).

Mendel's law of inheritance is the law that regulates the inheritance of the genetic properties of an organism to its offspring. The law consists of two parts (Cahyono, 2011):

1. Mendel's First Law of Segregation: During the formation of the gamet, each pair of genes will be segregated into each gamete.
2. The second law of Mendel: The separation of a gene pair does not depend on the segregation of the other gene pair, so

within the formed gamete there will be the free selection of gene-gen combinations.

Topic 3: Human Chromosome

Period before 1860 Discoveries that contributed to the development of genetics before 1860 include the invention of the light microscope, the theory of cells, and the publication by Charles Darwin of his book The Origin of Species. Previously, Robert Hooks, with his cell theory, and Antonie van Leeuwenhoek reported observations of microorganisms (protozoa and bacteria) in rainwater. In 1833, Robert Bown reported observations of the cell nucleus, and in 1839, Hugo von Mohl described mitosis in the cell nucleus. Until the end of 1858, Rudolf Virchow concluded all these discoveries in his theory of cells, which is famous in the Latin aphorism Omnis cellule e cellule, which means all cells come from previous cells. Until finally, in 1858, biologists understood how cells develop and knew about the cell nucleus. Although genetics is considered young, almost all products of the last 100 years have been produced by humans using genetic principles (Los, 2023).

During 1900–1944, experts discovered the theory of chromosomes, which stated that chromosomes are strands of genes. It was also during this time that the foundations of modern evolution and molecular genetics developed. In 1900, Mendel's writings on the laws of inheritance, published in 1866, were separately rediscovered by three different experts, namely Hugo de Vries, Carl Correns, and Erich von Tschermak. Furthermore, Water Sutton in 1903 issued a chromosomal behaviour hypothesis that could explain Mendel's theory of inheritance. This hypothesis eventually led to the discovery of the theory that genes are located on chromosomes. Followed by Alferd Sturtevant, who created the first genetic map that describes how genes are arranged and linked in a link on the chromosome.

Since 1944, when the concepts of genetic material (DNA) and molecular genetics were first discovered, numerous geneticists have published evidence supporting their discovery that DNA alone serves as the genetic material. The most amazing discovery was made by Watson and Crick when they pieced together the genetic puzzle that had been uncovered by earlier researchers by discovering the DNA structure. Since then, new disciplines have been developed as a result of ongoing advancements in gene theory and science. Mendel's Rules: Classic The first individual to suggest a hereditary process through genetic tests was J.G. Mendel. This experiment proved the Blending Theory of Inheritance, a then-current scientific theory of genetics, to be false. Prior to Mendel's pea plant (Pisum sativum) crossbreeding studies, scientists already believed that there existed a continuous life that passed on genetics from generation to generation. However, unlike Mendel, they did not perform experiments, and in addition, the scientific tools needed to support their theories were not yet available. Mendel was able to demonstrate that property transfers happen in a predictable way. Then, Mendel's theory serves as the foundation for using hybridization to get the desired traits. Mendel earned the moniker "Father of Genetics" based on his contributions to genetic research using pea hybrids. Mendel's law of inheritance is a law guiding the genetic inheritance of features from one organism to its children, despite the fact that genetics is still in the process of expanding beyond the discussion of heredity (Oktarisna et al., 2013).

The law is divided into two sections: 1. Mendel's First Law, sometimes known as the Law of Segregation The law of segregation's provisions: Each pair of genes will be distributed into a different gamete during gamete creation. 2) Law of Independent Amount (Mendel's Second Law): The provisions of the independent assortment law state that there will be an independent selection of gene combinations in the gametes produced since the segregation of one gene pair is not dependent on the segregation of other gene pairs (Cahyono, 2011).

The two parent genes are passed down in the form of a pair of alleles that will eventually separate, according to Mendel's first law. Each gamete will experience this division according to how many parental genes it inherits. Mendel's law, also known as the law of independent segregation, asserts that the division of the parent gene that takes place in monohybrid crossings results in the inheritance of parental features in the production of child gametes. A monohybrid is a cross between two members of the same species that have only one unique characteristic in common. Monohybrids give birth to identical first (F1) offspring. If dominance is clearly evident, the monohybrid first (F1) offspring will phenotypically resemble the dominant parent. When the first offspring (F1) heterozygotes generate gametes, the alleles become separated, resulting in the gametes having just one allele (Akbar et al., 2015).

Theory of Chromosomes Mendel has truly implied that genes are the fundamental elements that contribute to the formation of characteristics. He only refers to these inherited variables as a determining factor because he is unsure of their exact makeup or form. W. L. Johannsen, who lived from 1857 to 1927, coined the phrase "new gene," which was formed from the final syllable of the term "pangen," which was proposed by Darwin. The term "allele" was coined by William Bateson (1861–1926) to refer to the pair of genes identified by Mendel. The concept of genes as carriers of heredity was strengthened by research by Lucien Cuenot (France) on the influence of genes in mice's fur colour, W. E. Castle (America) on the influence of sex on mammal coat colour, and Johansen (Denmark) on the effects of inheritance and environment on plants (Oktarisna et al., 2013).

The chromosomes in the cell nucleus, according to Wilhem Roux (1883), are bearers of genetic factors. A row- or chain-shaped invisible structure that replicates during cell division is thought to be the mechanism for the transfer of genes from one cell to another. T. Boveri (1862–1915) and W. S. Sutton (1902), who demonstrated that genes are a component of chromosomes, backed up this claim.

Chromosome Shape. The shape of the chromosome known so far is linear. The X chromosome is straight, and the Y chromosome is shaped like an anchor. This form of chromosomes includes only the chromosomes in the nucleus of eukaryotic cells. There are various forms of chromosomes in groups of living things. The shape of the chromosomes in the virus group varies. Some viruses are rod-shaped (linear), some are circular or ring-shaped, and some viruses are linear but in certain circumstances are circular (e.g., phage virus) (Klug & Cumming, 2000).

The shape of the prokaryotic chromosome is circular or ring-double-stranded DNA. For example, E. coli is ring-shaped. The shape of eukaryotic chromosomes, regardless of their number, is linear or rod-shaped. The shape of chromosomes in mitochondria and chloroplast organelles is circular or ringlike in prokaryotes (Russel, 1992). Chromosomes vary in shape during the metaphase of cell division. The shape of the chromosome varies based on the location of the centromere; some are metacentric, submetacentric, acrocentric, and telocentric (Klug & Cumming, 2000).

The centromere is the indentation area on the chromosome and also the location of the kinetochore (where the spindle fibre is linked during cell division). Chromosomes are solid structures consisting of protein and DNA. Chromosomes have a unique structure as a form of gene packaging. In other words, in the chromosome, there are gene loci, namely the position and location of a gene in the chromosome. The gene itself is a stretch of DNA or DNA sequence that determines a protein. According to the genetic dogma, "one gene, one polypeptide". One type of chromosome can contain thousands of genes, like the number one human chromosome. Based on the Human Genome Project, the number one human chromosome is composed of 3,141 genes, and 1,000 of them are newly discovered genes. Chromosome 1 has twice the number of genes as a typical chromosome and makes up about 8 percent of the human genome. The shape of the chromosomes formed by forming the chromatids is the shape of the chromosomes during the cell division stage. At this stage, the chromosomes are duplicated by the mechanism of growth or inheritance. Both through meiosis and mitosis (Arsal, 2018).

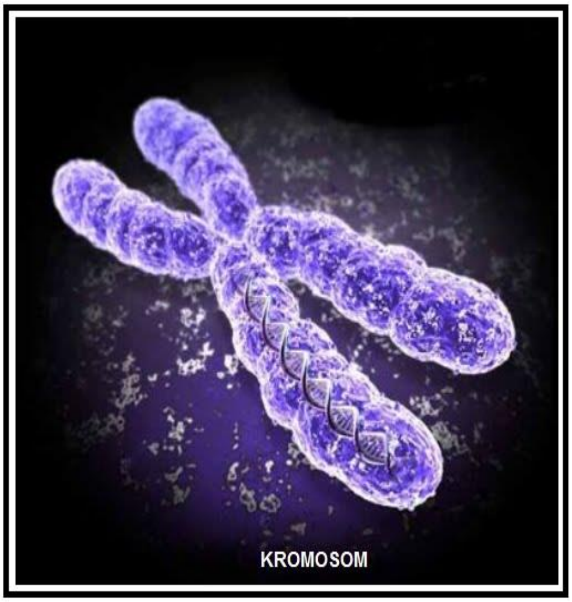

Figure 1. Chromosomes (Electron Microscopy) (Effendi, 2020)

Chromosomes. The number of chromosomes for various viruses is one in the form of DNA or RNA molecules, both double and single strands, linear or circular (Klug & Cummings, 2000). The number of bacterial chromosomes is one (Russel, 1992; Klug & Cumming, 2000). Bacterial chromosomes are in the form of one circular double-stranded DNA molecule associated with a certain protein. The number of chromosomes in eukaryotic species varies in both animals and plants, both diploid and monoploid. The similarity in the number of chromosomes in viruses, prokaryotes, and eukaryotes is not an indicator of species similarity. The number of mitochondrial and chloroplast chromosomes has only one circular shape (Klug & Cummings, 2000). Haploidy is a condition in which an individual does not have a chromosome pair because it only has a single genome. Haploid chromosomes can be duplicated to produce new homozygous individuals. Haploid cells are found in gametes, which can produce diploid properties because female gamete cells that have been fertilised by male sex cells will fuse and develop into diploid zygotes (Pangestuti & Sulistyaningsih, 2011). Diploid is the opposite condition of haploid, in which there are two sets of chromosomes (2n). Diploid conditions are found in most multicellular organisms. An example of a diploid organism is a fern plant, which has a somatic chromosome number of around 58 (Wulandari & Rahmawati, 2018).

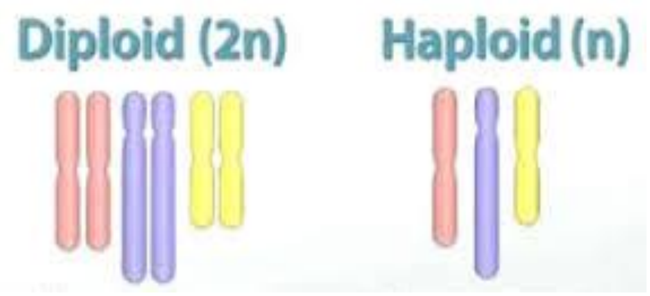

Figure 2. Comparison of Diploid and Haploid Chromosomes (Scienceabc, 2023)

Chromosome Parts. The chromosomal sections described are the chromosomes present in the nucleus of eukaryotic cells during the metaphase of mitosis. The main part of the chromosome is described as the protein covering the DNA. This was the depiction of chromosomes before the invention of the electron microscope. With the invention of the electron microscope, the structure of chromosomes can be described molecularly so that the structure of the chromosomes consisting of membranes, matrices and DNA should be removed or not shown again (Nusantari, 2010). The main part of a eukaryotic chromosome is the genome/DNA/RNA. So, the main part is the nucleic acid. Protein is not the main part. So, the function of the chromosome is to carry heredity to the genome, not the protein. Actually, there is no outer membrane covering the chromosomes, as well as no part which is called the matrix because in fact it is not the protein that covers the DNA but the DNA that is wrapped around the histone proteins. Furthermore, the chromosomes are divided into arms and centromeres (Klug & Cummings, 2000).

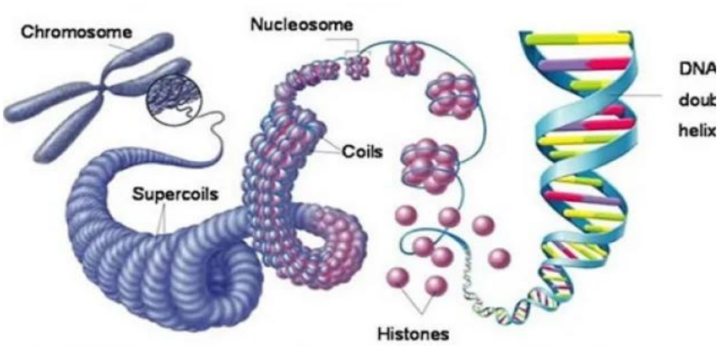

Figure 3. Chromosome Structure and Parts (Effendi, 2020)

Topic 4: Sex Variations in Humans/Sex Disorders

At first, we should note that the gender of an organism usually depends on a series of highly complex developmental changes under genetic and hormonal control. However, often one or more genes can determine which path of development an organism takes. The switch genes are located on the sex chromosome, a pair of heteromorphic chromosomes, when the chromosomes are present. (Sari et al., 2018). However, the sex chromosome is not the only determinant of the gender of an organism. Individual ploidy, as in many Hymenoptera (leopards, ants, and frogs), can determine gender; males are haploid and females are diploid.

Allel mechanisms can determine gender with a single allele or multiple alleles that are not associated with heteromorphic chromosomes; even environmental factors can control sex. For example, the temperature determines the gender of several thorns, and the sex of some sea worms and gastropods depends on the substrate where they landed. However, in this chapter, we focus on the mechanism of chromosome gender determination (Sari et al., 2018).

Basically, there are four types of mechanisms for determining the sex of chromosomes: XY, ZW, X0, and the chromosome mechanism of stacking. In the case of XY, like in humans or fruit flies, females have a pair of homomorphic (XX) chromosomes and males have heteromorphs. (XY). In the case of ZW, the male is homomorphic (ZZ) and the female is heteromorphic (ZW). (XY and ZW are notations for chromosomes and do not indicate the size or morphology of these chromosomes) In the case of X0, the organism only has one sex chromosome, as in some shrimp and donkeys; females typically have XX and males have X0; and in cases of cluster chromosomes, several X and Y chromosomes merge to determine gender, such as in bedbugs and some donkeys. We need to emphasise that the chromosomes themselves do not determine gender, but the genes they carry do. Generally speaking, the genotype determines the type of the gonad, which then defines the phenotype of the organism through the production of male or female hormones. (Xu et al., 2012).

The process of determining a person's sexual orientation is the transformation of gonads into testes or ovaries. While gender differentiation is a process in which the Wolffian or Mullerian ducts develop into the final form of the internal reproductive organs, for example, the Wolff ducts evolve into the seminalis vesicula, the deferent vas, and the epididymide in men, while the Mullerian canal develops into the uterus, the fallopian tube, and the upper third of the vagina in women. Gender determination is entirely governed by gender determination in the Y region and is called SRY. Further, SRY stimulates Sertoli cells to produce anti-Mullerian hormone and further promotes the degeneration of the Mullerian tube. Thus, the SRY gene mutation in humans with XY triggered complete dysgenesis, whereas transgenic XX mice that expressed SRY displayed male phenotypes, had testicles, and had male marital behaviour. In addition to the SRY gene, androgen is necessary for the development of the external genitals. Androgen is the hormone that causes the androgenization of the external genitalia, including the penis and scrotum, and moves from the testicles from the urogenital ridge to the final position in the scrotum. (Achermann J. C. & Hughes, 2011). Unlike in men, external genital estrogenisation in women includes breast enlargement and ovarian development; the uterus is silent until the time of puberty and is called the default process or SRY negative development pathway. However, recent research shows that female gender differentiation also involves the RSPO1, DAX-1, and WNT4 genes that serve as antagonists of testicular development (Taufiqurrachman, 2015).

Sex abnormalities in humans are forms of sexual drive and satisfaction that are obtained or shown to sexual objects in an unusual way. It is called unusual because sexual deviant behaviour is followed by sexual fantasies that are oriented towards achieving orgasm through intercourse outside of heterosexual sex with the same sex or from underage sex partners or sexual relations that are normatively contrary to the norms of sexual behaviour recognized by society. in general. This is what underlies the assumption, sexual deviation is a form of abuse of human nature and contrary to common sense (Junaedi, 2010).

Various sex abnormalities in humans like fetishism, homosexual, sadomasochism, masochism, voyeurism, paedophilia, bestially, incest, necrophilia, zoophilia, sodomy, frotteurism. Fetishism is deviant sexual behaviour in which sexual satisfaction is obtained by masturbating or masturbating with inanimate objects such as panties, bras, dresses, and the like. Homosexual is disorder in which a person likes to have sex with the same sex. Men are called gay and women are called lesbians. Sadomasochism is sexual deviation where a person feels sexual pleasure after hurting his sex partner. Masochism is sexual disorder where a person enjoys sex after first being tortured by his partner. Voyeurism is sexual deviant behaviour in which a person obtains sexual satisfaction, being naked, bathing and the like. Paedophilia is adults who like to have sex with children who are underage. Bestially is sexual disorders where a person likes to have sex with animals such as dogs, horses, goats, chickens, and others. Incest, someone who has sex with other family members (blood). Necrophilia is sexual disorder in which a person likes to have sex with a dead body. Zoophilia is sexual disorder where a person feels aroused after seeing an animal having sex. Sodomy is sexual disorder in which a man likes sex through his partner's anus. Frotteurism is a sexual disorder in which a man feels that he is getting sexual satisfaction by rubbing his genitals against a woman's genitals in public/public places such as buses, trains, and the like (Sarwono, 2002).

The mechanism by which sex is established is called sex determination. We define the sex of an individual organism in terms of its phenotype. Sometimes an individual organism has chromosomes or genes that are normally associated with one sex but have morphology associated with the opposite sex. For example, human female cells usually have two X chromosomes, and male cells have one X and one Y chromosome. Some people rarely have male anatomy, even though their cells each contain two X chromosomes. Even though these people are genetically female, we refer to them as males because their sexual phenotype is male (Syafitri et al., 2013).

There are many ways in which sex differences arise. In some species, both sexes are present in the same organism, a condition called hermaphroditism. Organisms that contain both male and female reproductive structures are said to be monoecious (meaning "one house"). Species in which the organisms have either male or female reproductive structures are said to be dioecious (meaning "two houses"). Humans are dioecious. Among dioecious species, sex can be determined chromosomally, genetically, or environmentally (Limahelu et al., 2019).

The sex chromosomes determine the sex of the baby or offspring. Humans have two types of sex chromosomes, namely the X chromosome and the Y chromosome. A person will be male if he has an X chromosome and a Y chromosome (XY). Someone who has two X chromosomes (XX) will have a female sex. In a woman's ovaries, the sex chromosomes (XX) will segregate so that each egg has one X chromosome (haploid). While in the testes, sex chromosomes (XY) will experience segregation so that there are 2 types of sperm cells, namely sperm with an X chromosome (X sperm) and sperm with an Y chromosome (Y sperm). In theory, the number of sperm with an X chromosome (X sperm) is the same as the number of sperm with a Y chromosome, so the odds for a boy's or girl's opinion are 50:50 (Limahelu et al., 2019).

Genes located on the sex chromosomes are called sex-linked genes. Genes located on the Y chromosome are called Y-linked genes (genes linked to the Y chromosome). While the genes located on the X chromosome are called X-linked genes (X chromosome genes). The genes linked to the Y chromosome determine sex. While there are many genes linked to the X chromosome that are not related to sex determination, male mammals will pass the X chromosome to a girl but will not pass the X chromosome to a boy. In contrast, female or maternal mammals can pass the X chromosome to daughters, girls, or boys (Trent & Davies, 2012).

The existence of phenotypic abnormalities in humans as a result of an anomaly in the number of sex chromosomes, such as in patients with Klinefelter syndrome (XXY, XXYY, or XXXY) or Turner syndrome (having only one X chromosome), indicates that sex chromosomes (X and Y) in humans have an important role in determining sex and other important physiological roles. Among them:

1. The X chromosome contains important genetic information for both male and female individuals. At least one X chromosome is needed for the development of the sex system in humans.
2. The gene that determines male sex in humans is located on the Y chromosome. At least one Y chromosome is needed to determine male sex in humans, even if there is more than one X chromosome in the individual.
3. The absence of a Y chromosome will result in the emergence of a female gender.
4. Genes that affect fertility are present on both sex chromosomes (X and Y). A woman needs at least one set (or pair) of X chromosomes to be fertile.
5. An excess number of X chromosomes will result in the emergence of normal developmental problems in both male and female individuals.

The gene, present on the Y chromosome in both humans and most other mammals, determines an individual's virility. In humans, the SRY (Sex Determining Region Y) gene is the main gene that determines male sex. The SRY gene encodes a protein transcription factor that attaches to DNA and induces transcription of other genes that stimulate testicular growth. Apart from the SRY gene, there are also other genes on the X, Y, and autosome chromosomes that also contribute to determining male fertility and sex.

Topic 5: Metabolic Disorders

Metabolic disease is a collection of metabolic risk factors that are directly related to the occurrence of atherosclerotic cardiovascular disease. Conditions in which a person has high blood pressure, central obsession and dyslipidaemia, with or without hypertriglyemia. These risk factors include atherogenic dyslipidaemia, increased blood pressure, increased plasma glucose levels, protothrombotic state, and pro-inflammation (Rini, 2015). Metabolic disease is also a condition in which the body experiences inappropriate chemical production processes. With an abnormal process, it causes the body to get important substances that are not suitable and the body will be prone to illness. The nutrients needed are: Carbohydrates, Fats, Proteins (Adind, 2022).

Type of metabolic disease are disorders of carbohydrate metabolism, disturbances in protein metabolism and disorders of fat metabolism. Disorders of carbohydrate metabolism such as diabetes mellitus (a common metabolic problem because the hormone insulin causes uncontrolled changes in blood sugar levels), galactosemia (abnormalities in the body resulting in glucose that cannot be broken down properly). Disturbances in protein metabolism such as phenylketonuria (a condition in which the level of the amino acid (protein), phenylalanine in the blood is too high) and Friedreich’s ataxia (reduced frataxin protein in the body so that it damages the nervous system which is supposed to function as pumping work of the heart). Disorders of fat metabolism such as xanthoma (disturbed skin condition due to accumulation of fat on the surface of the skin, gaucher (a disease that makes the body unable to break down fat so that fat in the body accumulates in the spleen, marrow, liver so that it will damage the bones), causes of metabolic abnormalities. The cause of metabolic disorders is caused by the cessation of organ function, due to lack of hormones and essential nutrients, consuming excess food, as well as genetic/hereditary factors. Metabolic disorders are generally caused by gene mutations, namely genetic disorders passed down in families called congenital metabolic disorders.

This genetic disorder affects the performance of the endocrine glands (a group of glands and organs that produce hormones) in producing nutrients used in metabolic processes (Adind, 2022). Other metabolisms, including lipid, protein, and carbohydrate metabolism, will be discussed in the following chapter.

Summary

The three primary components of a cell are the cell membrane, cytoplasm, and nucleus. Cells are the smallest units of life in living organisms and are composed of the cell membrane, cytoplasm, and nucleus. Water, carbohydrates, proteins, lipids, mineral compounds, and vitamins make up protoplasm, a viscous liquid. Cells are the fundamental element of structure and function in life, with some organisms performing all the functions of life while others have specialised cells for each task. The human body is composed of trillions of different categories of microscopic cells organised into numerous specialised tissues. The elements and organelles of a cell vary in size, shape, structure, and function.

Cytologists use a biochemical technique known as cell fractionation to isolate cell components of various sizes in order to study the components of cell organelles and their functions. The cell membrane is selectively permeable or semipermeable and is composed of lipids (phospholipids), proteins, and carbohydrates. 5 m in diameter, the nucleus is the most prominent organelle in

eukaryotic cells. It is responsible for governing protein synthesis, regulating cell metabolism, storing genetic information in the form of DNA, and duplicating (replicating) DNA. The nucleolus is a prominent structure in a non-dividing nucleus that regulates protein synthesis, cell metabolism, DNA storage, and DNA replication.

Genetics is a branch of biology that aims to explain the similarities and differences in inherited traits in living things. It also tries to answer questions related to what is inherited or passed on from parents to their offspring, how the mechanism of genetic material is passed on, and what is the role of this genetic material. Human activities have unknowingly applied genetic principles. J. G. Mendel was the first to establish a mechanism for decreasing inheritance through experiments in genetics.

Mendel's Law is a theory put forward by Gregor Mendel that inherited traits are brought about by determining factors (genes) and are determined by half of the male parent (sperm) and half of the female parent (ovum). This law consists of two parts: Mendel's First Law of Segregation and Mendel's Second Law of Segregation, which regulates the inheritance of the genetic properties of an organism to its offspring. The most important details in this text are the discoveries that contributed to the development of genetics before 1860, such as the invention of the light microscope, the theory of cells, and the publication by Charles Darwin of his book The Origin of Species. During 1900-1944, experts discovered the theory of chromosomes, which stated that chromosomes are strands of genes. Mendel's law of inheritance is a law guiding the genetic inheritance of features from one organism to its children, and the concept of genes as carriers of heredity was strengthened by research by Lucien Cuenot, W. E. Castle, and Johansen.

Chromosomes vary in shape during the metaphase of cell division, and the number of chromosomes in eukaryotic species varies in both animals and plants. Haploidy is a condition in which an individual does not have a chromosome pair because it only has a single genome, and diploidy is the opposite condition of haploid, in which there are two sets of chromosomes (2n).

A series of genetic and hormonal developmental changes determine the gender of an organism. The sex chromosome contains switch genes, but individual ploidy, allelic mechanisms, and environmental factors can also determine gender. There are four chromosome sex determination mechanisms: XY, ZW, X0, and the layering mechanism. Through the production of male or female hormones, the genotype determines the phenotype of the organism. Transformation of gonads into testes or ovaries is the process that determines a person's sexual orientation.

The SRY gene controls gender determination by stimulating Sertoli cells to produce anti-Mullerian hormone. Androgen is required for the development of the penis and scrotum. Human sexual abnormalities consist of fetishism, homosexualism, sadomasochism, masochism, voyeurism, paedophilia, bestially, incest, necrophilia, zoophilia, sodomy, and frotteurism. Fetishism is an aberrant sexual behaviour in which sexual gratification is obtained through masturbation or masturbation with inanimate objects, whereas homosexuality is a disorder in which a person prefers to have sex with people of the same sex. Sex determination is the mechanism for establishing sex.

It is determined by an organism's phenotype, which can be chromosomally, genetically, or environmentally determined. The X and Y chromosomes are the two forms of sex chromosomes found in humans. Sadomasochism is a sexual deviation in which a person derives sexual enjoyment from inflicting pain on their sex partner. Masochism is a sexual disorder in which a person loves sex after their partner has tortured them. Voyeurism is sexually deviant behaviour characterised by sexual gratification.

Paedophilia refers to adults who enjoy having sexual relations with minors. Bestially refers to sexual disorders in which an individual prefers to have intercourse with animals. Incest is a sexual disorder in which an individual desires sexual relation with other family members. Necrophilia is a sexual disorder in which an individual enjoys having sex with a corpse. Zoophilia is a sexual disorder in which a person feels attracted to animals. Human sex chromosomes (X and Y) play an important role in determining sex and in other crucial physiological functions.

The X chromosome contains essential genetic information for both male and female individuals, whereas the Y chromosome contains the gene that determines male sex in humans. The absence of a Y chromosome will result in the development of female characteristics. Fertility-influencing genes are present on both chromosomes, and a woman requires at least one set of X chromosomes to be fertile. In addition to the SRY gene, other genes on the X, Y, and autosomal chromosomes contribute to determining male fertility and sex. Abnormal chemical production processes are the cause of metabolic disease, which is a collection of metabolic risk factors associated with atherosclerotic cardiovascular disease.

Needed nutrients include carbohydrates, lipids, and proteins. Metabolic disorders include disturbances in carbohydrate metabolism, protein metabolism, and lipid metabolism. They are brought on by cessation of organ function, deficiency in hormones and essential nutrients, overeating, and genetic/hereditary factors. Congenital metabolic disorders impair the endocrine organs' ability to produce nutrients utilised in metabolic processes.

Review Questions

1. Mendel wanted to be a teacher, but after two certifications that always failed, he decided to continue his research on plants. Exercise for eight years:

A. 1856 – 1863
B. 1825 – 1883
C. 1856 – 1879
D. 1888 – 1933
E. 1878 – 1939

Answer : A

2. The slide map describes

A. Charter used to track genetic abnormalities for several generations.
B. Hereditary Charter of Decreasing Disease
C. Charter of the Genetic Relationship between Individuals
D. The Charter of the People with Disease Decreases
E. Charter of Interpersonal Relations

Answer : C

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CHAPTER 3
BIOCHEMISTRY BASIC PRINCIPLES IN NURSING

Learning Objectives:

1. Understanding the enzyme and coenzyme
2. Understanding the metabolism: carbohydrate metabolism, fat metabolism, and protein metabolism
3. Understanding the hormonal regulation in metabolism
4. Understanding the BMR measurement metabolism

Introduction

Enzymes, minerals, and vitamins help our bodies' regulators and reactions go more quickly. The role of elemental support in the metabolism of macro-nutrient elements is discussed in this chapter. Students should be able to describe the concepts of enzyme and coenzyme, carbohydrate, fat, and protein metabolism, hormonal regulation of metabolism, temperature setting, temperature measurement, and BMR measurement once they have finished this chapter.

These skills are absolutely necessary for implementing nursing care in both clinics and hospitals. Your ability to identify the correct issue and create a nursing care plan with careful consideration for clients in the clinic and the community will be aided by your knowledge of enzymes and coenzymes, biological oxidation, carbohydrate, fat, and protein metabolism, hormone regulation in metabolism, temperature setting, temperature measurement, and BMR measurement.

Topic 1: Enzyme and Coenzyme

Protein molecules called enzymes serve as catalysts in biological reactions. They control how quickly chemical reactions occur in living cells. In order to speed up reactions, enzymes work by lowering the amount of energy required for activity. Additionally, enzymes only catalyse certain reactions with specific substrates because of their very selective catalytic function. Non-protein molecules known as coenzymes work with enzymes to catalyse biological reactions. In enzymatic processes, they frequently act as donors or carriers of functional groups. Coenzymes are crucial for the effective performance of complicated chemical reactions (Nelson & Cox, 2008).

Proteins called enzymes serve as biocatalysts in cellular chemical processes. By reducing the activity energy needed to achieve a transition state and consequently boosting the reaction's speed, enzymes aid in the acceleration of chemical processes. Protein synthesis and post-translational processing are two processes that go into the formation of an enzyme.

The general processes in the production of enzymes are as follows:

1. Translation and transcription: The enzyme RNA polymerase transcribe the gene that encodes the enzyme into an RNA molecule (ribonuclease). The resulting RNA molecule, called mRNA (messenger RNA), then contains instructions for enzyme synthesis. The ribosome then translates the mRNA into a polypeptide chain (protein) with a specific amino acid sequence.
2. Folding protein: The polypeptide chain resulting from translation undergoes folding to adopt a proper three-dimensional structure. This folding is also important for forming the functionally active structure of the enzyme. This folding process is aided by protein chaperons, which help prevent aggregation or the formation of unwanted structures.
3. Post-translational modification: After flooding the protein, the enzyme can undergo post-translational modifications necessary to obtain its biological activity. These modifications

may take the form of additional peptide cleavage, enhancement of prosthetic groups, or the addition of chemical groups such as phosphate or carbohydrate groups. These modifications are important for function and enzyme regulation.

On the other hand, coenzymes are non-protein molecules that help catalyse enzymes. Coenzymes also often serve as carriers of chemical groups or electrons needed for biochemical reactions. Coenzymes can also take the form of vitamins or compounds related to vitamins. Some common coenzymes include NAD+ (nicotinamide adenine dinucleotide) and ATP (adenosine triphosphate). Coenzymes can be formed through biosynthetic pathways that involve various biochemical reactions in cells. For instance, specific enzymes can modify vitamins to form coenzymes. Once formed, coenzymes can associate with enzymes to help catalyse certain chemical reactions by carrying or transferring chemical groups or electrons. The process of forming enzymes and coenzymes is a complex and tightly regulated step in the cell to ensure proper biochemical function (Nelson & Cox, 2017). The process of forming coenzymes involves several biosynthetic steps involving various enzymes and biochemical reactions. Coenzymes are generally formed through metabolic pathways in cells.

Enzyme Structure. Enzymes based on their structure can be divided into two categories: 1) simple enzymes, which are composed of protein only; and 2) complex enzymes, whose structure is composed of protein and non-protein. Complex enzymes consist of an apoenzyme and a prosthetic group. Apoenzyme is the part of the enzyme that is composed of protein. The prosthetic group is the non-protein part of the enzyme. Prosthetic groups can be grouped into two categories: coenzymes (composed of organic matter) and cofactors (composed of inorganic materials).

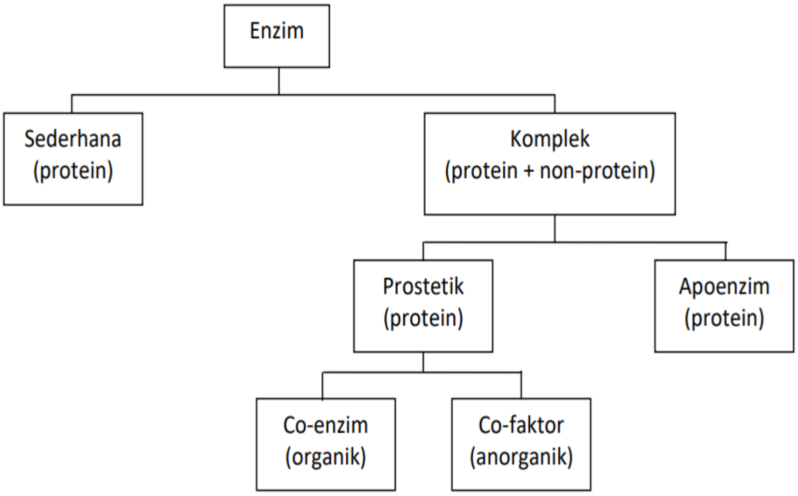

Figure 3.1. Enzyme Structure Division Diagram (Nelson & Cox, 2017)

We can also tell the structure of the enzyme by its active surface. This means that if there is an enzyme group, not all surfaces can be a place for substrate attachment, and the substrate can only stick to the active side (Figure 3.2).

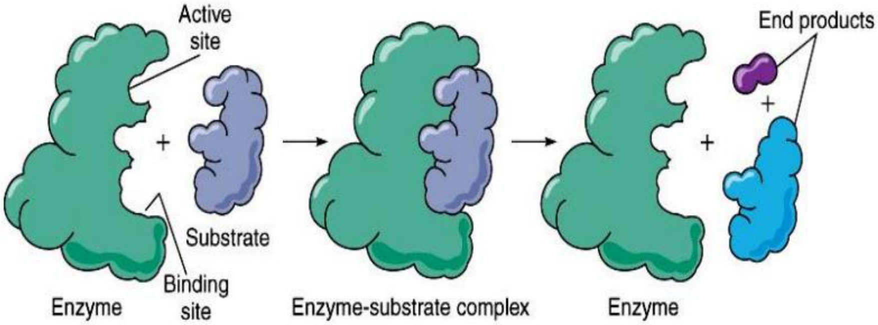

Figure 3.2. Active Side of Enzyme, Reaction with Substrate and Final Product (Nelson & Cox, 2017)

Factors Affecting Enzymes and Coenzymes. At the beginning, we all knew that the basic structure of an enzyme is a protein, so its work is greatly influenced by several things.

1. Temperature
   Enzymes are made up of protein molecules. Therefore, enzymes still have protein properties whose work is affected by temperature. Enzymes can work optimally at a certain temperature range, which is around 40°C. Enzymes are not active at 0°C. If the temperature is raised, the enzymes will start to activate. If the temperature is raised even higher to a limit of around 40-50°C, the enzymes will work even more actively. However, further heating causes enzymes to break down or denature like other proteins. In this state, the enzymes cannot work. Enzymes are not active at temperatures less than 0°C. Enzyme activity ability doubles at every 10°C temperature. Enzyme activity ability is at its optimum at 37°C.
2. Degree of Acidity (pH)
   Enzymes work at a certain pH, generally a neutral pH, except for a few types of enzymes that work in an acidic or alkaline environment. If an enzyme that works optimally in a neutral environment is placed in an alkaline or acidic environment, it will not work or even be damaged. Vice versa, if an enzyme works optimally in an alkaline or acidic environment but is placed in an acidic or basic condition, it will be damaged.\For example, the enzyme pepsin, found in the stomach, is effective at low pH. Each enzyme acts most efficiently at a certain pH value, which is referred to as the optimum pH. The optimum pH for most enzymes is pH 7. There are some exceptions; for example, the enzyme pepsin in the stomach reacts most efficiently at pH 2, while the enzyme trypsin in the small intestine acts most efficiently at pH 8.
3. Inhibitors
   Another thing that affects the work of the enzyme is the inhibition of the feedback response by the feedback inhibitor.

A "feedback inhibitor is a condition when the product of an enzyme that accumulates in excessive amounts inhibits the work of the enzyme in question. Competition inhibitors occur when the addition of a substrate can reduce their inhibition because the inhibitor competes with the substrate to bind to the active part of the enzyme. For example, the enzyme succinate dehydrogenase functions to catalyse the oxidation reaction of succinic acid to fumarate; if malonic acid is added to this process, the activity of the succinate dehydrogenase enzyme will decrease. But if succinic acid is given again as a substrate, the reaction will return to normal. So that the activity of this inhibitor is very dependent on the concentration of the inhibitor, the concentration of the substrate, and the activity of the inhibitor and substrate enzymes.

The effect of non-competition inhibitors cannot be removed by the addition of other substrates; these inhibitors will bind to the surface of the enzyme without being separated, and their location cannot be replaced by the substrate. So that the working power of the inhibitor is very dependent on the concentration of the inhibitor and the activity of the inhibitor enzyme against

4. Substrate Concentration

The mechanism of enzyme action is also determined by the amount or concentration of available substrate. If the amount of substrate is small, the rate of enzyme action is also low. Conversely, if the amount of substrate available is large, the enzyme work is also fast. In the presence of excess substrate, the work of the enzyme does not decrease but is constant. At low substrate concentrations, the number of enzyme molecules exceeds the number of substrate molecules.

So that only a small part of the enzyme molecule reacts with the substrate molecule. If the concentration of the substrate increases, the enzyme molecule can react more with the substrate molecule so that it can reach the maximum level of the enzyme reaction. The addition of further substrate concentrations will not increase enzyme activity because the enzyme concentration is already saturated.

5. Enzyme concentration
   In order for the reaction to run optimally, the ratio between the enzyme and the substrate must be appropriate. If there are too few enzymes and too many substrates, the reaction will be slow, and there may even be uncatalyzed substrates. The more enzymes, the faster the reaction.

Topic 2: Metabolism

One of the most important functions of the gastrointestinal tract is digesting nutrients in the form of carbohydrates, fats, minerals, vitamins, and water, which living things use to produce energy; preparing complex proteins and fats; and maintaining electrolytes and total body fluid reserves. Energy production involves the oxidation of nutrients (carbohydrates, fats, and proteins) to produce high-energy phosphate bonds where energy is stored for life processes, and carbon dioxide and water are produced as by-products. The most important high-energy phosphate bond is adenosine triphosphate (ATP). This molecule, distributed throughout the body, is the energy storehouse for the body, providing the energy necessary for all physiological processes and chemical reactions. Perhaps the most important intracellular process that requires energy from ATP hydrolysis is the formation of peptide bonds between amino acids during protein synthesis. In addition, skeletal muscle contractions cannot occur without energy from ATP hydrolysis (Ezekia, 2017).

Nutrient metabolism is required for the formation of ATP, which, when hydrolysed, will produce energy for ion transport across all cell membranes. Active transport is required to maintain the distribution of ions required for several cellular processes, including the propagation of nerve impulses. In the renal tubules, 80% of the ATP is used for membrane ion transport. In addition to its function as an energy transfer molecule, ATP is also the precursor of cyclic adenosine monophosphate (cAMP), an important signalling molecule. The calorific values of carbohydrates, fats, and proteins range from 4.1 kcal/g to 9.3 kcal/g and 4.1 kcal/g, respectively. Fat accounts for most of the energy storage because of its greater mass and higher caloric value. Therefore, the main form of chemical energy stored in the body is fat (triglycerides). The high caloric density and hydrophobic nature of triglycerides allow efficient energy storage without any adverse osmotic effects (Ezekia, 2017).

Carbohydrate Metabolism

Carbohydrates are a group of organic compounds that include sugars and starches, and besides carbon, they contain hydrogen and oxygen in the same ratio as water (2:1). Three very important disaccharides for humans are sucrose (glucose and fructose); lactose (glucose and galactose); and maltose (glucose and glucose). Starch, which is found in grains such as wheat, rice, and barley and other plants such as potatoes and maize, consists of many glucose units held together by glycosidic bonds. Sugar is an important source of energy for the body and the only source of energy for the brain. The liver is the site of carbohydrate metabolism, where the regulation, storage, and production of glucose take place. The liver is the only organ that contains glucose kinase, an enzyme that has a high reaction rate (mm) and is capable of phosphorylating glucose, but only when the concentration is high. Adequate concentrations occur immediately after a meal when glucose concentrations in the portal vein increase. At least 99% of all energy derived from carbohydrates is used by mitochondria to form ATP in cells (Ezekia, 2017).

The end products of the digestion of carbohydrates in the gastrointestinal tract are glucose, fructose, and galactose. Once absorbed into the circulation, fructose and galactose are immediately converted to glucose. Thus, glucose is the main molecule used to produce ATP. Before the cell can use this glucose, it must travel across the cell membrane and into the cytoplasm. In diabetes mellitus or sepsis, this transport uses carrier proteins in carrier-mediated diffusion, which insulin enhances, resulting in glucose transport into cells and hyperglycaemia with other side effects. The hexokinase enzyme immediately converts glucose to glucose-6-phosphate after it enters the cell. Phosphorylated glucose ionises at pH 7, and because the plasma membrane is impermeable to ions, phosphorylated glucose cannot cross the membrane back and is trapped inside the cell. The foetus gets almost all of its energy from glucose, which it gets from the maternal circulation. Immediately after birth, the baby's glycogen reserves are sufficient to supply glucose for several hours. Furthermore, gluconeogenesis is very limited in neonates. As a result, neonates are prone to experiencing hypoglycaemia if they are not given food immediately (Ezekia, 2017).

Fats are hydrophobic organic molecules that include waxes, sterols, fat-soluble vitamins, triglycerides, phospholipids, and other compounds. Fat contains high potential energy but is also important as a structural component of cell membranes, in signalling pathways, and as a precursor to several cytokines. Fatty acids and their derivatives, as well as sterol-containing molecules such as cholesterol, are also considered fats. Although there are biosynthetic pathways for synthesising and degrading fats, some fatty acids are essential for the body and must be consumed through the diet. Fatty acids are carboxylic acids consisting of long hydrocarbon chains ending in a carboxyl group.

Humans can desaturate no more than the 9^{th} carbon from the tail of an aliphatic chain. However, humans require fatty acids (which are thus essential for the body) desaturated down to the 6^{th} and 3^{rd} carbons of the aliphatic chain—the 6 and 3 fatty acids, respectively. The twenty-carbon chain of fatty acids is stored in the second position of the phospholipid and, when released, serves as a substrate for several very important cytokines, including the eicosanoids, prostaglandins, thromboxane, and leukotrienes. Arachidonic acid, a 6-fatty acid with a 20-carbon chain (C20:46), is the precursor for prostaglandins and thromboxane from the second series and leukotrienes from the fourth series, while eicosapentaenoic acid, C20:53, is the precursor for prostaglandins and thromboxane from the third series and leukotrienes from the fifth series. A glycerol bonded to three linked fatty acid molecules is known as a triglyceride. A triglyceride molecule in which one fatty acid is replaced by a phosphate ion is known as a phospholipid. Phospholipids are the building blocks of cell membranes; they form myelin, and because of their unique structure and function, they are used in other scientific applications (Ezekia, 2017).

Triglycerides, after being absorbed from the gastrointestinal tract, are transported in the lymph and then through the thoracic duct, entering the circulation in the form of droplets called chylomicrons. Chylomicrons are rapidly excreted from the circulation and stored as they pass through capillaries in adipose tissue and skeletal muscle. Triglycerides are used in the body primarily to provide energy for the same metabolic processes as carbohydrates. Cholesterol does not contain fatty acids, but cholesterol is fat because it is composed of carbon and hydrogen, not as aliphatic carbon chains but with four rings made of carbon. Seventy-five percent of cholesterol is produced in the liver in a synthesis process involving 37 steps, while 25% is other cholesterol consumed from food. The molecule that is half fat and half protein, lipoprotein, is also synthesised primarily in the liver. It is suspected that the function of lipoproteins is to provide a fat transport mechanism throughout the body. Lipoproteins are classified according to their density, which relates best to their fat content. All cholesterol in plasma is found in the lipoprotein complex, with low-density lipoprotein (LDL) comprising the majority of the cholesterol component in plasma. LDL provides cholesterol to tissues, which is an essential component of cell membranes and is used for the synthesis of corticosteroids and sex hormones (Ezekia, 2017).

Receptor-mediated endocytosis is what takes up LDL in the liver. This intrinsic feedback control system increases endogenous cholesterol production when exogenous intake is reduced, explaining the relatively mild lowering of cholesterol concentrations that occurs with a low-cholesterol diet. If this endogenous increase in cholesterol synthesis is blocked by drugs that inhibit hydroxymethylglutaryl coenzyme A (HMG-CoA) reductase, there will be a decrease in plasma cholesterol concentrations. Drugs that selectively inhibit HMG-CoA are known as statins. Statins effectively lower plasma LDL cholesterol and provide protection against acute heart disease. In addition, statins decrease plasma triglyceride concentrations and slightly increase high-density lipoprotein (HDL) cholesterol concentrations. Drugs that bind bile salts (cholestyramine and colestipol) prevent cholesterol from re-entering the circulation as part of the enterohepatic circulation. The disadvantage of using drugs that bind bile salts to lower plasma cholesterol concentrations is an increase in plasma triglyceride concentrations (Ezekia, 2017).

Fat Metabolism

Lipids are biological molecules that are insoluble in water but soluble in organic solvents. Often, when we say fats and oils, we think of them as triglycerides (Ezekia, 2017). *Types of lipids*. Based on the level of solubility with water and the bonds of the carbon groups, we can distinguish several types of lipids. Fatty acids are compounds consisting of a long hydrocarbon with a carboxylic group attached at the end. Fatty acids have two important physiological roles: (1) forming phospholipids and glycolipids, which are molecules amphiprotic as a component of biological membranes; and (2) as a molecule of energy. Glycerides are lipids that have the main function of being an energy reserve. Glycerides consist of neutral glycerides and phosphoglycerides. Complex lipids are lipid groups that bind to other compounds. Complex lipids consist of lipoproteins, lipids that bind to proteins (cholesterol), and glycolipids, which bind to glycogen compounds. Non-glycerides, lipid compounds that are not linked to glycerol, consist of sphingolipids, steroids, and waxes.

Based on the degree of saturation or the presence of double-chain carbon atoms, lipids are divided into two parts, namely: 1) saturated lipids; they do not have double bonds in the carbon group.

In everyday life, we can recognise saturated fats, including animal fats and plant fats (oils) that have been heated to temperatures above 60°C.2) unsaturated lipids have a double bond on the carbon atom group. In everyday life, we can recognise unsaturated fats, including vegetable fats and marine fish fats. Of the two types of lipids, we really need unsaturated lipids.

After we get to know several kinds of lipids based on their solubility and saturation, if we look at the complexity of their bonds, we can distinguish them into two categories: 1) simple fat, which is a fatty group that is not bound to other elements; 2) Complex fat is a lipid compound consisting of fat bonds with other elements. We can divide complex fats into four main groups of plasma lipoproteins, each of which is composed of several types of lipids, namely: a) Chylomicrons. Chylomicrons function as a means of transporting triglycerides from the intestine to other tissues, except the kidneys. b) VLDL (very low-density lipoproteins). VLDL binds triglycerides in the liver and transports them to adipose tissue. c) LDL (low-density lipoproteins). LDL plays a role in transporting cholesterol to peripheral tissues as a raw material for building steroid hormones. HDL (high-density lipoproteins). HDL binds to plasma cholesterol and transports it, especially LDL cholesterol, to the liver.

Lipid function. We have studied various digestive processes and lipid (fat) metabolism, and then we will study the important role of fat in the body's metabolic processes in general. Some of the biological roles of lipids are as follows: (1) As a component of membrane structure, lipids make up part of the cell membrane structure together with phosphor (phospholipid). The membrane, which is formed from a phospholipid bilayer, is semi-permeable, so material can be passed selectively. (2) As a protective layer on several tissues and organs of the body, as we learned in anatomy and physiology, the structure of the lungs and heart is composed of lipids on the edges, making the organs more flexible when in contact with surrounding tissues as well as minimising direct impact in the event of a collision. (3) As a form of reserve energy, it is stored in the form of subcutaneous fat, which will be broken down (lipolysis) if the energy prepared from carbohydrates is exhausted or unable to compensate. (4) As a component of the cell surface that plays a role in the process of tissue immunity, as we know in the function of digestion, especially on the inner surface of the stomach, which is composed of prostaglandins, Prostaglandins are lipid compounds that function as mucosal barriers so that the stomach is protected from high acidity. (5) As a component in the transport process through the membrane, Lipin, as a constituent of the membrane, also functions as a canal selector for substances that are introduced into the cell.

Fat Metabolism. Fat metabolism is the body's process of producing energy from fat intake after entering it into food essences in the body. In metabolising fat into energy, we need the help of glucose from carbohydrates. Therefore, our body tends to demand sweets after eating foods that are rich in fat. Fat in our body will enter the metabolic process after passing through the absorption stage, so the formation of fat that enters the fat metabolism pathway is in the form of triglycerides (triglycerides are a form of body fat storage). In the form of triglycerides, fat is synthesised into fatty acids and glycerol, as described in the figure below. These fatty acids and glycerol enter into the process of energy metabolism. In the process, glycerol and fatty acids require glucose to enter the Krebs cycle, usually known as TCA. By entering this cycle, glycerol and fatty acids can be converted into energy, as described in the image of the fat metabolism pathway below.

Fatty acids resulting from fat synthesis consist only of 2-carbon fractions; therefore, body cells cannot form glucose from fatty acids, as well as glycerol, because glycerol is only 5% of fat. Thus, body cells cannot form glucose from fat. Because the body cannot form glucose from fat, certain organs, such as the nervous system, cannot get energy from fat, and because of that, the process of burning body fat requires a long process, one of which must require glucose assistance.

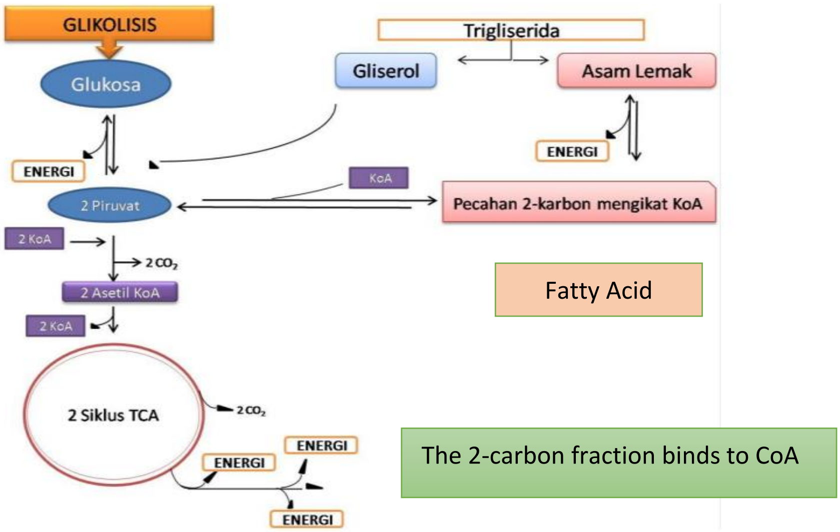

Figure 3.3. Pathways of Fat Metabolism to Energy
(Whitney & Rolfes, 1993)

Lipids are used as a source of energy in the form of glycerol and fatty acids, which are converted into pyruvate. In the form of pyruvate, fat can enter the Krebs cycle to produce energy, while the conversion of fatty acids and glycerol into pyruvate has residual products in the form of ketone bodies.

The end products of lipid breakdown in food are fatty acids and glycerol. If the energy source from carbohydrates is sufficient, then the fatty acids undergo esterification, namely forming esters with glycerol to become triglycerides as a long-term energy reserve. If at any time there is no available energy source from carbohydrates, then fatty acids are oxidised, both from the diet and if you have to break down tissue triglyceride reserves. The process of breaking down triglycerides is called lipolysis. The process of oxidation of fatty acids is called beta-oxidation and produces acetyl CoA. Furthermore, as acetyl CoA is produced from the results of carbohydrate and protein metabolism, acetyl CoA from this pathway will also enter the citric acid cycle so that energy is produced. On the other hand, if energy requirements are sufficient, acetyl CoA can undergo lipogenesis into fatty acids, which can then be stored as triglycerides. Some nonglyceride lipids are synthesised from acetyl CoA. Acetyl CoA undergoes cholesterogenesis to become cholesterol. Cholesterol then undergoes steroidogenesis to form steroids. Acetyl CoA, as a result of fatty acid oxidation, also has the potential to produce ketone bodies (acetoacetate, hydroxybutyrate, and acetone). This process is called ketogenesis. Ketone bodies can cause a disturbance of the acid-base balance, which is called metabolic acidosis. This situation can cause death.

The processes for producing energy (catabolism) from lipids are glycerol metabolism and fatty acid oxidation (beta-oxidation). Glycerol, as a result of the hydrolysis of lipids (triglycerides), can be a source of energy, or we often refer to it as an energy reserve after carbohydrates. This glycerol then enters the carbohydrate metabolism pathway, namely glycolysis. In the initial step, glycerol gains one phosphate group from ATP to form glycerol 3-phosphate. This compound then enters the respiratory chain to form dihydroxyacetone phosphate, an intermediate product in the glycolysis pathway. Fatty acid oxidation (beta-oxidation) To obtain energy, fatty acids can be oxidised in a process called beta oxidation. Before being catabolized in beta-oxidation, fatty acids must be activated first to become acyl-CoA. In the presence of ATP and coenzyme A, fatty acids are activated, catalysed by the enzyme acyl-CoA synthetase (Thiokinase). Free fatty acids are generally long-chain fatty acids. These long-chain fatty acids will be able to enter the mitochondria with the help of carnitine compounds with the formula $(CH_3)_3N^+$-CH_2-CH(OH)-CH_2-COO^-.

The steps for the entry of acyl CoA into the mitochondria are described as follows:

1. Thiokinase is an enzyme that catalyses the activation of free fatty acids (FFA) into acyl-CoA.
2. After becoming the active form, acyl-CoA is converted by the enzyme carnitine palmitoyl transferase I, which is present in

the mitochondrial external membrane, to acyl carnitine. After becoming acylcarnitine, the compound can penetrate the inner mitochondrial membrane.

3. In the internal mitochondrial membrane, there is the enzyme carnitine acylcarnitine translocase, which acts as a transporter of acylcarnitine in and carnitine out.
4. Carnitine acyl that enters the mitochondria then reacts with CoA catalysed by the enzyme carnitine palmitoyltransferase II, which is in the mitochondrial internal membrane, to become acyl CoA, and carnitine is released.
5. Acyl CoA that is already in the mitochondria then enters the beta-oxidation process.

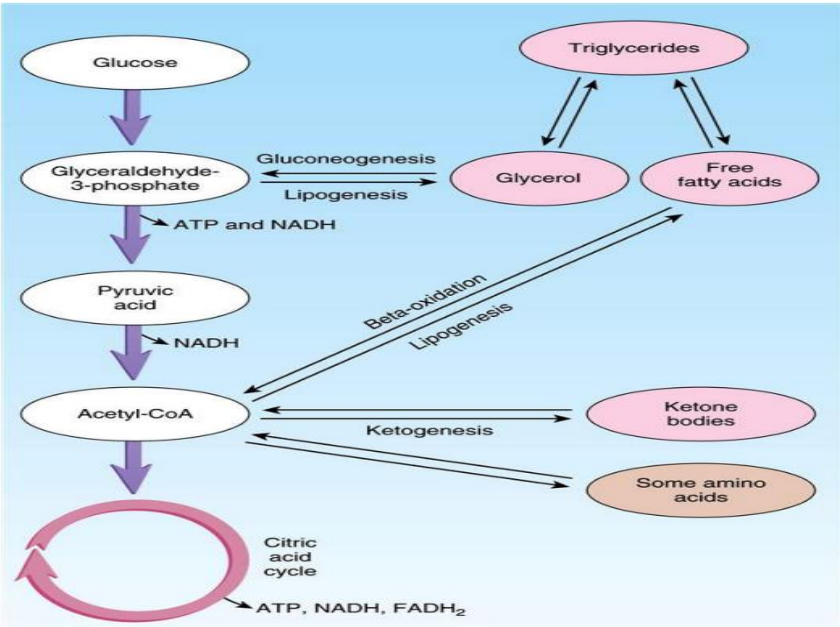

Figure 3.4. The process of forming energy from lipids (Guyton and Hall, 2006)

The process of forming energy from lipids has a side effect in the form of ketone bodies, which are harmful to the body if consumed in large amounts. In beta oxidation, fatty acids enter a series of cycles with five process stages, and in each process, two C atoms are removed, with the end result being acetyl CoA. Then acetyl CoA enters the citric acid cycle. In this oxidation process, the carbon of fatty acids is oxidised to ketones. It has been explained that fatty acids can be oxidised if they are first activated into acyl-CoA. This activation process requires 2P of energy. (-2P).

Once inside the mitochondria, acyl-CoA will undergo the following stages of change:

1. Acyl-CoA is converted to delta^2-trans-enoyl-CoA. At this stage, the respiration chain occurs by producing 2P (+2P) energy.
2. Delta^2-trans-enoyl-CoA is converted to L(+)-3-hydroxy-acyl-CoA.
3. L(+)-3-hydroxy-acyl-CoA is converted to 3-ketoacyl-CoA. At this stage, the respiration chain occurs by producing 3P (+3P) energy.
4. Next, acetyl CoA is formed, which contains 2 C atoms, and acyl-CoA, which has lost 2 C atoms.

In one beta oxidation, 2P and 3P energy are produced, so the total energy for one beta oxidation is 5P. Because, in general, fatty acids have many C atoms, the remaining acyl-CoA will undergo beta-oxidation again and lose another 2 C atoms to form acetyl-CoA. And so on until the last result is 2 acetyl-CoA. Acetyl-CoA produced by beta oxidation will then enter the citric acid cycle.

Calculation of energy products from lipid metabolism. From the description above, we can calculate the energy produced by the beta-oxidation of a fatty acid. For example, there is a fatty acid with 10 C atoms, so we need 2 ATP energy for activation, and the energy produced by beta oxidation is 10 divided by 2 minus 1, which is 4 times the beta oxidation, meaning the result is 4 x 5 = 20 ATP. Because fatty acids have 10 C atoms, 5 acetyl-CoA are formed. Each acetyl-CoA will enter the Kreb's cycle, which will produce 12 ATP each, so the total is 5 x 12 ATP = 60 ATP. Thus, a fatty acid with 10 C atoms will be metabolised with the result: -2 ATP (for activation) + 20 ATP (product of beta oxidation) + 60 ATP (product of Kreb's cycle) = 78 ATP. Part of the acetyl-CoA will turn into acetoacetate, and then acetoacetate will turn into hydroxybutyrate and acetone. Acetoacetate, hydroxybutyrate, and acetone are known as ketone bodies. The process of converting acetyl-CoA into ketone bodies is called ketogenesis.

Protein Metabolism

Definition of proteins in your daily life, have you eaten foods such as eggs, fish, and tofu? This food is an example of a protein food. Protein is a biomolecule substance that has an important role in living things besides carbohydrates and fats. You probably already know that humans are made up of the smallest parts, namely cells. Cells have a cell wall, and the material to form the cell wall requires protein. Based on that, you know that protein is needed by the body (Ezekia, 2017). Next, we will discuss the meaning of protein. The word protein comes from the Greek word protos, which means "most of all". Protein is a complex organic compound with a high molecular weight in the form of a combination of amino acid molecules connected to each other by peptide bonds to form a single strand. To better understand the following, an illustration of the simple structure of a protein can be seen in Figure 3.5.

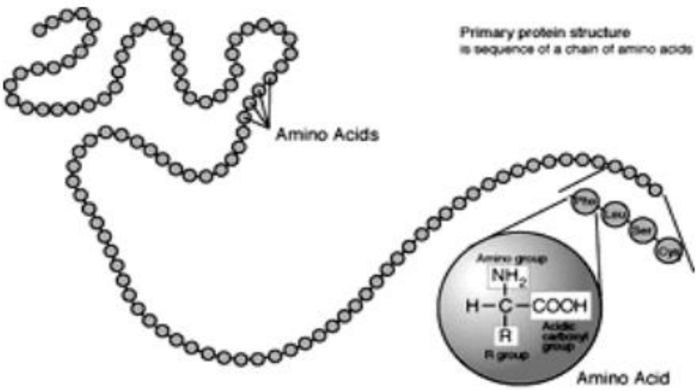

Figure 3.5. Simple Structure of Proteins (Whitney & Rolfes, 1993)

With the picture above (Fig. 3.5), it is clear to us that protein is like a bond chain of amino acid molecular compounds consisting of carbon (C) in the middle, then this C atom has bonds with hydrogen atoms (H), the molecule R (in various forms), amine compounds (NH2), and carboxylic acid compounds (COOH). To clarify the shape of the bond in the amino acid molecule, you can look at the following picture:

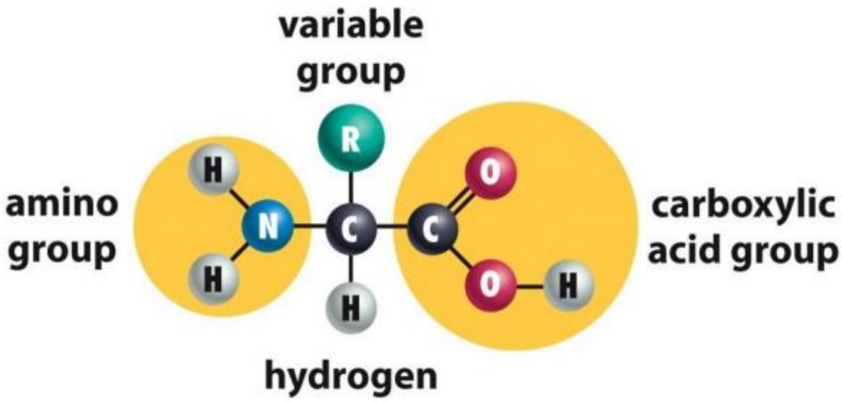

Figure 3.2. Amino Acid Structure (Whitney & Rolfes,1993)

By paying attention to the pictures of protein bonds above, we understand that protein molecules contain N (15.30-18%), C (52.40%), H (6.90-7.30%), O (21-23, 50%), can bind with other elements such as S, sometimes P, Fe and Cu and we will call it a protein complex compound. You can understand that protein has an important function in our body as a substance for communicating between parts so that the body can function regularly.

Function and Role of Proteins. In the previous review, you already understood that protein is known as a builder and regulatory substance because it very easily binds to other elements in our body, so in our body, protein plays an important role in various life processes. Next, we will study the role and function of protein in our body systematically. The following is the function of protein in our body:

1. Structural function
   Structurally, proteins function by forming internal protein structures, namely protein structures that function as organs within the cell itself (cytoplasm and organelles) and the cytoskeleton (cell framework), maintaining the shape and physical integrity of the cell. In cells, proteins are present both in the plasma membrane and in the internal membrane that make up cell organelles such as mitochondria, endoplasmic reticulum, nucleus, and Golgi bodies, with different functions depending on their location. The structure of the cell and its organelles are composed of specific amino acids and have different functions.

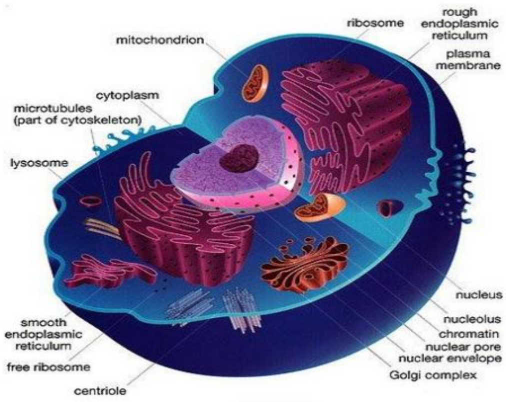

Figure 3.3. Structure of Cells and Organella (Guyton & Hall, 2006)

2. Enzymatic catalysis
   Almost all chemical reactions in biological systems are catalysed by enzymes, and almost all enzymes are proteins.
3. Transportation and storage
   Various small molecules and ions are transported by specific proteins. For example, oxygen is transported in erythrocytes by haemoglobin and in muscles by myoglobin.

4. Movement coordination
   Muscle contraction can occur due to the shift of two protein filaments, namely actin and myosin. Other examples are the movement of chromosomes during mitosis and the movement of sperm by flagella.
5. Mechanical support
   Skin and bone tension is caused by collagen, which is a fibrous protein.
6. Immune protection
   Antibodies (immunoglobulins or Ig) are highly specific proteins that can recognise and combine with foreign bodies such as viruses, bacteria, and cells from other organisms.
7. Generates and transmits nerve impulses.
   Nerve cell responses to specific stimuli are mediated by receptor proteins. For example, rhodopsin is a light-sensitive protein found in retinal rod cells. Another example is the receptor proteins at synapses.
8. Regulating growth and differentiation
   In higher organisms, growth and differentiation are regulated by growth factor proteins. For example, nerve growth factors control the growth of nerve tissue. In addition, many hormones are proteins.

Characteristics of Proteins. Furthermore, here we will try to understand the characteristics of proteins in general. Because the protein group at one end of the C chain contains amine compounds, most proteins are polar or have different potentials. With this polar nature, protein compounds have the ability to attach to other molecules, or what we often call adhesins. When protein is heated at high temperatures, it will coagulate, which is called coagulation. For example, when you are making sunny-side-up eggs, when you heat the eggs, some of the clear egg whites will turn thick white. Another property of protein is that it will also clump when it is in acidic conditions; this happens when we leave milk in open conditions for a long time. The clumping of proteins is caused by broken protein chains due to high temperatures and acidic conditions.

Protein digestion stages. The process of protein digestion begins in the stomach (gaster), where there are chief cells in the stomach wall that produce the enzyme pepsinogen. This enzyme produces pepsin (a proteolytic enzyme), which can digest food proteins. Furthermore, the pancreas organ produces several enzymes that are distributed to the pancreaticus ductus, namely: proteolytic enzymes, which have members of the peptidase, pepsinogen, enterokinase class, etc., which function to break down polypeptide proteins into short peptide chains, or amino acids.

Absorption of food occurs in the intestinal mucosa through protrusions of villi and microvilli. Within the lumen of each villus is a network of capillaries and a lymphatic vessel. Proteins that have been digested into amino acids are actively moved through the microvilli epithelial cells to enter the capillaries and continue to enter the bloodstream throughout the body, reaching all body cells, especially muscle cells, where they are used for protein synthesis. Amino acids that are not used are channelled to the liver and then converted into carbohydrates or fats (gluconeogenesis) and used for energy or stored throughout the body. Transport and storage of amino acids (Guyton & Hall, 2006).

1. The end result of protein digestion and protein absorption in the digestive tract is almost entirely in the form of amino acids. Then, the blood circulation transports amino acids into the blood and tissue fluid (intercellular) amino acid pool (amino acid storage).
2. Furthermore, amino acids enter the cell by active transport. Once inside the cell, amino acids are joined by peptide bonds under the direction of messenger RNA and the ribosome system to form cellular proteins, replace damaged tissue, and, if necessary, be converted into energy sources.
3. Therefore, the concentration of amino acids in cells usually remains low due to the storage of most of the amino acids in the form of true proteins. However, many intracellular proteins

can quickly be broken down back into amino acids under the influence of intracellular lysosomal digestive enzymes, and these amino acids are in turn transported back out of the cell and into the blood.

4. Some body tissues that store amino acids and proteins in large quantities include the liver, while the kidneys and the mucosa of the small intestine store relatively small amounts of amino acids and proteins.
5. There is a reversible balance in the body between proteins from different parts of the body. Cellular protein in the liver (and very little in other tissue cells) can be synthesised rapidly from plasma amino acids, and many amino acids are then broken down and returned to the plasma at nearly the same rate, so that there is a constant balance between amino acids in the blood plasma and protein labile in the cells of the body. For example, if any particular tissue needs protein, that tissue can synthesise new proteins from blood amino acids; conversely, to replace the reduced blood amino acids, other body cells, especially liver cells, will break down their proteins into amino acids to be transported back into the body. blood plasma.
6. The normal concentration of amino acids in the blood is between 35 and 65 mg/dl.
7. Each cell has the maximum capacity to store amino acids and proteins. After all cells store amino acids and proteins within the maximum limit, the excess amino acids in the blood circulation will be broken down into other products, used for energy, or converted into fat or glycogen and stored in this form.
8. In the blood plasma, amino acids can be in the form of plasma proteins, namely albumin, globulin, and fibrinogen. These plasma proteins are formed by the liver and then transported into the blood vessels. The speed at which the liver forms plasma proteins can be very high, i.e., 30 mg/day.

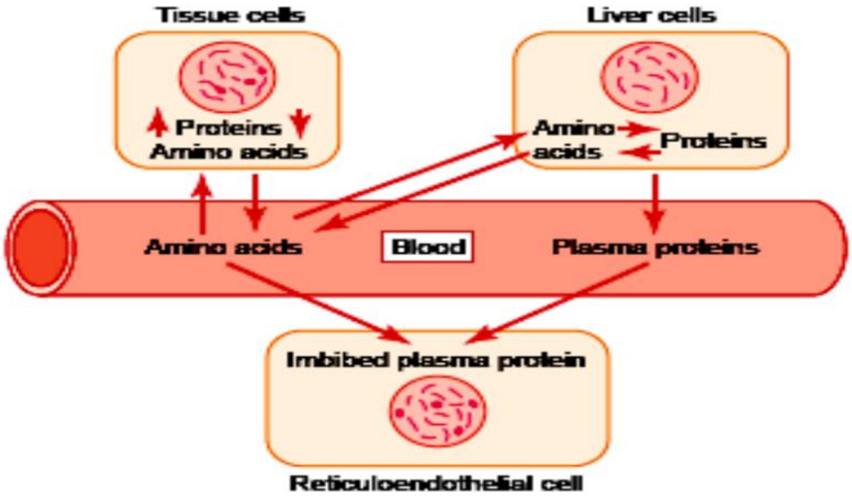

Figure 3.4. Amino Acid Transport in the Body (Guyton & Hall, 2006)

Protein Metabolism. Proteins in the body can be turned into simpler molecules through deamination and transamination processes. Transamination is the process of changing an amino acid into another type of amino acid. The transamination process is preceded by the transfer of NH_2 from an amino acid to another bond, namely a keto acid (a change of amino acid to a keto acid form), which then enters the cell cytoplasm, which will later be used for protein synthesis.

Once cells are filled to the limit of their protein stores, any additional amino acids in the body fluids will be broken down and used for energy, stored as fat, or stored in small amounts as glycogen. This breakdown is almost entirely in the liver and begins with the process of deamination. Deamination is the process of removing an amino acid or separating an amino group (NH_2) from an amino acid into several other acceptor substances. Deamination is a form of catabolism of N atoms (nitrogen).

Topic 3: Hormonal Regulation in Metabolism

Metabolic hormones are hormones produced by beta cells of the pancreatic island that have an acute anabolic effect and maintain normal blood glucose levels. There are several hormonal regulations in human body metabolism, such as:

1. Pancreas

   The pancreas is a large gland like the liver. When the pancreas embryo develops from the primitive foregut. The pancreas is an exocrine gland as well as an endocrine gland. The exocrine portion of the pancreatic gland secretes an alkaline fluid that is rich in enzymes. This fluid will be secreted through the pancreatic duct. The pancreas is rich in autonomic nerves, which also function to regulate pancreatic secretions. In addition to innervation, pancreatic secretion is also regulated hormonally. Neuroendocrine cells present in the duodenum release the hormone secretin. Secretin stimulates the secretion of bicarbonate-rich fluid from the pancreas. In addition to secretin, duodenal neuroendocrine cells also release cholecystokinin and pancreozymin (CCK). CCK will stimulate the secretion of fluid rich in enzymes from the pancreas. In addition to the duodenum, gastric pyloric neuroendocrine cells also secrete a hormone, namely gastrin. As with CCK, gastrin plays a role in stimulating the secretion of fluid rich in enzymes from the pancreas (Young et al., 2006: 299).

   The pancreas is located in the abdominal-pelvic space between the stomach and small intestine. This organ extends laterally from the duodenum towards the spleen. The pancreas is located retroperitoneally and is firmly attached to the posterior wall of the abdominal cavity (Martini, 2001: 872). Histologically, the pancreas is a lobulated gland enclosed in a thin collagen capsule. The collagen capsule extends into the organ, forming septa between the lobules. The exocrine part of the pancreas consists of groups of acini that open into ducts. Sometimes fat cells can be found in the parenchyma of pancreatic tissue. Fat cells vary in number. In the pancreas of young individuals, there are few of them, while in the elderly, they increase a lot. This shows the natural form of atrophy that occurs in the pancreas gland along with age (Young et al., 2006: 299).

2. Insulin

   The role of insulin in the body is very important, among other things, because it regulates blood sugar levels so that they remain within the normal range of values. During and after eating, the carbohydrates we consume are immediately broken down into sugar and enter the bloodstream in the form of glucose. Glucose is a ready-to-use compound to produce energy. When the situation is normal, the high glucose level after eating will be responded to by the pancreatic gland by producing the hormone insulin. In the presence of insulin, glucose will soon enter the cell. In addition, with the help of insulin, glucose levels that are higher than needed will be stored in the liver in the form of glycogen. If blood glucose levels drop, for example, during fasting or between two meals, glycogen will be broken down back into glucose to meet energy needs (Warta Medika, 2008).

   There are two kinds of disorders caused by insulin. First, abnormalities in the pancreas mean that insulin cannot be produced. This situation is called type 1 diabetes. Both pancreases can still produce insulin, but the amount is inadequate, or the amount of insulin production is still normal, but the body's cells cannot use it (resistant). This last condition is called type 2 diabetes. Diabetes types 1 and 2 both cause increased levels of glucose in the blood. Type 1 diabetics usually absolutely need insulin. Unlike the case with type 2 diabetes, Insulin is only given when anti-diabetic drugs are no longer working (Daniell, 2007).

3. Hormonal glucagon

   Glucagon is a hormone secreted by the alpha cells of the islets of Langerhans when the level of glucose in the blood falls. Where the functions conflict with insulin (Guyton & Hall, 1997:1231). So, if the concentration of glucose in the blood increases, this condition is a stimulus for the liver cells to convert glucose into glycogen so that the blood glucose level drops, conversely if the blood glucose level rises, the alpha cells of the islets of Langerhans will secrete the hormone glucagon which causes the reshuffling of the blood. glycogen in the liver becomes glucose so that glucose in the blood will increase (Santoso, 2007:226).

In addition to insulin and glucagon, which are hormones that can affect blood glucose levels, there is also epinephrine, which has the same function as glucagon, which can increase blood glucose levels. Where epinephrine is a hormone secreted by the adrenal medulla in response to low blood glucose levels or in a state of severe hypoglycaemia. The role of epinephrine in the body as a response to stress, both positive and negative. In muscle, epinephrine activates adenylate cyclase which causes an increase in glycogenesis and inhibits glycogen synthesis. In adipose tissue, epinephrine increases the breakdown of triacylglycerols to provide fuel for muscle tissue. As a result, glucose uptake into the muscles decreases and causes an increase in blood glucose levels. Epinephrine is formed when a person is experiencing stress and then stimulates nerve cells, where these nerve cells will secrete the neurotransmitter acetylcholine in the adrenal medulla so that it can stimulate the release of epinephrine so, epinephrine helps to protect against severe hypoglycaemia (Santoso, 2007: 341).

Topic 4: BMR Measurement Metabolism

BMR (measurement of basal metabolic rate) is defined as the energy required to conduct vital body functions at rest and represents the largest portion of total energy expenditure. According to numerous studies, fat-free mass or lean body mass plays a significant influence in BMR variation. Age, sex, diet, thyroid status, exercise, and stress are additional factors that affect BMR. 1 Because BMR is a significant component of humans' daily energy expenditure, it is an essential calculation for determining, comprehending, and implementing weight-related policies.

An analysis of BMR, or basal metabolic rate, is the body's calorie needs in humans when carrying out any activity. When doing any activity or not doing any activity, humans will still have body calories, or BMR. These calories affect the daily food calorie intake. The maximum and minimum limits for each food calorie that must be received by the body should not be much more or less than this BMR. Everyone's BMR is different, according to the current age, the person's sex, current weight, and current height. Therefore, each person's BMR is different. To find out the BMR that the body needs, calculate it using the Harris-Benedict formula. The BMR formula differentiates between men and women.

Metabolic BMR Measurement. BMR is the energy required to maintain normal physiological functions at rest. Basal Metabolic Rate is the minimum calorie requirement needed to survive when the body is resting without doing any activity. This number is the number of calories burned if we sleep for 24 hours. When resting, the body continues to burn energy for our survival, such as for breathing, circulation, digestion, maintaining body temperature, brain activity and others. The Harris-Benedict formula is commonly used to calculate BMR, taking into account height, weight, gender and age. The unit is BMR = $kcal/m^2/hour$ (kilo calories of energy used per square meter of body surface per hour). These normal physiological functions include: the internal chemical environment of the body, namely the ion concentration gradient between intracellular and extracellular, electrochemical activity of the nervous system, electromechanical activity of the circulatory system, temperature regulation. Factors that affect BMR:

1. Meals, protein-rich foods will increase BMR more than lipid-rich or carbohydrate-rich foods. This may occur because the deamination of amino acids occurs relatively quickly

2. Thyroid hormone status, increase oxygen consumption, protein synthesis, and degradation which is the activity of thermogenesis. An increase in BMR is classic in hyperthyroidism, and decreases in decreased thyroid levels.
3. Sympathetic nerve activity, administration of sympathetic agonists also increases BMR. The sympathetic nervous system directly through the vagus nerve to the liver activates the formation of glucose from glycogen so that sympathetic nervous activity increases BMR.

Summary

Enzymes and coenzymes are proteins that function as catalysts in biochemical reactions. Enzymes reduce energy needed for activity and are specific in their catalytic action. Coenzymes are non-protein molecules that interact with enzymes and assist in the catalysis of biochemical reactions. Enzymes are formed through several steps, including translation and transcription, folding, and post-translational processing. Coenzymes play an important role in enabling complex chemical reactions to occur efficiently.

The process of forming enzymes and coenzymes is a complex and tightly regulated step in the cell to ensure proper biochemical function. Enzymes are divided into two categories: simple enzymes, which are composed of protein only, and complex enzymes, which consist of an apoenzyme and a prosthetic group. Factors affecting enzymes and co-enzymes include temperature, peptide cleavage, enhancement of prosthetic groups, and chemical groups. Enzymes are made up of protein molecules and their work is affected by temperature, pH, acidity, and inhibitors. The optimum pH for most enzymes is pH 7, but there are exceptions such as the enzyme pepsin in the stomach reacting most efficiently at pH 2, while the enzyme trypsin in the small intestine acts most efficiently at pH 8.

Inhibitors also affect the work of the enzyme by inhibiting the feedback response. A feedback inhibitor is a condition where the product of an enzyme that accumulates in excessive amounts inhibits the work of the enzyme in question. Competition inhibitors occur when the addition of a substrate can reduce their inhibition, while non-competition inhibitors cannot be removed by the addition of other substrates. Substrate concentration determines the mechanism of enzyme action, and the ratio between the enzyme and the substrate must be appropriate. If there are too few enzymes and too many substrates, the reaction will be slow and may even be uncatalyzed substrates.

The metabolic process involves the digestion and storage of carbohydrates, lipids, minerals, vitamins, and water. It entails the oxidation of these nutrients in order to produce high-energy phosphate bonds, which are stored for use in biological processes and chemical reactions. The most essential high-energy phosphate bond is adenosine triphosphate (ATP), which serves as the body's energy reservoir, supplying the energy required for all physiological processes and chemical reactions. Due to its increased mass and caloric content, fat accounts for the majority of energy storage. Due to its high caloric density and hydrophobic nature, the primary form of chemical energy stored in the body is fat (triglycerides).

Carbohydrate metabolism is a group of organic compounds composed of carbohydrates, starches, and hydrogen and oxygen in the same proportions as water (2:1). Sugar is an essential energy source for the body and the sole energy source for the brain. The liver is the site of glycogen metabolism, where glucose regulation, storage, and production occur. Fats are hydrophobic organic molecules with a high energy potential that are essential as a structural component of cell membranes, in signalling pathways, and as a precursor to a number of cytokines. Fatty acids are carboxylic acids with lengthy hydrocarbon chains that terminate in a carboxyl group.

Cholesterol is composed of carbon and hydrogen and is synthesised in the liver through a 37-step process. According to their density, lipoproteins are categorised, with low-density lipoprotein (LDL) constituting the preponderance of the cholesterol in plasma. Statins are drugs that inhibit hydroxymethylglutaryl coenzyme A (HMG-CoA) reductase, which effectively lower plasma LDL cholesterol and provide cardiovascular benefits.

Metabolic hormones are hormones produced by beta cells of the pancreatic island that have an acute anabolic effect and maintain normal blood glucose levels. There are several hormonal regulations in human body metabolism, such as the pancreas, which is an exocrine gland and endocrine gland. It secretes an alkaline fluid that is rich in enzymes and is regulated by neuroendocrine cells present in the duodenum and gastric pyloric neuroendocrine cells. The pancreas is located in the abdominal-pelvic space between the stomach and small intestine and is located retroperitoneally and is firmly attached to the posterior wall of the abdominal cavity. Insulin regulates blood sugar levels so that they remain within the normal range of values.

Glucose is a ready-to-use compound to produce energy. When the situation is normal, the pancreatic gland produces the hormone insulin to enter the cells and store glucose levels in the liver in the form of glycogen. There are two kinds of disorders caused by insulin: type 1 diabetes and type 2 diabetes. Glucagon is a hormone secreted by the alpha cells of the islets of Langerhans when the level of glucose in the blood falls. Epinephrine is a hormone secreted by the adrenal medulla in response to low blood glucose levels or in a state of severe hypoglycaemia.

Epinephrine activates adenylate cyclase which causes an increase in glycogenesis and inhibits glycogen synthesis. Epinephrine increases the breakdown of triacylglycerols to provide fuel for muscle tissue, resulting in an increase in blood glucose levels. BMR (measurement of basal metabolic rate) is the energy required to conduct vital body functions at rest and represents the largest portion of total energy expenditure. Fat-free mass or lean body mass plays a significant influence in BMR variation, as well as age, sex, diet, thyroid status, exercise, and stress. It is an essential calculation for determining, comprehending, and implementing weight-related policies.

BMR is different for everyone, according to their age, sex, weight, and height. The Harris-Benedict formula is used to calculate the Basal Metabolic Rate (BMR) which is the energy required to maintain normal physiological functions at rest. It takes into account height, weight, gender and age, and the unit is BMR = kcal/m^2/hour (kilo calories of energy used per square meter of body surface per hour). Factors that affect BMR include meals, protein-rich foods, thyroid hormone status, and sympathetic nerve activity. Meals increase BMR more than lipid-rich or carbohydrate-rich foods, while thyroid hormone status increases oxygen consumption, protein synthesis, and degradation. Sympathetic nerve activity also increases BMR.

Review Questions

1. Explain what does it mean by enzymes and coenzymes, make a table of the differences between these enzymes and coenzymes!
2. Explain the structure of the arrangement of enzymes using a structural diagram approach!
3. Explain the types of enzymes based on their reactions!
4. Describe the factors that affect the work of enzymes!
5. Enzymes have the function of accelerating chemical reactions, in our body enzymes are needed if there are no enzymes, then chemical reactions in the body will be hampered and result in the accumulation of negative side effects in the body. Body, as a catalyst/accelerates enzyme reaction has the following characteristics:
   A. Serves as a catalyst at high temperatures
   B. There is a change in the structure of the enzyme when it reacts with the substrate
   C. Enzymes are stable in changing substrate reactions
   D. More active at high pH
   E. More passive at low pressure
   Answer: C

6. Enzymes have relative characteristics which mean:
   A. One enzyme only works for one substrate
   B. One enzyme can be active with several substrates with the same type of bond
   C. One enzyme can be active with several substrates with the same pH
   D. One enzyme can be active with several substrates at the same temperature
   E. One enzyme can be active with one substrate with the same type of bond

   Answer: B

7. Enzim pepsin in the stomach functions to break down protein into amino acid peptones needed by our body. The specificity of the characteristics of gastric pepsin enzymes is greatly influenced by their environment.
   A. Works better at high temperatures
   B. Works better at lower temperatures
   C. Works better at high pH
   D. Works better at lower pH
   E. Works better at lower pressure

   Answer: A

8. The trypsin enzyme in the duodenum functions to break down protein into amino acids needed by our body, the specific characteristics of the duodenal trypsin enzyme are greatly influenced by their environment, the following are the most correct of the characteristics of the trypsin enzyme:
   A. Works better at high temperatures
   B. Works better at lower temperatures
   C. Works better at high pH
   D. Works better at lower pH
   E. Works better at lower pressure

   Answer: D

9. The lipase enzyme functions in the process of:
A. Carbohydrate metabolism
B. Starch metabolism
C. Fat emulsifier
D. Change the peptone
E. Formation of amino acids
Answer: C

10. Enzymes that play a role in changing starch into simple sugars in the oral cavity in the digestion of carbohydrates are:
A. Lipase
B. Trypsin
C. Amylase
D. Proteases
E. Dehydrogenase
Answer: C

11. Cholesterol is often thought of as something that is harmful to our bodies, even though our bodies really need cholesterol, the following is the main function of cholesterol:
A. Accelerating the process of blood clotting
B. Regulator of blood plasma osmolality
C. Source of energy reserves
D. The raw material for the hormone cortisol
E. Body tissue isolator
Answer: D

12. One of the functions of lipids is as an energy reserve after the breakdown of carbohydrates cannot compensate for the body's energy needs, fat becomes an energy reserve in the form of:
A. Chylomicrons
B. Glycerol and free fatty acids
C. Triacylglycerol and chylomicrons
D. Triacylglycerol

E. HDL and VLDL
Answer: D

13. The process of breaking down lipids into calories occurs in the cell (cytoplasm), however, lipids that are catabolized will produce harmful by-products if there are too many of them, these by-products are:
A. Pyruvate
B. Lactic acid
C. Acetic acid
D. Acetyl Co A
E. Ketone bodies
Answer: E

14. Transamination is the change from one amino acid group to another amino acid. During the transamination process, the amino acids will be transferred into:
A. Palmitate
B. Glutamate
C. α-keto acids
D. α-ketoglutarate
E. β-ketoglutarate
Answer: D

15. The by-product of protein metabolism is ammonia, the process of forming ammonia occurs in:
A. Lien
B. Liver
C. Duodenum
D. Bone marrow
E. Intestinal epithelium
Answer: B

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CHAPTER 4
FUNDAMENTALS OF ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY

Learning Objectives:

1. Understanding the fundamentals of the anatomy of the human body
2. Understanding the fundamentals of the physiology of the human body

Introduction

The foundational sciences for subsequent learning outcomes in the field of nursing are anatomy and physiology. Our knowledge of the anatomy and physiology of women who are customers within the intended scope of nursing services begins with an awareness of the nature of the fundamental principles of anatomy and physiology. Here, the conversation is centred on the fundamental ideas of anatomy and physiology, which serves as a crucial foundation for talking about anatomy and physiology as a whole (Anderson, 2015).

The study of anatomy and physiology in nursing will focus on the growth and development of women during the reproductive cycle, from the newborn phase to the adult phase when they reach reproductive age and the senescence period. The fundamentals of anatomy and physiology are essentially the study of two things: the fundamentals of anatomy and the fundamentals of physiology.

The science of anatomy focuses on the structure and makeup of the body as a whole and its constituent components, as well as the interactions between the body's organs. The science of physiology is the study of how each bodily tissue or component of the body's organs functions (Jones & Barrett, 2017).

Topic 1: Anatomy of Human Body

The word anatomy comes from the Greek which literally means "to open a piece". Anatomy is a science that studies the inside (internal) and outside (external) of the structure of the human body and its physical relationship with other body parts.

Anatomy is also literally translated into Latin, from the word order *ana* is part or separates, and *tomi* is a slice or piece. So, that anatomy can also be interpreted as a science that studies the shape and composition of the body both as a whole and its parts and the relationship of the organs of the body to one another. From a medical point of view, anatomy consists of various knowledge about the shape, location, size, and relationships of various structures of the healthy human body so that it is often referred to as descriptive or topographical anatomy (Jones & Barrett, 2017).

From a medical point of view, anatomy consists of various knowledge about the shape, location, size, and relationships of various structures of the healthy human body so that it is often referred to as descriptive or topographical anatomy. In this anatomy, there are two levels in the structure of the human body. The two levels of the structure are the microscopic level and the macroscopic level. The microscopic level in anatomy is known as histology, while the macroscopic level in anatomy is also commonly referred to as gross anatomy (Jane, 2017).

1. Histology (microscopic)
   Microscopic level anatomy or histology studies all structures of the human body microscopically with the aid of a microscope. This is closely related to the tissues that make up the organs of the body. So, histology is the study of body tissues.
2. Gross anatomy (macroscopic)
   The structure of the human body that is studied at this macro level is enough to use the naked eye. In studying anatomy at

this level there are two approaches, namely the regional approach and the systemic approach. Anatomical terms describe body regions, anatomical positions and directions, and body sections.

Anatomical Structure

According to Anderson (2015), there are several anatomical structures, including the following:

1. Frame System

   The human body is supported by the skeletal system, which consists of 206 bones connected by tendons, ligaments and cartilage. This bone is composed of the axial skeleton and the appendicular skeleton. Functions of the skeletal system: to move, support and give shape to the body, protect internal organs, and for the attachment of muscles.
2. Muscular System

   The muscular system consists of approximately 650 muscles that help with movement, blood flow, and other bodily functions. There are three types of muscles namely skeletal muscles which are connected to bones, smooth muscles which are found within the digestive organs, and cardiac muscles which are found in the heart and help pump blood to circulate blood.
3. Bloodstream System

   The circulatory system includes the heart, blood vessels, and the approximately 5 litres of blood that is carried from the vessels. The circulatory system is supported by the heart, which is only about the size of a closed fist. When at rest, almost all hearts easily pump more than 5 litres of blood around the body every minute.
4. The circulatory system has three main functions, the following are:
   a. Distributes blood throughout the body.
   b. Protect the body through white blood cells and fight pathogens (germs) that have entered the body.

c. Strengthen homeostasis (balance of body condition) in some internal conditions.

5. Digestive System

   The digestive system is a group of organs that work to receive food, convert and process food into energy, absorb nutrients contained in food into the bloodstream, and dispose of leftover food that is left or cannot be digested by the body anymore. Food passes through the digestive tract which consists of the oral cavity, pharynx (throat), larynx (oesophagus), stomach, small intestine, large intestine, and ends at the anus.

6. Endocrine System

   The endocrine system consists of several kinds of secreting glands hormone into the blood. These glands include the hypothalamus, pituitary gland, thyroid gland, pineal gland, adrenal glands, parathyroid glands, pancreas, and gonads. The glands control directly by stimulation from the nervous system and by chemical receptors in the blood as well as hormones produced by other glands.

7. Nervous System

   The nervous system consists of the brain, spinal cord, sensory organs, and all the nerves that connect these organs to the rest of the body. These organs are responsible for the control of the body and the communication between its parts.

8. Respiratory System

   To stay alive, humans need oxygen flow. The respiratory system provides oxygen to the body's cells while expelling carbon dioxide and waste products that can be deadly if allowed to accumulate.

9. Immune System

   The immune system is the body's defence against bacteria, viruses, and other pathogens that can be harmful, by protecting and attacking these pathogens. These include any of the lymph nodes, bone marrow, spleen, lymphocytes (including B cells and T cells), thymus, and leukocytes, which are white blood cells.

10. Lymphatic System
    In human anatomy, the lymphatic system includes lymph nodes, lymph ducts, and lymph vessels, and plays a role in the body's defence. Its main job is to make and move lymph, a clear fluid that contains white blood cells, which help the body fight infection. The lymphatic system can also remove excess lymph fluid from body tissues and return it to the blood.
11. Excretory and Urinary System
    The excretory system removes residual substances that are no longer needed by living things. In the anatomy of the human body, the excretory organs consist of the kidneys, liver, skin, and lungs. The urinary system includes the excretory system consisting of the kidneys, bladder, ureters and urethra. Kidneys filter blood to remove waste and produce urine. The ureters, bladder and urethra join and form the urinary tract, which functions as a system for draining urine from the kidneys, storing it and excreting it when we urinate.

Structural Field of the Body

Anatomy of the human body is the study of certain parts of the human body separately. In anatomy, there are structural divisions, directions and positions that have been determined by experts so that it will make it easier to understand the anatomy and physiology of the human body (Jane, 2017).

1. Field (section)
   The human body is an imaginary plane that can penetrate the body to show reference points to make it easier to determine direction and location.
2. Sagittal plane
   The sagittal plane is the plane that divides the human body into left and right halves. In the division of the sagittal plane, there are two kinds of planes, namely the midsagittal plane

divides the body into two equal parts right and left. Meanwhile, the parasagittal plane divides the body into unequal right and left halves.

3. Frontal (coronal) plane
   The frontal plane is one of the planes to the right of the sagittal plane. This plane divides the body parts or organs into the front and back.
4. Transverse plane
   The transverse plane (horizontal, cross-sectional) is the plane that divides the body or organ into upper and lower parts.

Anatomical Positions

Anatomy makes easier for us to study in order to achieve uniformity of description, an anatomical position has been selected and determined, namely the body is in an upright position, facing forward, the head is perpendicular, with the arms at the side and both hands are by the side with the thumbs on the side or outside. To make it easier to describe the anatomy, the following imaginary lines and planes are also defined:

1. The midline or sagittal line is an imaginary line that crosses vertically through the midline of the body from the top of the head down, between the legs which divides the sides into two right and left
2. Horizontal division divides the body into superior and inferior sections
3. The sagittal division divides the body into right and left halves, parallel to the midline
4. Coronal division divides the body into anterior and posterior parts

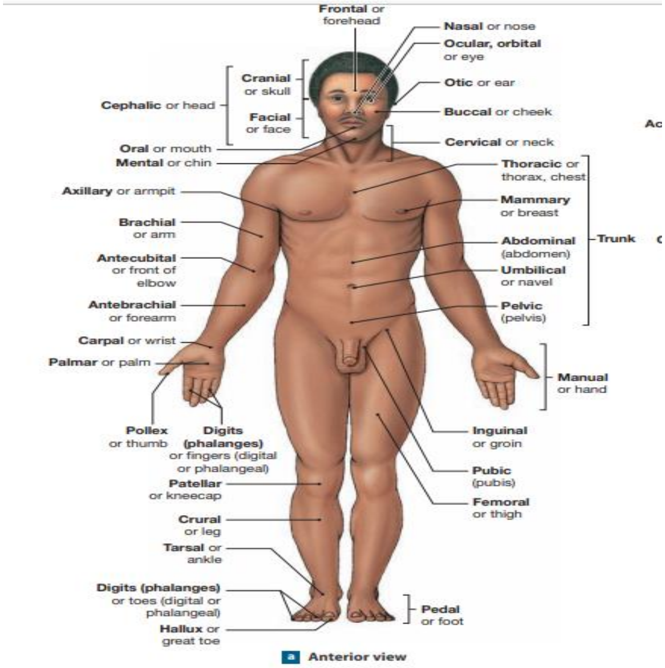


Figure 4.1 Anterior View (Anderson, 2015)

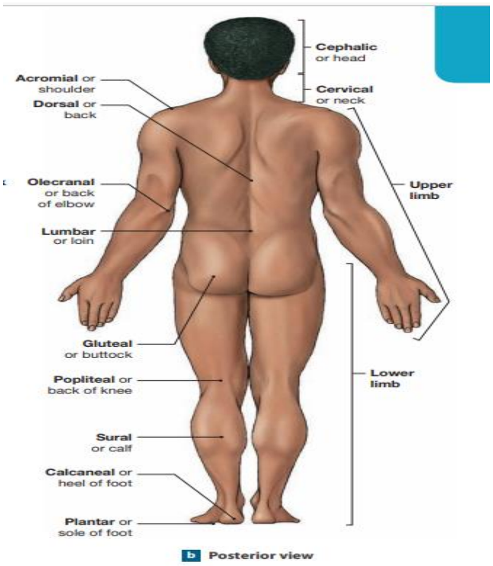
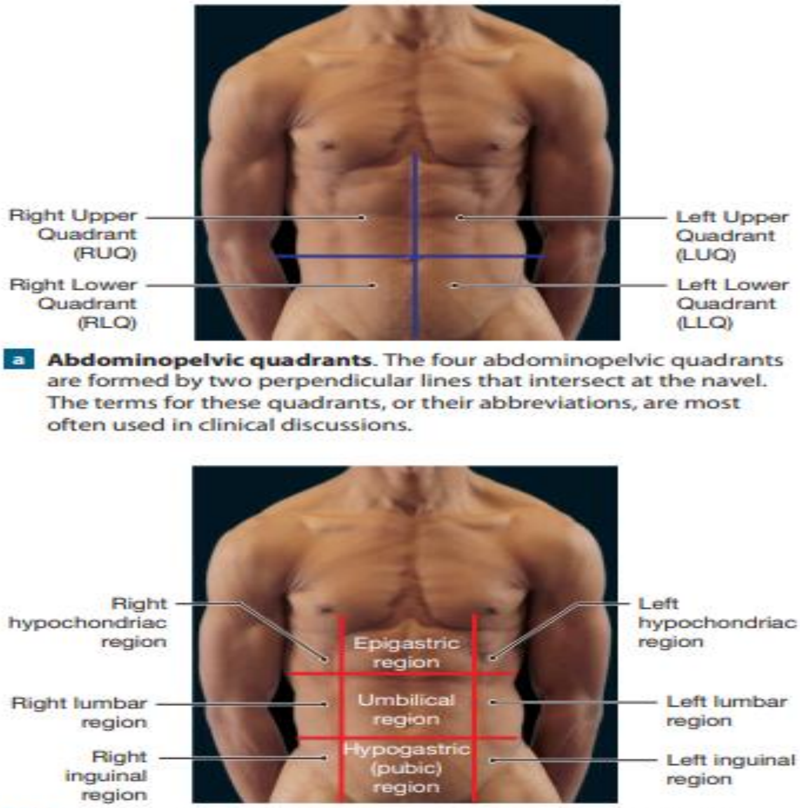


Figure 4.2 Posterior View (Anderson, 2015)



a **Abdominopelvic quadrants.** The four abdominopelvic quadrants are formed by two perpendicular lines that intersect at the navel. The terms for these quadrants, or their abbreviations, are most often used in clinical discussions.

b **Abdominopelvic regions.** The nine abdominopelvic regions provide more precise regional descriptions.

Figure 4.3 Abdominopelvic Regions (Anderson, 2015)

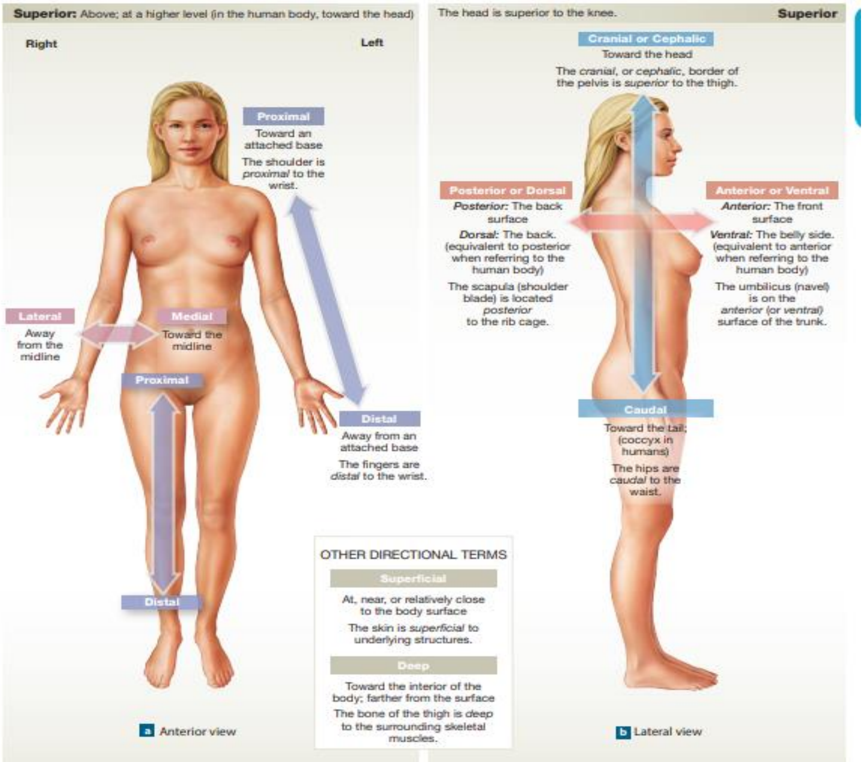


Figure 4.4 Anterior and Lateral View (Anderson, 2015)

Body Cavities

Body cavities of the trunk protect internal organs and allow them to change shape. The body's trunk is subdivided into three major regions established by the body wall: the thoracic, abdominal, and pelvic regions. Most of our vital organs are located within these regions of the trunk. The true body cavities are closed, fluid-filled, and lined by a thin tissue layer called a serous membrane, or serosa. The vital organs of the trunk are suspended within these body cavities.

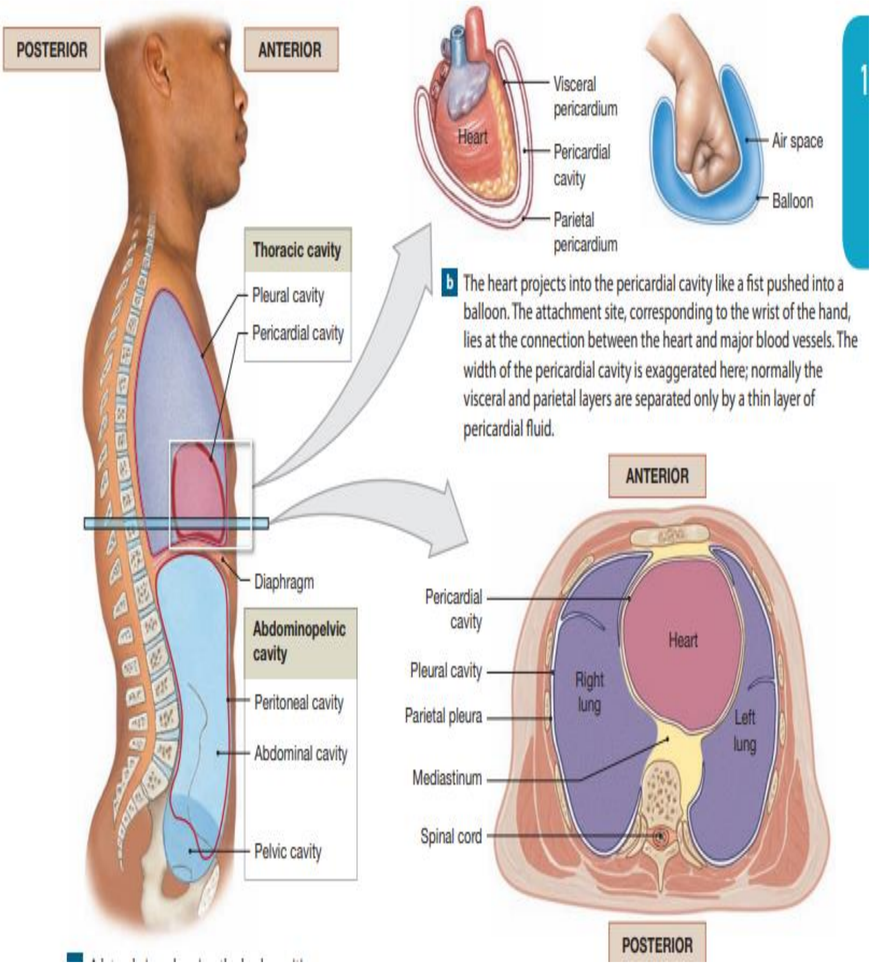


Figure 4.5 Sectional Planes (Guyton & Hall, 2012)

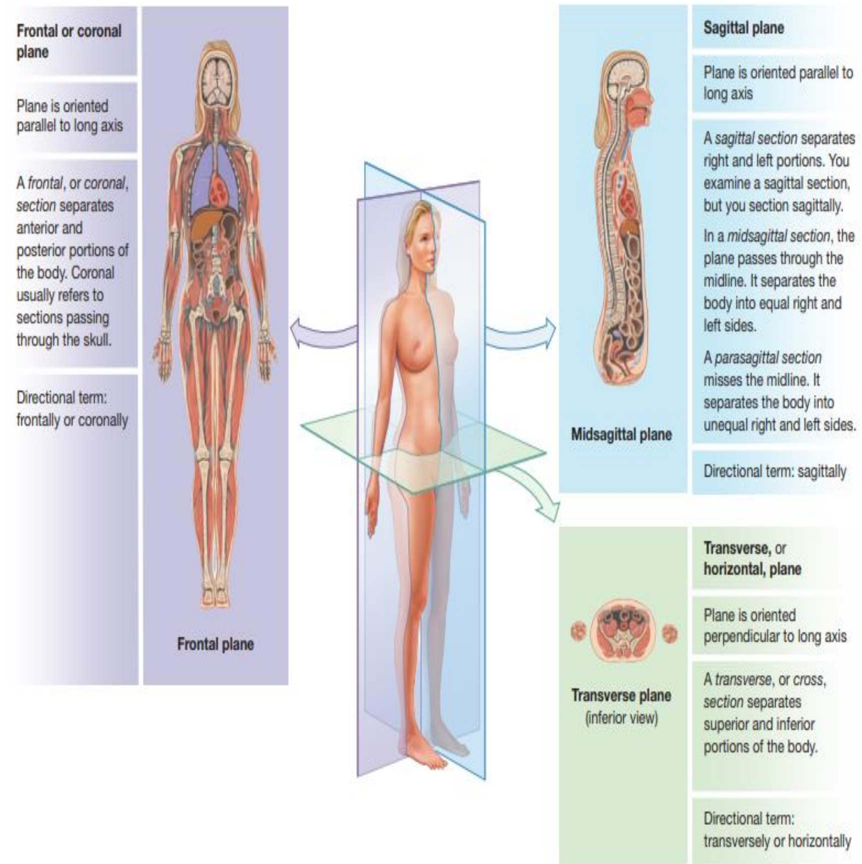


Figure 4.6 Body Cavities (Guyton & Hall, 2012)

Topic 2: Physiology of Human Body

The word physiology also comes from the Greek language (Greek) which is the study of how an organism performs its main function. Physiology in the meaning of the word comes from Latin, derived from the word *Physis* (Physis) is nature or how it works. *Logos* (Logi) is science. So, physiology is the science that studies the physiology or work or function of each body tissue or part of the body's organs and their functions. Physiological anatomy are two things that are closely related to one another both theoretically and practically, so that a concept emerges that is "all specific functions are formed from specific structures" (Jones & Barrett, 2017).

Physiology is the study of the function of anatomical structures. Human physiology is the study of the functions, or workings, of the human body. These functions are complex processes and much more difficult to examine than most anatomical structures. As a result, there are even more specialties in physiology than in anatomy. Examples include:

a. Cell physiology, the study of the functions of cells, is the cornerstone of human physiology. Cell physiology looks at events involving the atoms and molecules important to life. It includes both chemical processes within cells and chemical interactions among cells.
b. Organ physiology is the study of the function of specific organs. An example is cardiac physiology, the study of heart function—how the heart works.
c. Systemic physiology includes all aspects of the functioning of specific organ systems. Cardiovascular physiology, respiratory physiology, and reproductive physiology are examples.
d. Pathological physiology is the study of the effects of diseases on organ functions or system functions. Modern medicine depends on an understanding of both normal physiology and pathological physiology.

The human body has a unique way of maintaining its stable state. Various changes that occur in the internal and external environment of the body can affect homeostatic conditions. Disruption of homeostatic conditions can affect all organ systems.

Homeostasis is the state of internal balance. Homeostasis refers to the existence of a stable internal environment. Maintaining homeostasis is absolutely vital to an organism's survival. Failure to maintain homeostasis soon leads to illness or even death. The principle of homeostasis is the central theme of this text and the foundation of all modern physiology. Homeostatic regulation is the adjustment of physiological systems to preserve homeostasis.

Homeostatic regulation involves two general mechanisms: autoregulation and extrinsic regulation.

a. Autoregulation is a process that occurs when a cell, a tissue, an organ, or an organ system adjusts in some environmental change. For example, when oxygen levels decline in a tissue, the cells release chemicals that widen, or dilate, blood vessels. This dilation increases the rate of blood flow and provides more oxygen to the region.
b. Extrinsic regulation is a process that results from the activities of the nervous system or endocrine system. These organ systems detect an environmental change and send an electrical signal (nervous system) or chemical messenger (endocrine system) to control or adjust the activities of another or many other systems simultaneously. For example, when you exercise, your nervous system issues commands that increase your heart rate so that blood will circulate faster. Your nervous system also reduces blood flow to lessen active organs, such as the digestive tract. The oxygen in circulating blood is then available to the active muscles, which need it most. A homeostatic regulatory mechanism consists of three parts: (1) a receptor, a sensor that is sensitive to a particular stimulus or environmental change; (2) a control centre, which receives and processes the information supplied by the receptor and sends out commands; and (3) an effector, a cell or organ that responds to the commands of the control centre and whose activity either opposes or enhances the stimulus. You are probably already familiar with similar regulatory mechanisms, such as the one involving the thermostat in your house or apartment.

Most homeostatic regulatory mechanisms involve negative feedback, a way of counteracting a change. Negative feedback opposes variations from normal, whereas positive feedback exaggerates them. An important example is the control of body temperature, a process called thermo regulation. In thermoregulation, the relationship between heat loss, which takes place mainly at the body surface, and heat production, which takes place in all active tissues, is altered. Negative feedback is the primary mechanism of homeostatic regulation, and it provides long-term control over the body's internal conditions and systems. Homeostatic mechanisms using negative feedback normally ignore minor variations. They maintain a normal range rather than a fixed value. In our example, body temperature fluctuated around the set point temperature. The regulatory process itself is dynamic. That is, it is constantly changing because the set point may vary with changing environments or differing activity levels. For example, when you are asleep, your thermoregulatory set point is lower. When you work outside on a hot day (or when you have a fever), it is set higher. Body temperature can vary from moment to moment or from day to day for any individual, due to either (1) small fluctuations around the set point or (2) changes in the set point. Comparable variations take place in all other aspects of physiology.

The Role of Positive Feedback in Homeostasis. In positive feedback, an initial stimulus produces a response that exaggerates or enhances the original change in conditions, rather than opposing it. You seldom encounter positive feedback in your daily life, simply because it tends to produce extreme responses. For example, suppose that the thermostat was accidentally connected to a heater rather than to an air conditioner. Now, when room temperature rises above the set point, the thermostat turns on the heater, causing a further rise in room temperature. Room temperature will continue to increase until someone switches off the thermostat, turns off the heater, or intervenes in some other way. This kind of escalating cycle is often called a positive feedback loop.

Homeostatic regulation controls aspects of the internal environment that affect every cell in the body. No single organ system has total control over any of these aspects. Instead, such control requires the coordinated efforts of multiple organ systems.

A state of equilibrium exists when opposing processes or forces are in balance. In the case of body temperature, a state of equilibrium exists when the rate of heat loss equals the rate of heat production. Each physiological system functions to maintain a state of equilibrium that keeps vital conditions within a normal range of values. This is often called a state of dynamic equilibrium because physiological systems are continually adapting and adjusting to changing conditions. For example, when muscles become more active, more heat is produced. More heat must then be lost at the skin surface to re-establish a state of equilibrium before body temperature rises outside normal ranges. Yet the adjustments made to control body temperature have other consequences. The sweating that increases heat loss at the skin surface increases losses of both water and salts. Other systems must then compensate for these losses and re-establish an equilibrium state for water and salts.

Summary

The study of anatomy examines the inside and exterior of the human body's structure as well as how individual body parts relate to one another physically. It is made up of numerous bits of information on the arrangement, dimensions, and connections of various structures in a healthy human body. The macro (gross anatomy) and microscopic (histology) layers of the human body's structure are separated by a third layer. While macroanatomy analyses the body's structure thoroughly enough to be seen with the naked eye, histology investigates every bodily structure in detail under a microscope. Body areas, anatomical locations and orientations, and body portions are all described by anatomical words.

The anatomical structures of the human body are the most crucial information in this work. These include the immunological system, skeletal system, muscular system, blood circulation system, digestive system, endocrine system, and neurological system. The muscular system is made up of 650 muscles that aid in movement, blood flow, and other biological activities, while the skeletal system is made up of 206 bones joined by tendons, ligaments, and cartilage. The heart, blood arteries, and the roughly 5 litres of blood that are transported from the vessels make up the circulatory system. The mouth cavity, pharynx (throat), larynx (oesophagus), stomach, small intestine, large intestine, and anus make up the digestive system.

The neurological system is made up of the brain, spinal cord, sensory organs, and all of the nerves that link these organs to the rest of the body. The endocrine system is made up of many types of glands that discharge hormones into the blood. The respiratory system releases carbon dioxide and waste products while supplying oxygen to the body's cells.

Review Questions

1. Would you explain the meaning of the basic principles of anatomy and physiology?
2. Would you mention 5 anatomical terms based on anatomical position by paying attention to the direction lines and imaginary planes?
3. Would you describe the levels of organisation in the human body?

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CHAPER 5
CELLS, TISSUES AND HUMAN BODY SYSTEMS

Learning Objectives:

1. Describe the structure and function of cells
2. Understanding the structure and function of tissues
3. Understanding the human body's systems

Introduction:

The cell is the structural unit of living things, and all living things are composed of cells. This material will serve as a basic foundation for understanding the next chapter and will give you a sense of curiosity to learn about it.

The cell, as the smallest unit that makes up organisms or living things, contains a living substance called protoplasm. Protoplasm is a combination of two words derived from Greek, namely protos, meaning first, and plasma, meaning form. The structure of living cells is divided into two types, including prokaryotic cells and eukaryotic cells. Prokaryotic (prokaryote) comes from the Greek, namely pro meaning 'before' and karyon meaning 'kernel' or 'nucleus'. Based on the origin of the word, prokaryotic cells are defined as living cells that do not have a nucleus. The characteristics of prokaryotic cells are that their genetic material is in the nucleoid, without a membrane, and lacks several special organelles, such as mitochondria, chloroplasts, endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes. In addition, perichoretic cells have genetic material such as DNA and RNA, plasmid DNA, and several cell organelles such as ribosomes, cell walls, mesosomes, and chromatophores that function similarly to chloroplasts and mitochondria. Living things with perichoretic cell types, such as bacteria and blue-green algae. In contrast, a eukaryotic cell is a living cell with a nucleus enclosed in a membrane. Inside this membrane is a fluid called the cytoplasm.

The material in this chapter will provide you with a clear description of the structure of a cell, which consists of the cell's devices for maintaining life, known as cell organelles, and the role of each cell organelle. You will also have a clear picture of the shape and structure of the cell membrane as a protective cell, which is composed of layers of lipids and proteins, as well as the role of the cell membrane and a detailed picture of the cell nucleus in carrying out its functions.

Tissues are made up of cells and an extracellular matrix composed of many types of molecules capable of forming complex structures, such as collagen fibres and basement membranes. Cells and extracellular matrix function and react together to stimulation and inhibition, so they are interrelated (Junqueira & Carneiro, 2003).

Topic 1: Cells

The word cell comes from the Latin word *cella*, which means small room. It was discovered by Robert Hooke on cork slices with images of small rooms. The cell is a small room bounded by a membrane, and in it is fluid, or protoplasm. While the protoplasm consists of the cell plasma, or cytoplasm, and the cell nucleus, in the cell nucleus there is the nuclear plasma, or nucleoplasm. The cell is the smallest structural and functional unit that makes up the tissues of a living thing (Fawcett, 2002; Subowo, 2009). The human body is composed of three different elements that have their own functions:

1. Cells that are covered with a membrane as a protective structure inside
2. Intracellular or extracellular substances located between cells serve as a support and supply of nutrients.

3. Body fluid, consisting of blood in blood vessels and tissue or intercellular fluid found between and around cells, functions as an intermediary for free substances between blood and intercellular fluid. Lymph functions to return fluids to the venous system via the capillaries.

Cells that have the same function will join together with the extracellular matrix to form a network, including bones, muscles, and so on. A collection of several tissues will form a functional unit, namely organs such as the skin, kidneys, lungs, and so on. A collection of various organs to perform more complex body functions is called an organ system, including the respiratory system consisting of the nose, larynx, trachea, and lungs; for example, the urinary system, which consists of the kidneys, ureters, bladder, and urethra (Lesson et al., 1996).

The most important feature of tissue preparations is the presence of cells, each surrounded by a membrane, although the overall boundaries are not very clear. The cell is composed of protoplasm, which is a heterogeneous living substance with a liquid-to-solid consistency. In primitive cells such as bacteria, the metabolic and hereditary components mix. Such cells are called prokaryotic cells, while in plants and animals they are called eukaryotic cells. Eukaryotic cells are separate hereditary materials in a nucleus covered by a cell membrane (Lesson et al., 1996).

There are a variety of cell shapes and sizes that reflect the different functions of the different cell types. Even so, most of the cells have similarities in the general description of their structure (Lesson et al., 1996).

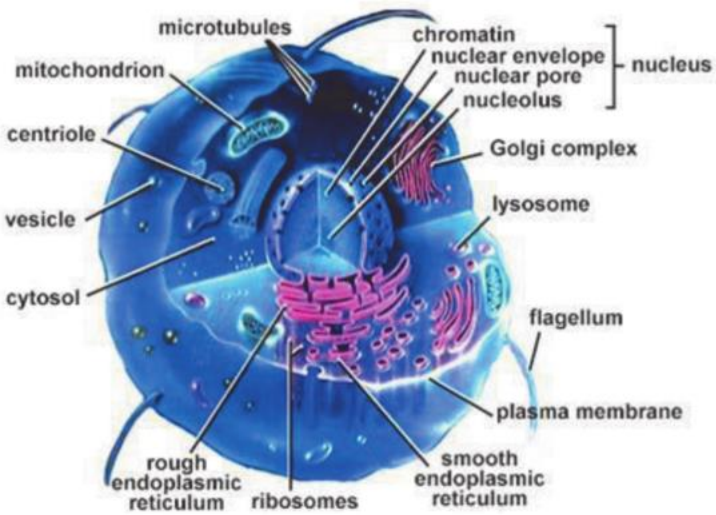

Figure 5.1 Cell Structure (Junqueira & Carneiro, 2003).

Cell Parts

Cells in the human body have several parts, which will be explained next (Lesson et al., 1996).

1. Protoplasm

   Protoplasm is a part of a living cell. The protoplasm functions as a regulator of activities that exist in the cell. Protoplasm consists of proteins, nucleic acids, carbohydrates, lipids, and inorganic substances. Protein is the main structural unit of cells and intercellular material in its pure protein form. Nucleic acids in cells play a role in protein synthesis and carry messages from the cell nucleus to the cytoplasm. There are two types of nucleic acids in cells: DNA, which is the genetic material and can be found in the nucleus, and RNA, which is found in the nucleus and cytoplasm.

   The simplest form of carbohydrate molecule, namely glucose, is stored in cells in the form of glycogen as a backup energy source. Lipids are the main source of energy for cells and are important components of cell membranes. Inorganic materials exist in the form of free radicals and are also combined with proteins and lipids. These materials play an important role in maintaining the osmotic pressure difference between cells and their environment, muscle contraction or relaxation, tissue rigidity, and enzyme activation. Protoplasm has several properties, including (Lesson et al., 1996):

a. Irritability, namely the ability of the protoplasm to respond to a stimulus.
b. Conductivity, indicating protoplasm can continue the wave of excitation (an electrical impulse from the point of stimulus to the rest of the cell).
c. Contractility is a property that can change the shape of the protoplasm, usually in the form of shortening. This property is highly developed in muscle cells.
d. Respiration is the process of interaction between oxygen and food to produce energy, carbon dioxide, and water, which are essential for life.
e. Absorption includes the imbibition (absorption) of substances, which can then be assimilated by cells in metabolism or used directly.
f. Secretion, namely the process of removing substances by cells, Substances released are useful results, such as digestive enzymes or hormones. If the material released is in the form of waste, it is called excretion.
g. Growth, namely the increase in cell size caused by an increase in the amount of protoplasm.

2. Cytoplasm

The main metabolic activities and various functions of the cell are carried out in the extra nucleus, that is, in the cytoplasm, which contains various types of cell organelles that carry out different functions that are important for cell metabolism. Most organelles are membranous elements with a characteristic internal structure and shape. These organelles are immersed in a semiliquid cytoplasmic matrix called the cytosol. Coarse plaits, consisting of bundles of fine filaments that traverse the cytoplasm and attach to the cell membrane, provide internal strength and help maintain the normal shape of the cell. All contain slender, straight microtubules, constituting a cytoskeleton (Lesson et al., 1996).

3. Plasma Membrane

The cell membrane is a layer that serves to separate cells and organelles in cells. All cells are covered by a cell membrane that is only 7.5 nm thick, so it is often not visible with a light microscope. The cell membrane functions for cell-to-cell communication. The cell membrane is permeable, so ion and gas diffusion occurs in a solution but prevents excess molecules from entering passively (Sursana & Atika, 2002).

The cell membrane plays a role in cell life by maintaining selective permeability to small and large molecules, controlling the flow of hormone and metabolite information, and supporting the process of changing ion energy and voltage gradients. The cell membrane functions as a protective cell, as cell excitability, as a cellular transport system, as dividing cell organelles, as a conductor of signal transduction, as a medium for supporting biochemical reactions, as a receptor, and as an introduction when other cells are present (for example, in the case of grafting). The components of the cell membrane consist of lipids (phospholipids, glycosphingolipids, and sterols); carbohydrates; and proteins (Sursana & Atika, 2002).

4. Ribosomes

Ribosomes are small, dense particles consisting of electrons. Ribosomes contain four types of RNA and 80 different proteins. Ribosomes can be found in chloroplast and mitochondrial cell organelles. In addition, it can also be found in eukaryotic and prokaryotic cells. However, the types of ribosomes in the cell or cell organelles are different. These two groups of ribosomes consist of two subunits of different sizes. Several ribosomes come together via mRNA strands to form polyribosomes. mRNA functions to carry messages in the form of codes for amino acid strands of proteins made by cells, while ribosomes act as translations of messages carried by mRNA during protein synthesis (Junqueira & Carneiro, 2003).

5. Endoplasmic Reticulum

   The cytoplasm of the cells is diverse and contains interconnected and anastomosing channels and sacs that create cisterns (cisternal spaces), which are spaces with intact membranes. On the preparation, cisterns appear separate, but on a high-resolution microscope, they can show cisterns. This cistern of the membrane is called the endoplasmic reticulum (RE). Polyribosomes, which produce protein molecules and insert them into cisterns, cover the endoplasmic reticulum that faces the cytosol. This is what distinguishes rough ER from smooth ER (Junqueira & Carneiro, 2003).

   In the rough ER, there are polyribosomes on the surface of the cytosol in the membrane. The presence of polyribosomes also causes these organelles to easily absorb alkaline dyes when viewed with a light microscope. The rough ER is composed of sac-like squamous cisterns. Whereas smooth ER does not have polyribosomes because the smooth ER membrane looks smooth and not granular. Both systems are more tubular and more likely to be seen as stacks of interconnected channels of varying shape and size (Junqueira & Carneiro, 2003).

6. Golgi Apparatus (Golgi Complex)

   The Golgi complex completes posttranslational modifications, packages, and places templates on products synthesised by the cell. This organelle consists of cisterns with a smooth membrane. The Golgi has different enzymes at different cis-trans levels and is important in glycolisation, sulfation, phosphorylation, and limited proteolysis of proteins. The Golgi also initiates the packaging, concentration, and storage of secretion products (Junqueira & Carneiro, 2003).

7. Lysosomes

   Lysosomes are formed from fragments of the Golgi apparatus. Lysosomes are small spherical organelles that enclose hydrolytic enzymes in a membrane layer. Lysosomes are a place to digest proteins, so when enzymes are not needed, they will be destroyed for reuse. Lysosomes are also a place for digesting food and for the destruction of bacteria during phagocytosis (Young & Heath, 2000).

8. Centrioles

   Centrioles consist of two bundles of microtubules that are attached at right angles to one another. In each bond, there are nine vessels with a distinctive arrangement. At the start of mitosis and meiosis, the centrioles divide, and one part migrates to each end of the cell to form a spindle fibre. The spindle threads will shorten to divide the chromosomes (Young & Heath, 2000).

9. Mitochondria

   Mitochondria can be found scattered throughout the cytosol and are relatively large. Mitochondria are sites of aerobic respiration where energy from a mixture of organic matter is converted into ATP. Mitochondria are also often called the powerhouse of the cell. Mitochondria can be found more often in cells that require high energy, for example, muscle cells and heart cells (Young & Heath, 2000).

   Two membranes surround mitochondria; the first is the smooth outer membrane, which serves as a partition between the mitochondria and the cytosol. The second membrane is the inner membrane, which has many long folds, also known as cristae, where these folds increase the surface area of the membrane so that more ATP is produced. Mitochondria are semi-autonomous organelles; that is, mitochondria can reappear when old mitochondria split. This can happen because mitochondria have their own DNA (Young & Heath, 2000).

10. Nucleus
    The nucleus is the largest organelle in eukaryotic cells. In prokaryotic cells, no nucleus is found, but prokaryotes have a nuclear body. The nucleus contains the chromosomes of the cell, which normally break down to form chromatin networks containing proteins and linear DNA, also known as histones. These proteins fuse early in the process of forming the nucleus. The nuclear envelope is a pair of membranes that encloses the nucleus and has numerous nuclear pores through which mRNA and proteins can pass. In general, the nucleus consists of at least one nucleolus. The nucleolus is the site of ribosome synthesis. When the nucleus splits, the nucleolus disappears (Young & Heath, 2000).
11. Peroxisomes
    Peroxisomes are present in all eukaryotic cells. Eukaryotic cells are composed of oxidative enzymes such as urate oxidase and catalase, which are present in high concentrations in some cells. Peroxisomes are the largest sites capable of producing oxygen. One study suggested that peroxisomes are remnants of old organelles that carried out oxygen metabolism in the primitive ancestor of eukaryotic cells. Peroxisomes consist of one or more enzymes that use oxygen to convert hydrogen atoms into specific organic substrates. Oxidation reactions produce hydrogen peroxide as a by-product.

    The reaction for the formation of hydrogen peroxide is as follows (Junqueira & Carneiro, 2003):

$$RH_2 + O_2 = R + H_2O_2$$

    Catalase activity with various enzymes in an organelle that uses H_2O_2 for peroxidase reactions functions to oxidise various substrates, such as phenol, formic acid, formaldehyde, and alcohol (Junqueira et al., 2003).

12. Cytoskeleton (cell skeleton)

The cytoskeleton is a bundle of proteins that make up the cytoplasm in eukaryotic and prokaryotic cells. The function of the cytoskeleton is to provide mechanical strength, give the cell shape, and adjust the location of organelles by moving to various parts of the cell, such as swimming and crawling on the surface of the cell (Junqueira & Carneiro, 2003).

The cytoskeleton is composed of microtubules, intermediate filaments, and microfilaments. Microtubules consist of two tubulin protein molecules joined together to form a tube. Microtubules play a role in providing defence against pressure on cells, cell movement using cilia and flagella, chromosome movement during cell division (anaphase), organelle movement, and the formation of centrioles in animal cells (Junqueira & Carneiro, 2003).

Microfilaments are small protein filaments consisting of two actin protein chains woven together. Microfilaments function to provide voltage to the cell, change the shape of the cell during muscle contraction, amoeboid movement of cells using pseudopodia, flow of cytoplasm, and cell division. Intermediate filaments are two protein chains that form a strand. Intermediate filaments have a diameter of 8–10 nm. Intermediate filaments are also known as intermediate filaments because they are larger than microfilaments but smaller than microtubules. Intermediate filament fibres are composed of the protein fimetin. One of the cells that are not composed of fimetin, namely skin cells, because the cells are composed of the protein keratin (Junqueira & Carneiro, 2003).

Cell Division

Growth, restoration, and renewal in all multicellular organisms depend on the formation of new cells by division of existing cells. There are two mechanisms for the process of cell division: mitosis and meiosis. Mitosis occurs in somatic cells, while meiosis occurs in the germ cells that develop in the ovaries and testes. The two have much in common but differ in the treatment of chromosomes during the early stages of division. Understanding both is fundamental to genetics because many congenital disorders are caused by abnormal behaviour of chromosomes during cell division (Fawcett, 2002).

1. Mitosis

   Mitosis is a cell division that produces two cells with identical genomes to the parent cell. The process of mitosis is divided into four sequential stages, including prophase, metaphase, anaphase, and telophase. Prior to division, the DNA is replicated so that it enters mitosis with twice the normal diploid complement. The period between two successive episodes of cell division is called interphase. During interphase, only the nucleolus and a few dense clumps of chromatin are visible in the nucleus. Except for these solid (heterochromatin) segments, the chromosomes are in a decomposed (euchromatic) state and are not visible in the preparation (Fawcett, 2002).

   The appearance of the chromosomes signals the start of prophase. Throughout this stage, the chromosomes continue to condense, shorten, and thicken. Each consists of two parallel strands called chromatids, connected at the centromere by a constricting segment common to both strands. In this place is the trilaminar disc, the kinetochore, consisting of two dense layers separated by a paler middle layer. Simultaneously with this incident, centrioles replicate and migrate to opposite poles of the cell. This is followed by the rupture of the nuclear membrane, which marks the end of the prophase (Fawcett, 2002).

   Metaphase begins with the arrangement of chromosomes in the same plane at the centre of the cell to form the equatorial plate (metaphase plate). This orderly arrangement of chromosomes is followed by the formation of mitotic coils and fusiform rows of microtubules, some extending from centrioles to chromosomes on the equatorial plate, while others extend from pole to pole (Fawcett, 2002).

The initial event in anaphase is the splitting of the single kinetochore of each pair of chromosomes into two, so that each chromatid has its own. Since each chromatid is no longer attached to the same kinetochore, they can freely move to the opposite poles of the coil as a single chromosome. The movement of chromosomes in anaphase is analogous to the transport of vesicles along the microtubules (Fawcett, 2002).

At telophase, the chromosomes that have gathered at the poles will unravel. The nucleoli reform, and the nuclear envelope segments form the intact perinuclear cisterna. While nuclear recovery is taking place, cytoplasmic constriction occurs midway between the nuclei. In the short term, the daughter cells can still communicate via cytoplasmic bridges filled with remnants of fused coiled microtubules. After a brief delay, the microtubules depolymerize, the intercellular bridge shifts to one side of the midbody, and the two halves are pulled into the cytoplasm of the daughter cell to complete cytokinesis (Fawcett, 2002).

2. Meiosis

Meiosis is a type of cell division that occurs during the development of the ovum and spermatozoa. Meiosis consists of two successive divisions with only one chromosome replication. In the first division, the members of each homologous pair separate and go to opposite poles, reducing the number of chromosomes in the daughter cells by half. The second division includes the replication of each chromosome and the separation of the two chromatids that are formed. The four cells resulting from meiosis have half the normal diploid number of chromosomes, and therefore the gametes that develop are haploid. After the male and female gametes unite, fertilisation occurs, and the diploid number of chromosomes is restored in the cells of the zygote (Fawcett, 2002).

Meiosis is characterized by a very long prophase which is divided into 5 stages. The initial stage (leptotene), in the form of chromosomes that appear in the nucleus in the form of a single long chain. The second stage (zygoten) is the homologous chromosomes begin to approach lined up with adjoining places. In the third stage (pachytene) the coiled chromosomes thicken and shorten. At this stage, homologous chromosomes give the impression that only one chromosome is visible. However, at the diplotene stage, the chromosomes have been separated lengthwise and have undergone replication and double-stranded. Each pair of chromosomes consists of four chromatids. At certain zones along the strand, homologous chromatin crosses over, breaks, and the fragments reassemble. The shortening and thickening of the chromosomes continue and collects in the centre of the nucleus. The existing nucleoli become broken and disappear (Fawcett, 2002).

At metaphase, the nuclear membrane ruptures and coils form. Chromosomes pair toward the equatorial plate, but the kinetochores do not divide. As a result, in the anaphase of the first meiotic division, the chromosomes are still intact. At telophase the nucleus is reformed again, then enters a second division which is very similar to mitosis. The chromatids separate, the kinetochores divide, and the chromatids go to opposite poles. Thus, both meiotic divisions produce 4 cells with haploid nuclei (Fawcett, 2002).

Topic 2: Tissues

Tissue consists of a group of cells that usually look similar to one another and originate from the same area in the developing embryo. Groups of cells that make up a tissue have physiological functions that work together in a coordinated way to support specific functions. The specific function of the tissue is also affected by the type of material that surrounds it and the communication between the tissue cells. Different types of tissue have different physical properties. There are four types of tissue based on differences in anatomy and function: epithelial tissue, connective tissue, muscle tissue, and nervous tissue (Totora et al., 2009).

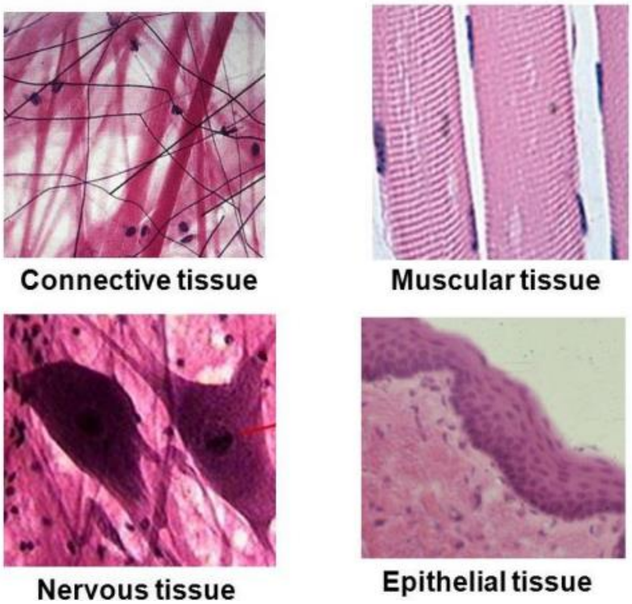

Figure 5.1. Network Types (Totora et. al., 2009)

Tissue is a collection of cells that have the same structure and function. The basic tissues in the body are divided into 4 groups, namely epithelial tissue, muscle tissue (muscle), nerve tissue, and connective tissue.

1. Epithelial Tissue
   Epithelial tissue is a collection of cells that cover the surface of the body, both inside and outside. Epithelial tissue can be grouped based on its shape, namely: cuboidal (like dice), columnar (like bricks), and squamous (like a flat floor). Epithelial types can also be grouped based on the number of cell layers, namely simple epithelium, stratified or stratified epithelium, and pseudostratified epithelium.

Simple epithelium has a single layer of cells, consisting of simple squamous epithelium and simple columnar epithelium. Simple squamous epithelium can be found in the blood vessels and air sacs of the lungs. Simple columnar epithelium is found at the sites of absorption and secretion. Meanwhile, stratified or multilayered epithelium can be found on surfaces exposed to abrasive conditions, such as the outer skin and the lining of certain channels or body cavities. The following is a picture of epithelial tissue.

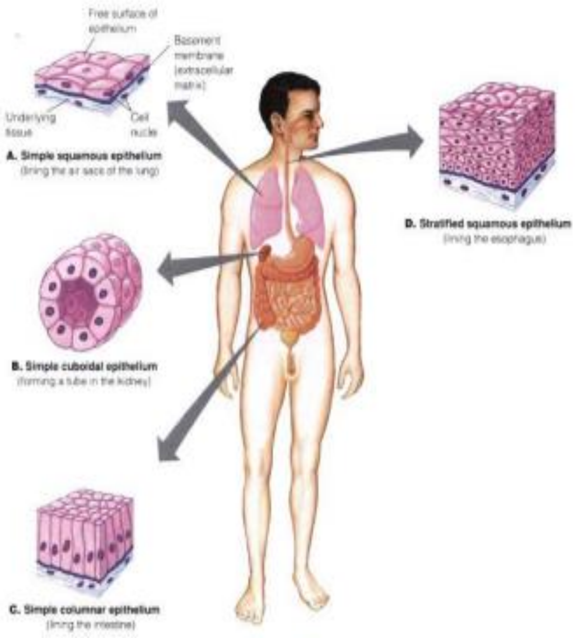

Figure 5.1 Epithelial Tissue (Chapman, 2002)

2. Muscle Tissue

   Muscle tissue is tissue that has the ability to contract so that it can perform a movement. There are 3 types of muscles that have different structures and functions, namely striated muscles (skeletal muscles), smooth muscles, and cardiac muscles.

Striated muscles (skeletal muscles) are usually attached to bones by tendons and are voluntary. The striated muscles have transverse and alternating striped fibres of light and dark colours, and have a nucleus. Each fibre is formed by a number of myofibrils and is covered by a membrane called the sarcolemma (muscle membrane). A number of fibres come together to form bundles, the bundles are tied together by connective tissue to form large and small muscles. When a muscle contracts, it shortens, and each fibre moves by contracting. This muscle only contracts when stimulated by nerve stimulation (neurogenic). Smooth muscle is a muscle that is smooth, not striped, has a nucleus and contracts without nerve stimulation (involuntary muscle). This muscle is found in the walls of blood vessels and lymph vessels, in the walls of the digestive tract and hollow viscera, trachea, bronchi, iris of the eye, ciliary muscle of the eye, and in involuntary muscles in the skin. Cardiac muscle is found only in the heart. Cardiac muscle has a striated structure like striated muscle. The difference is in the fibres that branch out and anastomose (continue with each other), and are unconscious (cannot be controlled by will).

Cardiac muscle has a special ability to carry out automatic and rhythmic contractions regardless of the presence or absence of nerve stimulation. This way of working is called myogenic, which distinguishes it from neurogenic.

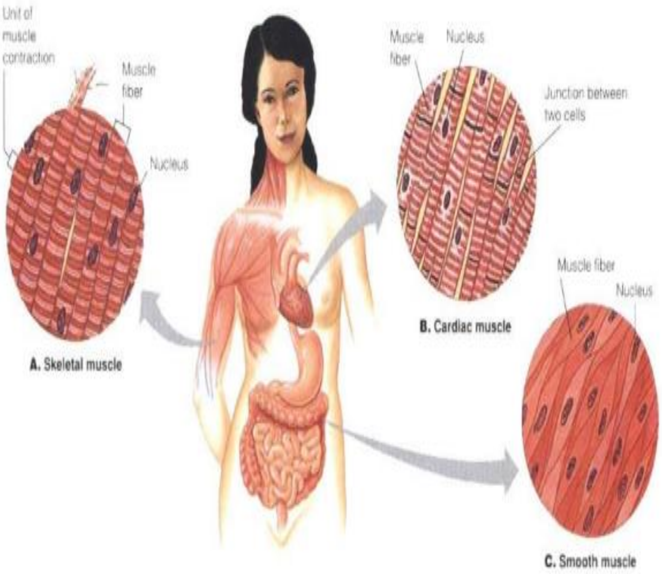

Figure 5.2 Muscle Tissue (Chapman, 2002)

3. Neural Networks

Nervous tissue is a network that functions to transmit nerve impulses. This network consists of a collection of nerve cells or also called neurons and glial (support) cells.

Neurons are divided into 3 parts: dendrites, cell body and axon. Dendrites are short, branched projections that receive stimuli from the environment and transmit signals toward the cell body. The cell body of the neuron is the centre of the entire nerve cell which is sensitive to stimulation, and contains the nucleus, cytoplasm and organelles. The cell body is responsible for conducting nerve impulses towards the axon. While the axon is a special protrusion to transmit impulses to other cells (nerve cells, muscle cells, or gland cells). Most neurons have only one axon, which extends from the cell body, which is called the axon hillock. An axon can branch which ends into a number of small branches called telodendria. A synaptic knob is a bulbous (bubbled) structure at the end of each telodondria.

Neurons, and their projections, vary greatly in size and shape. According to the size and shape of the protrusions, neurons can be classified into 3 namely (a) multipolar neurons with more than two projections, one of which is an axon and the other is a dendrite; Most of the neurons in the body are multipolar, (b) Bipolar neuron with one dendrite and one axon that can found in ear, retina, olfactory mucosa (c) Pseudounipolar neurons which are actually unipolar neurons that branch into two; one branch (dendrite) forms the peripheral nerve endings and another axon to the central nervous system. These neurons are found in the spinal ganglion.

Summary

The smallest structural and functional components of a living thing's tissues are its cells. They are made of protoplasm, a heterogeneous biological material that ranges in consistency from liquid to solid. Eukaryotic cells are distinct hereditary materials in a nucleus protected by a cell membrane, while prokaryotic cells are comprised of metabolic and hereditary materials. The various cell sizes and shapes correspond to the various functions of the various cell types. The protoplasm, a component of the cell that serves as an activity regulator, is one of the many elements that make up a cell in the human body.

It is made up of inorganic materials, lipids, carbohydrates, proteins, and nucleic acids. The primary structural component of cells is protein, whereas nucleic acids transport information from the nucleus to the cytoplasm. In addition to being coupled with proteins and lipids, free radicals are also the primary source of energy for cells. Protoplasm is capable of respiration, absorption, secretion, contractility, irritability, and other functions. Conductivity is the protoplasm's capacity to carry on an excitation wave, contractility is the protoplasm's capacity to change its shape, respiration is the process of interaction between oxygen and food to produce energy, absorption is the process of removing substances by cells, secretion is the process of removing substances by cells, and growth is the increase in cell size. The extra nucleus, which includes many kinds of cell organelles that perform distinct roles, is where the majority of the cell's metabolic operations and other activities take place.

These organelles are semi-liquid cytoplasmic matrices known as the cytosol that are surrounded by membrane components with a distinctive internal structure and form. The plasma membrane is a layer that divides cells and the organelles inside of cells. It also serves as a channel for communication between cells. Eighty distinct proteins and four different kinds of RNA may be found in ribosomes, which are tiny, electron-rich particles. The endoplasmic reticulum (ER) is a varied organelle that has sacs and channels that link and anastomose to form cisterns. The Golgi Complex (Golgi Apparatus) completes posttranslational alterations, packages, and affixes templates to the cell's manufactured goods. Small, spherical organelles called lysosomes contain hydrolytic enzymes inside a membrane layer. Two microtubule bundles known as centrioles are linked at the right.

A group of cells with the same form and function make up tissue. Based on variations in anatomy and function, there are four different kinds of tissue: epithelial tissue, connective tissue, muscular tissue, and nerve tissue. The body's exterior and interior surfaces are covered with epithelial tissue, a group of cells. It may be divided into three groups according to shape: cuboidal (like a pair of dice), columnar (like a set of bricks), and squamous (like a flat floor). Simple squamous epithelium and simple columnar epithelium make up the single layer of cells that make up simple epithelium.

Simple columnar epithelium may be found at the sites of absorption and secretion, while simple squamous epithelium can be found in the blood vessels and air sacs of the lungs. On surfaces that have been subjected to abrasive conditions, stratified or multilayered epithelium may be discovered. Muscle tissue is a kind of tissue that may contract to carry out a movement. There are three different kinds of muscles: cardiac muscles, smooth muscles, and striated muscles (skeletal muscles). While smooth muscles are smooth, not striped, and contract without nerve stimulation, striated muscles are often linked to bones by tendons.

Cardiac muscle is exclusively present in the heart, and although it has a striated structure similar to that of striated muscle, its anastomosing and branching fibres are unconscious. The cardiac muscle has the unique capacity to contract automatically and rhythmically whether there is or is not nerve input. A group of nerve cells called neurons are responsible for transmitting nerve impulses. They are split into three sections: axons, cell bodies, and dendrites. Short, branching projections called dendrites take in environmental cues and send information to the cell body.

While the axon is a unique protrusion that sends impulses to other cells, the cell body is in charge of carrying nerve impulses in that direction. The three subtypes of neurons are multipolar, bipolar, and pseudounipolar. Axons and dendrites are two of the more than two projections that multipolar neurons have. The ear, retina, and olfactory mucosa all include bipolar neurons, which have a single dendrite and a single axon. Pseudounipolar neurons contain two branches, one axon for the central nervous system and one dendrite for the peripheral nerve terminals.

Review Questions

Compare the alternatives in the right column to the statements in the left column!

Statement	Choice	Answer
Cannot live without parasites in other individuals	A. Nucleus B. Virus C. Exocytosis D. Mitochondria E. Ribosome F. Secondary lysosomes G. Cytoskeleton H. Autolysis I. Vacuoles	A
Cell respiration apparatus		D
The process of protein synthesis		E
The process of releasing enzymes out of the cell		C
Cell digestion tool that has performed its function		F
Cell framework		G
The process of cell self-destruction		H

Statement	Choice	Answer
ATP energy generator/cell energy generator	J. Mitochondria K. Microfilament L. Endoplasmic Reticulum M. Plastid	D

Instructions for answering the exercise

1. You must thoroughly read this chapter in order to be able to complete the activities stated above.
2. Learn about the functions of the many cell organelles.
3. By entering the letter code in the column on the far right, you may match the names of the cell organelles with their corresponding functions.

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CHAPTER 6
RESPIRATORY SYSTEM

Learning Objectives:

1. Understanding Anatomy of Respiratory System
2. Understanding Physiology of Respiratory System

Introduction:

We get the chance to conceptually consider human anatomy and physiology in this chapter. The explanation of this topic provides a summary of the systemic changes that occur. First, one must comprehend the makeup and function of each organ in the human body. A key building block of learning is having a solid understanding of human anatomy and physiology. This chapter will also address the respiratory system.

Breathing is one of the characteristics of living things. All living creatures, including humans, engage in this process. Both oxygen and carbon dioxide are expelled during breathing. Why does life need oxygen? What precisely does oxygen accomplish for the body? Because oxygen makes it easier for food components to break down in the body, all living things need it. This process of rearranging objects may provide energy. One may get the necessary oxygen via breathing. Breathing, which is an exchange of gases, is a result of interactions between living things and the gases in their environment. Reworking food components with oxygen to create energy and expel the carbon dioxide that remains after burning is the process of respiration.

Topic 1: Anatomy of Respiratory System

The act of breathing, or respiration, entails converting carbon dioxide (CO_2) from metabolic processes into the oxygen (O_2) needed by the body for cell metabolism. The upper respiratory tract heats, filters, and moistens the air that enters this region, whereas the lower respiratory tract, which comprises the lungs and is where gas exchange occurs, is separated into these two portions. The alveoli, a component of the lungs, is where O_2 and CO_2 exchange gases. Musculoskeletal pumps are found in the chest wall and pleural cavity, which regulate gas exchange while breathing. The pleural cavity is made up of two serous membranes, the parietalis pleura and the vesical pleura, which guard the lungs and the inner wall of the chest cavity, respectively.

Respiratory Organs

We begin our examination of the respiratory system with the upper respiratory organs. The upper respiratory system is made up of the nose, nasopharynx (which contains the pharyngeal tonsil and eustachian tube), oropharynx (where the oral cavity and pharynx meet and the base of the tongue is situated), and laryngopharynx (where the airflow and food flow connect).

1. Nose

   A nasal cavity is located within the nose, as well as a visible external nose. The right and left nasal cavities are separated by a septum in the nose. Through slits known as meatus, air enters. Known as the konka, the meatus' wall. The lower nasal turbinate and ethmoid bones of the face are what shape it. Filters, humidity, warmth, and impurity removal are all accomplished by the nasal hairs, mucus, blood vessels, and cilia that line the nasal cavities.

   Four pairs of paranasal sinuses, the frontal, maxillary, sphenoidal, and ethmoidal sinuses, surround the nasal cavity. The olfactory nerve, or the olfactory nerve's first nerve fibre, escapes via the ethmoidal sinus. The Eustachian tube, a tiny aperture in the middle of the ear that connects the nose to the medium ear, and the ductus lacrimal, which connects the nose to the eye, are among the surrounding organs with which the nose has a connection. Air passes through three processes in the nasal cavity: cilia filter it, the mucosal layer directly absorbs moisture from the air, and the blood vessels in the submucosa come into direct contact with the air that enters the body, which causes warmth.

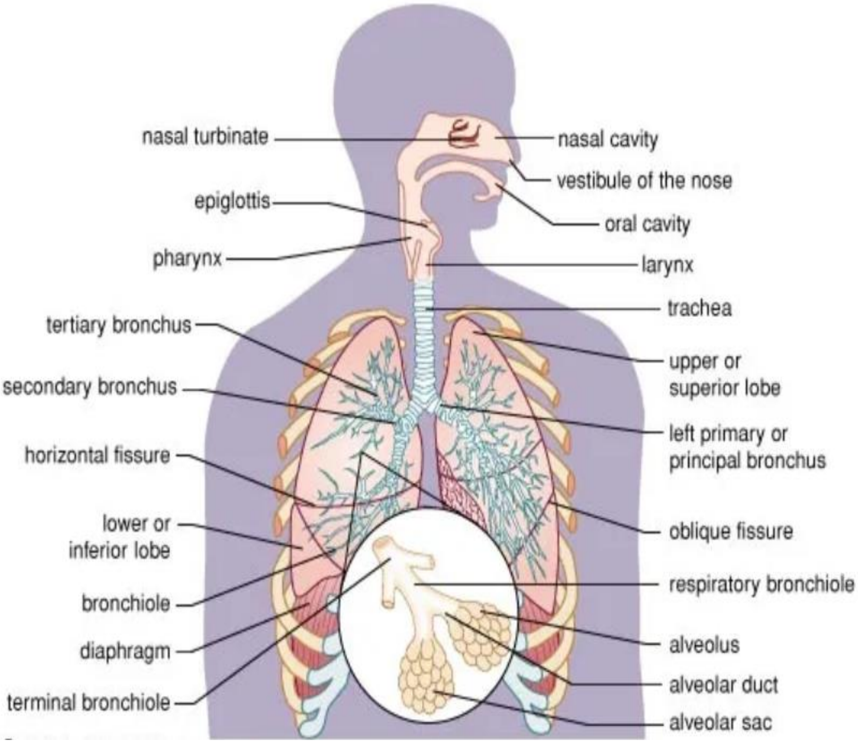


Figure 6.1 The Respiratory System (Britannica, 2021)

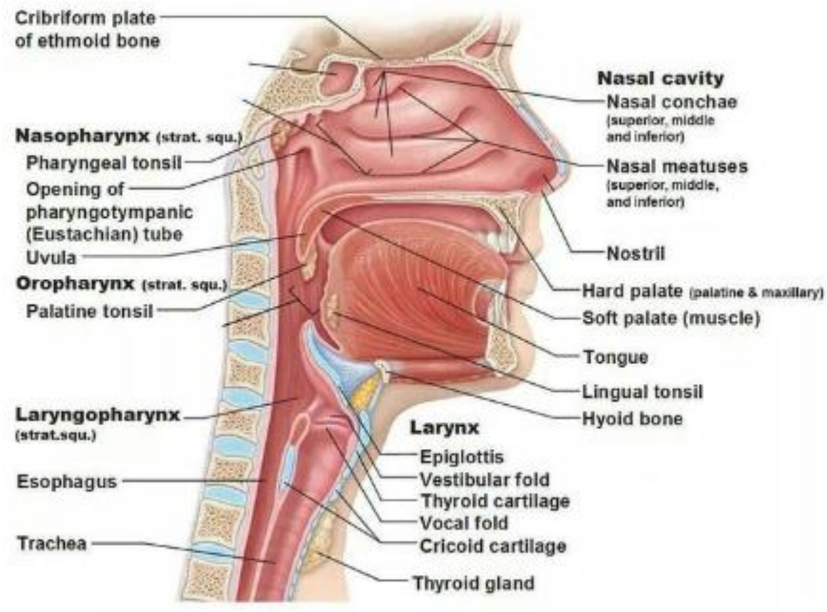


Figure 6.2 Upper Respiratory Tract
(Drake et al., 2010; Patwa & Shah, 2015)

2. Pharynx
   From the base of the skull to the level of the cricoid cartilage, the pharynx is a muscular tube. The Choana, a small aperture that connects the pharynx to the nose, and the Isthmus Faucium, which connects the pharynx to the mouth. The pharynx connects with the larynx below and the oesophagus in reverse. The nasopharynx, a section of the pharynx that runs parallel to the nose and receives air from the nose, is one of the three components that make up the pharynx. The middle ear has an eustachian tube that balances the air pressure there. The nasopharynx is positioned behind the pharyngeal tonsils, or adenoids. The pharynx, or oropharynx, is parallel to the mouth and takes food from the oral cavity and air from the nasopharynx. Here are the palatine and lingual tonsils. Part of the pharynx, the laryngopharynx carries air to

the larynx and food to the oesophagus while lying parallel to the larynx.

3. Larynx

The laryngopharynx supplies air to the larynx. The nine cartilage parts that make up the larynx are connected by membranes and ligaments. The laryngeal cartilage's initial segment is the epiglottis. The epiglottis covers the base of the throat to block the passage of food during swallowing, and the valve shuts and opens during breathing. The front of the larynx is shielded by thyroid cartilage. The Adam's apple is made up of the projecting cartilage. The thyroid cartilage is connected to the pairs of arytenoid bones behind by the folds of the mucous membrane (supraglottic). Folds When the muscles of the chest cavity are under pressure (such as during bowel motions or heavy lifting), the upper vestibular (false vocal cords) have muscular fibres that enable it to breathe for a short period of time.

Elastic ligaments may be seen in the voice chords of the lower vestibule. When the skeletal muscles pull the superior vocal cords towards the airway, they vibrate. As a result, we talk and make a range of noises. The ends of the larynx are made up of the cricoid cartilage, cuneiform cartilage, and corniculate cartilage.

4. Trachea

The trachea is a flexible tube with a length of 10 to 12 cm (4 inches) and a diameter of 2.5 cm (1 inch). The four layers of the wall are as follows:

a. Mucosa

The mucosa is the trachea's innermost lining. Goblet cells that produce mucus and ciliated pseudostratified epithelium are seen in the mucosa. The pharynx is where waste is swept out from the lungs by cilia.

b. Submucosa

The layer of areolar connective tissue that covers the mucosa is known as the submucosa.

c. Hyaline Cartilage

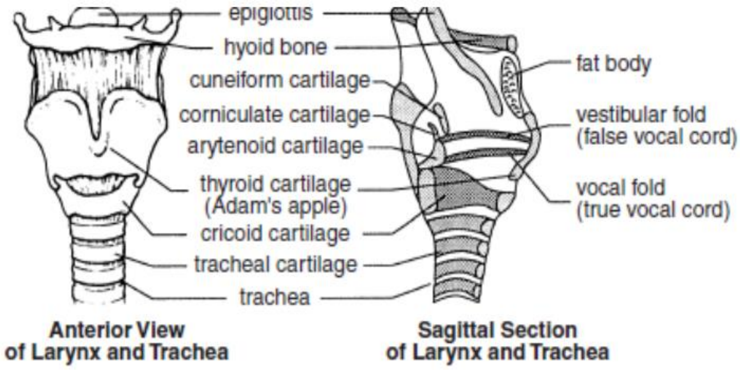
Hyaline cartilage in the form of 16–20 C-shaped rings surrounds the submucosa. The trachea is given a strong form by cartilage rings, which prevents it from collapsing and widens the airways.

d. Adventitia

The trachea's outermost layer is called the adventitia. This layer is made up of areolar connective tissue, which is loose. The pharynx splits into two bronchi just below the level of the fifth thoracic vertebra. The carina is the name for the trachea's branching point.

5. Bronchus

The right bronchus and left bronchus, which are both branches of the trachea and each go to the right lung and left lung, respectively, are the two halves of the bronchus. In comparison to the left bronchus, the right bronchus is longer, more upright, and bigger. It has three branches and is made up of 6–8 cartilage rings. The left bronchus has two branches, is longer and thinner, and is made up of 9–12 cartilaginous rings. Each major bronchus in the lungs splits into smaller dimensions to create secondary (lobar), tertiary (segmental), terminal (0.5 mm diameter), and microscopic respiratory bronchioles. The primary bronchial walls are similar to those of the trachea, but their branches are smaller and their mucosal and cartilage ring linings have been replaced by smooth muscle.



Picture 6.3 Anterior and Sagittal Sections of the Larynx and Trachea

6. Alveoli

   The alveolar ducts are the final branches of the bronchial tree. Each alveolar canal enlarged, like a bubble along its length. Each distinction is called alveoli, and a group of adjacent alveoli is called the alveolar sac. A number of adjacent alveoli are connected by alveolar pores.

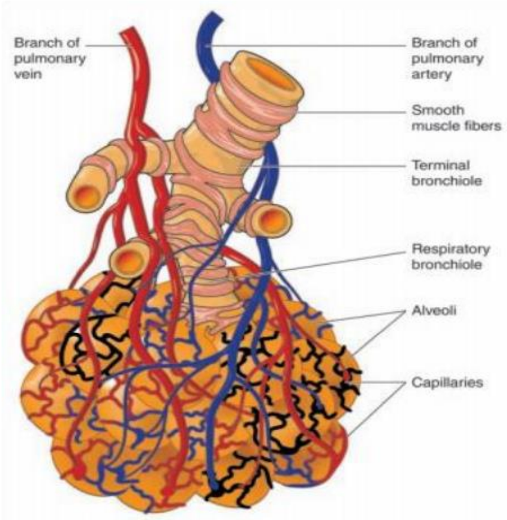


Figure 6.4 Structure of Alveoli (Whittemore, 2014)

7. Respiratory Membranes

The walls of the capillaries and alveoli make up the respiratory membrane. This membrane allows for gas exchange. These are this membrane's characteristics:

Type I: The main cells of the kind of alveolar wall are thin-cell, squamous epithelial cells. In the cells, oxygen diffusion takes place.

Type II: Between type I cells are cuboidal epithelial cells. Pulmonary surfactant, or protein-bound phospholipids, is secreted by type II cells, and it lowers the surface tension of the moisture coating the alveolar walls. When there is less surface tension, oxygen may diffuse more freely.

Additionally, a decreased surface tension prevents moisture from forming on the opposing walls of the alveolar ducts or alveolar nuclei, which leads to the collapse of the tiny airways. Dust cells called alveolar macrophages scour the alveolar walls for debris and bacteria. The outer layer of the alveolar wall is made up of a slender epithelial foundation membrane. Each alveolus is surrounded by a substantial network of capillaries. Endothelial cells and a thin membrane surround the capillary walls.

8. Lungs

Lung tissue fills the thorax like a cone-shaped body and is elastic, porous, and spongy. Both lungs are separated by the mediastinum, the cavity that houses the heart. The right lung has two lobes, whereas the left lung has three. Each lung lobe is further split into lobules, each of which has a bronchiole terminal, and bronchopulmonary segments, each of which has tertiary bronchi. Each lobe is laced with nerves, lymphatic vessels, and blood vessels. The characteristics of each lung include:

a. The top and bottom of the lungs are shown by the apex and bottom.
b. The ribs (front and rear) touch the surface of each lung.

c. The respiratory tract, blood vessels, and lymphatic vessels enter the lung at the hilus on the medial (mediastinal) surface, which each lung confronts in addition to the lungs.

The pleura is a double membrane that lines the chest cavity and has an inner pleura that surrounds each lung. This inner pleura is known as the visceral pleura. Pleural fluid, a lubricant released by the pleura, fills the small hole between the two membranes known as the pleural cavity.

Topic 2: Physiology of Respiratory System

Breathing is the action of transferring air into the lungs, allowing oxygen to enter the body, and expelling carbon dioxide. The nose, throat, larynx, trachea, bronchi, alveoli, and other structures are all involved in system breathing in addition to the lungs.

1. Breathing

   Breathing helps the respiratory system transport air via the lungs. While oxygen from the air diffuses from the lungs into the blood, carbon dioxide diffuses from the blood to the lungs. The processes listed below are a component of respiration:

   a. Lung Ventilation

      The act of breathing in air and breathing out air is referred to as pulmonary ventilation.

   b. The Exhalation of Air

      The process of transferring gases between the lungs and the blood is known as external respiration. While carbon dioxide diffuses from the blood into the lungs, oxygen diffuses into the blood.

   c. Transporting Gas

      The cardiovascular system handles gas transfer. Gas transportation involves moving oxygen across the body and collecting carbon dioxide to be exhaled back into the lungs.

   The respiratory system uses breathing to move air through the lungs. While carbon dioxide diffuses from the blood to the lungs, oxygen from the air diffuses from the lungs into the blood. The following processes are part of respiration:

a. Lung Ventilation
Pulmonary ventilation is the process of inhaling (breathing in air) and expiration (exhaling air).

b. Outer Breathing
External respiration is the process of exchanging gases between the lungs and the blood. Oxygen diffuses into the blood, while carbon dioxide diffuses from the blood into the lungs.

c. Gas Transportation
Gas transport is carried out by the cardiovascular system. Gas transportation is the process of distributing oxygen throughout the body and collecting carbon dioxide to be returned to the lungs.

d. Deep Breathing
The process of deep breathing involves the exchange of gases between the cells, interstitial fluid, which surrounds them, and the blood. Cellular respiration takes place within the cell, generating energy (ATP) and CO_2 from O_2 and glucose.

2. Breathing Mechanism
The connection between a gas's pressure (P) and volume (V) is described by Boyle's law. According to Boyle's law, if the volume rises, the pressure must fall—or vice versa. It is common to write this connection as PV = constant or P1V1 = P2V2. The second equations of pressure and volume are unchanged (the law is valid only in the absence of temperature changes).

When the muscles surrounding the lungs contract or relax, the amount of air in the lungs' airways (bronchi, bronchioles) changes overall. According to Boyle's law, the lungs' air pressure varies as their volume does. If the pressure within the lungs is higher than the pressure outside, air will escape. The air rushes in if the reverse occurs. This is how the human respiratory system works.

a. Inspiration

The external intercostal muscles and diaphragm contract during inspiration. The chest cavity expands when the diaphragm (a skeletal muscle of the lungs) contracts, while the external intercostal muscles raise the ribs and sternum. As a result, the muscles increase the capacity of the internal airways and cause the lungs to expand. As a result, the air pressure within the lungs falls below the air pressure outside the body. As a result, air enters the lungs because gases flow from an area of high pressure to one of low pressure.

b. Expiration

The external intercostal muscles and the diaphragm relax during exhalation. Elastic fibres in the lung tissue cause the lungs to self-contract to their original volume in response. The air pressure within the lungs rises above the air pressure outside the body at that point. As long as the rate of ventilation is high, the abdominal and intercostal muscles, which are used for expiration, will contract. Due to the suppleness of the lung tissue and the low surface tension of the lungs' internal moisture (from surfactant), normal lungs have high lung compliance, which is a measurement of the chest cavity's and lungs' ability to expand.

3. Breathing Regulation

a. Lung Volume and Capacity

The different exhalations' lung volumes are described by the phrases listed below:

1) Tidal volume (TV), or the average quantity of inspired air during relaxed breathing, is 500 ml.
2) The extra volume of air that may be forcefully inhaled after a typical tidal volume inspiration is known as the inspiratory reserve volume (IRV), which is about 3100 ml.
3) The extra air that may be forcibly expelled beyond the conclusion of the normal tidal volume is known as the expiratory reserve volume (ERV), which is about 1200 ml.

4) The amount of air that remains in the lungs after the expiratory reserve volume has been expelled is known as the residual volume (RV), which is around 1200 ml.

The different exhalations' lung volumes are described by the phrases listed below:

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4) The amount of air that remains in the lungs after the expiratory reserve volume has been expelled is known as the residual volume (RV), which is around 1200 ml.

Summing up a given lung volume yields the lung capacity as a following:

1) The total lung capacity (TLC), about 6,000 ml, is the maximum amount of air that can be inhaled can fill the lungs (TLC = TV + IRV + ERV + RV).
2) Vital capacity (VC), about 4,800 ml, is the total amount or volume of air that can be inhaled ends after full inhalation (VC = TV + IRV + ERV = approx. 80% TLC).
3) Inspiratory capacity (IC), about 3,600 ml, is the maximum amount of air that can be inhaled inspired (IC = TV + IRV).
4) Functional residual capacity (FRC), approximately 2400 ml, is the amount of air remaining in the lungs after a normal expiration (FRC = RV + ERV).

In the lungs, some of the air is not involved in gas exchange. Like Outside of the alveoli, in the anatomically dead gaps of the bronchi and bronchioles, is where air is found.

b. Gas Exchange

Each gas in a mixture of gases contributes to the overall pressure of the mixture. The partial pressure that each gas contributes is equal to the pressure that each gas would have if it were the only gas in the cage. The overall pressure of the mixture is equal to the sum of the partial pressures of the different gases in the mixture, according to Law Dalton. The following variables affect how well a gas dissolves in a liquid:

1) Gas partial pressure. Henry's law states that the more partial pressure of a gas there is, the more gas will diffuse into a liquid.
2) Solubility in gas. The kind of gas and liquid affects how easily gases dissolve in liquids.
3) Temperature of liquid. Temperature increases cause a reduction in solubility. Alveoli and blood and plasma exchange gases in the lungs, and plasma and interstitial fluid exchange gases throughout the body.

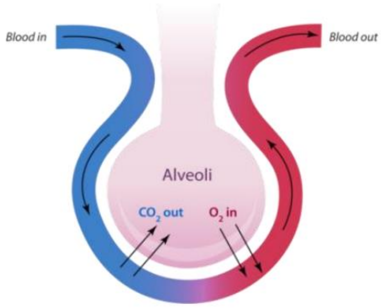

Figure 5.5 Pulmonary Gas Exchange

c. Partial Pressure and Solution

Increased partial pressure may compensate for low solubility, or vice versa. The following qualities of O_2 and CO_2 are compared:

1) Oxygen

   Air contains 21% oxygen, therefore the partial pressure of oxygen in the lungs is high, but the solubility is weak.

2) Carbon dioxide
   Although CO_2 has a relatively low partial pressure in air (air contains about 0.04% CO_2), it is 24 times more soluble in plasma than O_2.
3) Partial pressure gradient
   Any shift in amount from one location to another is referred to as a gradient. In other words, from a high partial pressure region to a high partial pressure lower location, diffusion of gas into liquid (or vice versa) takes place along a pressure gradient partial pressure. For instance, fast diffusion is facilitated by a significant pressure gradient for partial O2 (pO2) of the deoxygenated blood alveoli (105 mm Hg in the alveoli against 40 mm Hg in the blood).
4) The area available for petrol exchange.
   Wide diffusion is facilitated by the lung's enormous surface area. Diffusion is accelerated by the thin alveolar and capillary walls.

d. Gas Transportation
   Two processes carry oxygen in the blood:
   1. The plasma contains a tiny quantity (1.5 percent) of dissolved oxygen.
   2. Haemoglobin, a protein found in red blood cells, is where the majority of the oxygen (98.5%) found in blood is bonded. Four O_2 molecules are connected to an oxyhaemoglobin (HbO_2) that is totally saturated. The molecule is known as deoxyhaemoglobin (Hb) in the absence of oxygen.

The partial pressure of oxygen affects haemoglobin's capacity to bind oxygen. Hb may more readily bind oxygen the higher the partial pressure of oxygen in the blood. The graph below depicts the oxygen-hemoglobin dissociation curve, which demonstrates how Hb saturation rises as PO_2 approaches 100 mmHg. Fourth, the following elements reduce Hb's affinity for O_2, or tensile strength, and cause the O_2-Hb dissociation curve to move to the right:

1. Temperature increase.
2. A rise in CO_2 partial pressure (PCO2)
3. A greater acidity (lower pH). When H^+ attaches to Hb, a phenomenon known as the effect Bohr occurs, which reduces Hb's affinity for O_2.
4. A rise in BPG levels in red blood cells. Red blood cells make BPG (bisphosphoglycerate) as a by-product of using glucose as fuel.

There are many ways that carbon dioxide is carried through the blood:

1. The plasma contains a very modest (8%) quantity of dissolved CO_2.
2. When producing carbaminohaemoglobin ($HbCO_2$) in red blood cells, some CO_2 (25%) attaches to Hb. In contrast to O_2, CO_2 binds to a different location.
3. The plasma transports the majority of the CO_2 (65%) as dissolved bicarbonate ions (HCO_3^-). But in red blood cells, the enzyme carbonic anhydrase catalyses the production of carbonic acid (HCO_3^-), as seen in the following.

$$CO_2 + H_2O \text{ fl ‡ } H_2CO_3 \text{ fl ‡ } H + HCO_3^-$$

The majority of H^+-binding molecules, such as haemoglobin, are formed in red blood cells, leading to the Bohr effect and a modest drop in plasma pH. Additionally, HCO_3^- ions diffuse back into the plasma. The chloride ion spreads in the opposite way, from plasma to red blood cells, to balance out the overall increase in the negative charge entering the plasma (chloride shift).

e. Respiration Control

Brain regions that trigger the diaphragm and intercostal muscles to contract regulate breathing. The respiratory centre is the aggregate name for several regions, which are as follows:

1. The medullar inspiratory centre, which is situated in the medullar oblongata, produces nerve impulses that rhythmically trigger the muscles (the diaphragm and external intercostal muscles) to contract during inspiration. Normally, the muscles finish when they are relaxed, but with rapid breathing, the inspiratory centre speeds up expiration by activating the muscles that contract during expiration (the abdominal and internal intercostal muscles).
2. The pons-based pneumotaxic region inhibits the inspiratory centre, limits the muscles' ability to contract, and prevents the lungs from becoming excessively flat.
3. The apneustic region, which is likewise found in the pons and stimulates the inspiratory centre to extend the contraction of the inspiratory muscle.

The three categories of sensory neurons listed below all influence the respiratory centres with their stimuli:

1. Chemoreceptor centres, or CNS nerves, which are found in the medulla oblongata, keep track of the chemical of cerebrospinal fluid. When plasma CO_2 diffuses into the cerebral fluid, it forms HCO_3^- and H^+ and lowers the pH of the drop liquid, making it more acidic. The chemoreceptor centre is stimulated in response to a drop in pH, which activates the respiratory centre and raises the base of inspiration.
2. Peripheral chemoreceptors, or peripheral nervous system nerves, monitor blood chemistry in the aortic body at the walls of the aortic arch and the carotid bodies in the walls of the carotid arteries. The receptor activates the respiratory centre in response to changes in pH, pCO_2, or pO_2. When the lungs expand over their physical limitations, stretch receptors in the walls of the bronchi and bronchioles are triggered. This receptor tells the respiratory

centre to cease stimulating the muscles during inspiration so that expiration may begin. The inflation (Hering-Breur) reflex is what's causing this.

Summary

The upper respiratory tract, which includes the nose, nasopharynx, oropharynx, and laryngopharynx, and the lower respiratory tract, which includes the lungs, make up the respiratory system. The nose, nasopharynx, oropharynx, and laryngopharynx are the upper respiratory organs. The nose is made up of an inside nasal cavity and an exterior nose that is visible. The meatus, which is created by the face bones, is where air enters. The blood vessels, cilia, mucus, and nasal hairs that line the nasal cavities filter, humidify, warm, and purify the air.

The middle ear cavity and the media ear are connected to the nose by the Eustachian tube, while the nose is connected to the eye through the ductus lacrimal. A muscular tube called the pharynx extends from the skull's base to the level of the cricoid cartilage. The pharyngeal tonsils (adenoids), the oropharynx, which receives air from the nasopharynx and food from the oral cavity, and the laryngopharynx, which runs parallel to the larynx and carries food to the oesophagus and air to the larynx, make up this structure. The nasopharynx receives air from the nose. The epiglottis, thyroid cartilage, upper vestibular folds (false vocal cords), lower vestibular folds (vocal cords), corniculate cartilage, and lower vestibular folds are among the nine pieces of cartilage that make up the larynx and are connected by membranes and ligaments. The ends are made up of the corniculate cartilage, cuneiform cartilage, and cricoid cartilage. The trachea is a flexible tube that is 2.5 cm (1 inch) in diameter and 10 to 12 cm (4 inches) in length.

Mucosa, submucosa, hyaline cartilage, and adventitia are its four layers. The right and left bronchus are the two halves of the bronchus, which is a branch of the trachea. Secondary (lobar), tertiary (segmental), terminal (0.5 mm diameter), and microscopic respiratory bronchioles are formed when each major bronchi splits

into smaller dimensions. The terminal branches of the bronchial tree, the alveolar ducts, are joined by alveolar pores. Alveolar and capillary walls make up the respiratory membrane, allowing for gas exchange.

It is made up of pulmonary surfactant, type II cuboidal epithelial cells, and type I squamous epithelial cells. Alveolar macrophages roam among the other cells that make up the alveolar walls, and the alveolar wall's thin epithelial basement membrane serves as its outer layer. The mediastinum divides the two lungs, and lung tissue is elastic, porous, and spongy. Blood vessels, lymphatic vessels, and nerves are present throughout each of the bronchopulmonary segments and lobules that make up each lung lobe. The visceral pleura, an inner pleura that surrounds each lung, and the parietal pleura, an exterior membrane that lines the chest cavity, make up the pleura, which is a double membrane. Pleural fluid, a lubricant released by the pleura, fills the pleural cavity.

When you breathe, air enters your lungs, oxygen enters your body, and carbon dioxide is exhaled back into the atmosphere. Along with the lungs, other structures such as the nose, throat, larynx, trachea, bronchi, and alveoli are also involved. Lung ventilation, external respiration, gas transfer, and deep breathing are all types of respiration. Deep breathing is the process of exchanging gases between the blood, interstitial fluid, and cells. Lung ventilation is the process of inhaling and exhaling. External respiration is the process of exchanging gases between the lungs and the blood.

Gas transportation is the process of distributing oxygen throughout the body.The connection between a gas's pressure (P) and volume (V) is described by Boyle's law. When the muscles surrounding the lungs contract or relax, the amount of air in the lungs' airways (bronchi and bronchioles) changes overall. The air pressure in the lungs fluctuates in direct proportion to variations in lung capacity. Due to the suppleness of the lung tissue and the low surface tension of the lungs' internal moisture, lung compliance is a measurement of the ability of the lungs and chest cavity to expand. Tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), residual volume (RV), total lung capacity (TLC), vital capacity (VC), inspiratory capacity (IC), and functional residual capacity (FRC) are the terminologies used to characterise the lung volumes of different exhalations.

The greatest quantity of air that can be breathed is known as the total lung capacity (TLC), while the vital capacity (VC) is the entire volume of air that can be inhaled before the inhalation stops completely. The greatest quantity of air that can be breathed is known as the inspiratory capacity (IC), and the amount of air that remains in the lungs after a typical expiration is known as the functional residual capacity (FRC). Due to its location in the anatomically dead regions inside the bronchi and bronchioles, some of the air in the lungs does not participate in gas exchange. Alveoli, blood, and plasma exchange gases in the lungs, and plasma and interstitial fluid exchange gases throughout the body. Partial pressure, gas solubility, liquid temperature, and surface area for gas exchange are all parameters that aid in diffusion.

Although oxygen has a high partial pressure in the lungs, its plasma solubility is 24 times greater than that of oxygen (O_2). Despite having a low partial pressure in air, carbon dioxide is 24 times more soluble in plasma than oxygen. The enormous surface area of the lung facilitates broad diffusion, which is a shift in some amount from one location to another. The majority of the oxygen (98.5%) in red blood cells is attached to the protein haemoglobin, whereas just a minor quantity of oxygen (1.5%) is carried in the plasma as a dissolved gas. The partial pressure of oxygen (pO_2) affects haemoglobin's capacity to bind oxygen, and when pO_2 rises towards 100 mm Hg, Hb saturation approaches 100%. The O_2-Hb dissociation curve shifts to the right as a result of factors including temperature increases, a higher partial pressure of CO_2, increased acidity, and increased BPG in red blood cells. In the blood, carbon dioxide is transported in three different ways: most of the CO_2 (65%) is delivered as dissolved bicarbonate ions (HCO_3^-), a little quantity of CO_2 (8%), and a minor amount (25%), which binds to haemoglobin to produce carbaminohaemoglobin ($HbCO_2$). Red blood cells are where HCO_3 is formed. Brain regions that trigger the diaphragm and intercostal muscles to contract regulate breathing. The medullar inspiratory centre, the pneumotaxic area, and the apneustic area are these regions. Three different sensory neuron groups—chemoreceptor centres (nerves of the central nervous system), peripheral chemoreceptors (nerves of the peripheral nervous system), and stretch receptors on the walls of the bronchi and bronchioles—all influence the respiratory centres. When the lungs reach their physical limitations, stretch receptors in the walls of the bronchi and bronchioles become active. This signals the respiratory centre to stop stimulating the muscles during inspiration, allowing expiration to begin. The inflation (Hering-Breur) reflex is responsible for this.

Review Questions

1. Describe how the human nervous system is divided.

   Answer instruction:

   The central nervous system (CNS) and peripheral nervous system (PNS) are the two components of the human nervous system. Both the brain (encephalon) and the spinal cord (medulla spinalis) are parts of the central nervous system. Conscious and unconscious (autonomous) nerves make up the peripheral nervous system.
2. Explain what is called the Spinal medulla

   Answers Instruction:

   The spinal cord is an extension of the brainstem that begins at the foramen magnum and continues down through the vertebral canal to the first lumbar vertebra (L1). The spinal cord is located in its lower end position by the terminal phylum, an extension of the pia mater that is attached to the coccyx.
3. What nerves are included in the cranial nerves?

   Answer Instruction:

Cranial nerves are PNS nerves that originate or terminate in the brain. There are 12 pairs of cranial nerves, all of which pass through the cranial foramina. There are two types of cranial nerves: sensory nerves (only dominated by sensory fibers) and mixed nerves (containing sensory fibers and motor fibers). The twelve pairs of cranial nerves are: olfactory, optic, oculomotor, troclear, trigeminal, abducen, facial, tracheal, glossopharyngeal, vagus, accessory, and hypoglossal.

4. Describe the functions of the parts of the brain.

   Answer Instructions: The functions of the parts of the brain are: The frontal lobe, as a conscious control of skeletal muscles and intellectual processes, is useful in verbal communication. The parietal lobe, which controls the sensation of the skin and muscles, also controls speech. The Temporal lobe interprets auditory sensation, auditory memory, and sight. The occipital lobe integrates the focusing movement of the eyes and regulates the relationship of visual images to previous experiences and conscious vision. Insular activity regulates memory and integrates other cerebral activities.

5. What do you know about the autonomic nervous system?

   Answers Instruction: The autonomic nervous system consists of motor neurons that control smooth muscle, cardiac muscle, and glands. In addition, the ANS monitors visceral organs and blood vessels with sensory neurons, which provide input information to the central nervous system. The autonomic nervous system is further divided into the sympathetic nervous system and the parasympathetic nervous system. Both of these systems can stimulate and inhibit effectors. However, the two systems work antagonistically. Each system prepares the body for different types of situations.

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CHAPTER 7
CARDIOVASCULAR SYSTEM

Learning Objectives:

1. Understanding the anatomy of the cardiovascular system
2. Understanding the physiology of the cardiovascular system

Introduction:

Since we are aware of the heart's critical function in controlling blood circulation, the heart is one of the most crucial organs in our body. To ensure that blood flows to all areas of the body, our hearts beat continuously throughout the day. The word cardiac, which comes from the Greek word cardia meaning heart, indicates heart-related. One of the human organs involved in the circulatory system is the heart.

One of the most crucial parts of the body is the heart. Blood pumping is the heart's main job. Thus, the heart allows blood to circulate via blood veins throughout the body; when this circulation is compromised, it results in heart disease.

The heart is situated between the right and left lungs, somewhat to the left of the chest. The heart beats more than 100,000 times each day to continuously pump blood through the body's billions of cells, 60,000 miles (96,000 km) of veins. Approximately 2.5 ounces (74 millilitres) of blood are forced into the circulation with each heartbeat. Each minute, this amounts to around 10 quarts (4.7 litres) of blood.

You will learn about the location and composition of the heart, its valves, the blood channels that directly supply the heart, the innervation and characteristics of the heart muscle, and how the heart functions in this chapter.

Topic 1: Anatomy of Cardiovascular System

Our body's cardiovascular system is a vital organ, and as we all know, the heart plays a crucial part in controlling blood circulation. Without being aware of the time, our heart pumps blood throughout our body so that it reaches every region of the body. The heart (Latin: cor) is a muscular chamber that beats repeatedly and rhythmically to pump blood via blood arteries. The term cardiac, derived from the Greek word cardia meaning heart, indicates heart-related. One of the human organs involved in the circulatory system is the heart. One of the most crucial parts of the body is the heart. Blood pumping is the heart's main job. Therefore, the heart helps the blood circulate through the body's blood veins; when this flow is disrupted, it is known as heart disease.

1. Heart Structure

   The heart is situated between the right and left lungs, somewhat to the left of the chest. The heart beats continuously more than 100,000 times a day, forcing blood through the body's billions of cells over a distance of around 60,000 miles (96,000 km). Approximately 2.5 ounces (74 millilitres) of blood are forced into the circulation with each heartbeat. Each minute, this amounts to around 10 litres (4.7 litres) of blood.

   Conical and hollow, the heart is a muscular (cardiac muscle) organ. The base is up above, while the peak is down below. The apex cordis, which is somewhat pointed, is where the chord begins. Cardiac muscle is a unique kind of tissue because, while seeming like a striated muscle from the outside, it really functions more like a smooth muscle and can do tasks that are beyond our control.

   That is why, even as we sleep, our hearts continue to beat. Right hand grip size and weight are around 250–300 grammes. located closer to the left, behind the sternum, in the thoracic cavity, between the lungs. Its base is situated 2 cm from the sternum, between the left 2nd and right 3rd ribs on the right side. The apex is 2 fingers below the mama's papilla, 4 cm from the sternum to the left, and situated between the V and VI ribs (intercostalis V). The loudest heartbeat, known as ictus cordis, may be felt here.

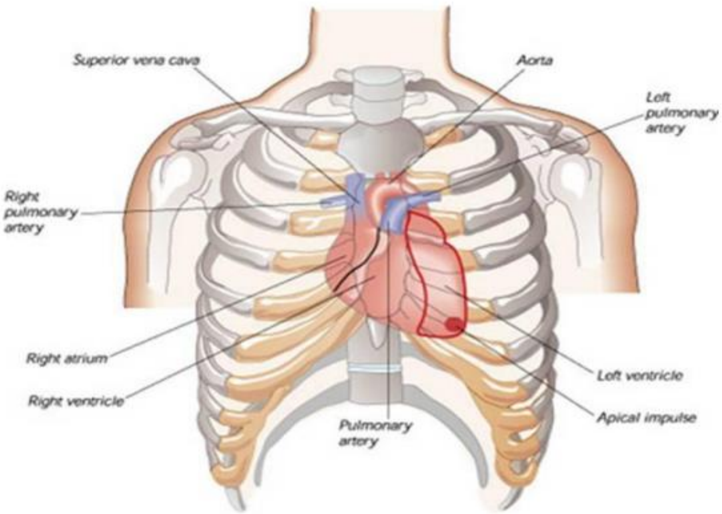

Figure 6.1 Heart Position (Guyton & Hall, 2012)

The three layers of the heart are as follows: the inner layer, known as the endocardium, the middle layer, known as the myocardium (a muscular layer), and the outside layer, known as the pericardium (composed of two layers, located adjacent to the visceral pericardium and outside the parietal pericardium).

The four (four) sections of the heart are as follows:

a. The right atrium, also known as the atrium dextra, is responsible for collecting contaminated blood from the superior and inferior vena cava, which is subsequently emptied into the right ventricle.

b. Right ventricle (dextra ventricle): This area receives blood from the right atrium, which subsequently pumps blood via the pulmonary artery to the lungs when the ventricles contract.
c. The four pulmonary veins transport oxygen-rich blood from the lungs to the left atrium, from which it enters the left ventricle.
d. Left Ventricle: This area takes blood from the left atrium, and when it contracts, it pumps the blood throughout the body.

2. Heart Valves

The heart has four valves, and each one can only open in one way. The Tricuspid Valve, a valve with three calyx that is located between the right atrium and right ventricle, is the first. When blood moves from the right atrium to the right ventricle, this valve will open. When the heart contracts, the tricuspid valve closes to prevent blood flow from returning to the right atrium. The Bicuspid valve, also known as the Mitralis Valve, is the second. Located between the left atrium and left ventricle, this valve has two petals. When blood moves from the left atrium to the left ventricles, this valve opens. The three aortic valves are situated in the aorta, which runs parallel to the left ventricle and is where their name comes from. When the left ventricle contracts, the aorta valve opens, allowing blood to circulate throughout the body. The pulmonary valve, also known as the fourth valve, is a part of the right ventricle and is situated in the pulmonary artery. When blood is pushed from the ventricles dextra to the lungs, these valves will open.

Tricuspid and bicuspid valves are referred to as atrioventricular valves because of their position between the atrium and ventricles. Due to its semi-circular form, the Semilunar Valve is also known as the Aortic Valve and the Pulmonary Valve.

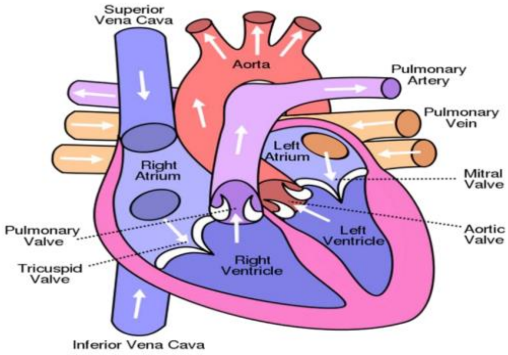

Figure 6.2 Heart Valve (Guyton & Hall, 2012)

3. Heart muscle and Nerve System Characteristics

a. Nerves System

Both sympathetic and parasympathetic nerves supply the heart with blood. Sympathetic nerve endings release the hormone norepinephrine, which has the effect of speeding up the emergence of S-A impulses, speeding up the conduction of all parts of the heart, and increasing the force of contraction of all cardiac muscles, which explains why sympathetic nerves can speed up heart rhythm. Parasympathetic also slows down heartbeat.

The hormone Acetylcholine, which has the following effects (reducing the pace of the S-A node rhythm and slowing supply to the ventricles), is released at the parasympathetic nerve terminals, which causes the parasympathetic (vagus) nerves to slow the heartbeat.

b. Heart muscle characteristics

The following are some characteristics of cardiac muscle such as the capacity to react to a stimulus is known as excitability, automaticity (the capacity to produce impulses devoid of external stimuli), rhythm (heart rhythm), conductivity (the capacity to transmit impulses) and contractility (the capacity to constrict in response to stimuli).

4. Heart Contraction

The autonomic nervous system's stimulus causes the heart to expand and constrict, or contract. The Sino Atrial (SA) Nodus, a group of nerve nodes in the right atrium close to the vena cava's entrance, are where the heart receives this stimulation. Additionally, the AV (Atrio Ventricular) Nodes on the atrium and septum wall will get/receive the stimulus. Package of His - Apex cordis - Purkinje fibres - contraction of all walls.

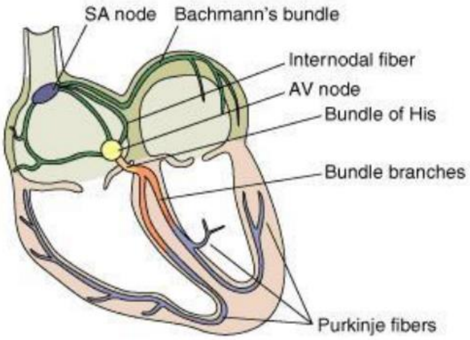

Figure 6.3 Heart Contraction (Guyton & Hall, 2012)

a. Period of Heart Contraction

The heart beats at three (3) different times, including:

1) Contraction/systole period

The bicuspid and tricuspid valves shut at that time, and the ventricles close as well. Blood from the right ventricle passes into the pulmonary artery and into the lungs via the opening of the aortic semilunar valve, whereas blood from the left ventricle goes into the aorta and is circulated throughout the body. The contractions last for 30 seconds.

2) Period of Dilation/Diastole

A syndrome in which the heart enlarges and the bicuspid and tricuspid valves open, allowing blood from the right atrium to enter the right ventricle, blood from the left atrium to enter the left ventricle, and blood from throughout the body to reach the right atrium through the vena cava.

3) Rest Periode

That is, the heart pauses beating for about 1/10th of a second in the interval between contraction and dilatation. At rest, the heart beats 70–80 times per minute. The heart may pump up to 60–70 cc of blood into the aorta with each contraction. When exercising, the heart may beat at a pace of 150 beats per minute and pump 20 to 25 litres per minute.

b. Heart Sounds and Heart Pump Power

The process of opening and shutting heart valves results in noises that are produced by the heart and big blood arteries vibrating. Heart sound is another name for sound heart sound. The first heart sound (S1) and the second heart sound (S2) are the two primary types of normal heart sounds. The mitral and tricuspid atrioventricular valves close, causing the first heart sound (S1) to be heard, and the heart muscles contract, causing S1. The aortic and pulmonary valves, which make up the semilunar valves, close during the second heart sound. The first heart sound, which is often described as sounding like a "lub," has a lower frequency and lasts a little bit longer than the second heart sound. The second heartbeat has a higher frequency, is shorter, and is most intense, and is often compared to a "dup" sound.

The heart beats around 70 times per minute when a person is at rest, pumping 70 ml every beat (pulsing volume of 70 ml). About 5 litres of blood, or 70 x 70 ml, are pushed out each minute. When exercising vigorously, the heart may beat at a pace of 150 beats per minute and a volume more than 150 millilitres each beat, which causes the heart to pump 20 to 25 litres per minute. The terms "stroke volume" and "minute volume," i.e., the volume of blood pumped by each ventricle every heartbeat (70 ml) and per minute, respectively.

c. Effect of Ions on Heart Function

Sidney Ringer noted in 1883 that the presence of ions in the extracellular fluid was required to sustain an isolated pulse and perfusion, indicating that ions play a function in the control of cardiac contraction. Cardiovascular Effects of Ions are:

1) Effects of potassium ions include the dilation and limpening of the heart and a slowing of heart rate. An excess of potassium ions in extracellular fluid. Blocking the propagation of cardiac impulses from the atria to the ventricles will have a significant benefit.
2) Effect of calcium ions: An excess of calcium ions counteracts potassium's effects by forcing the heart to beat rapidly and vigorously, while a deficit makes the heart sluggish.
3) Effect of sodium ions: An overabundance may impair heart function, and calcium ions operate less efficiently the more sodium ions are present in the extracellular fluid. Due to cardiac fibrillation (coordinated contractions), which might result from the very low concentration of sodium ions, death may result.

d. Blood Circulation

The components necessary for blood circulation include:

1) Arteries: supply clean, oxygen-rich blood at high pressure to the tissues (strong walls, rapid flow).
2) Arterioles are the last arteries' branches. They have robust walls and may totally shut or enlarge numerous times, switching the flow to capillaries.
3) Capillaries: a location for fluid exchange, oxygen, carbon dioxide, nutrients, electrolytes, and hormones; they have extremely thin walls and are porous.
4) The venule, which draws blood from capillaries.
5) Veins: carry soiled blood back to the heart from the tissues at low pressure due to their thin walls.

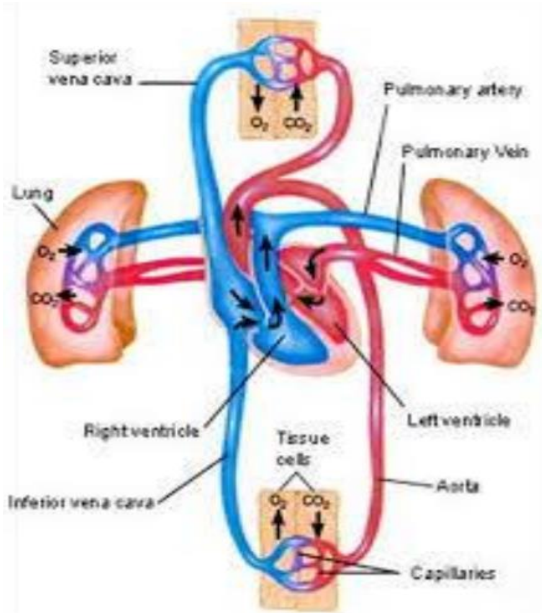

Figure 6.4 Blood Circulation (Guyton & Hall, 2012)

e. Human Circulatory System

The human circulatory system consists of a small circulatory system and a large circulatory system.

Small circulation, namely blood circulation between the heart to the lungs and back again to the heart. Blood travels through: Right ventricle --> Pulmonary artery --> Lungs --> Pulmonary vein --> Left atrium. This blood circulation is also often referred to as pulmonary circulation, because if abbreviated it would be like this Heart -> Lungs -> Heart.

Large blood circulation, namely the circulation of blood from the heart to all body organs and back to the heart. Blood travels through: Left ventricle --> Aorta --> Arteries --> Arterioles --> Capillaries --> Venula --> Vena --> Superior vena cava and inferior vena cava --> Right atrium. This blood circulation is also often referred to as systemic circulation, because if abbreviated it would be like this: Heart --> Whole body --> heart.

Summary

The cardiovascular system is an important system in the body, as it plays a role in the regulation of blood circulation. The heart is a cavity of a muscular organ that pumps blood through blood vessels through repeated rhythmic contractions. It is one of the most important organs of the body, and its function is to pump blood. The location of the heart is slightly to the left of the chest, between the right and left lungs. In continuous work, the heart contracts more than 100,000 times a day, pushing blood through about 60,000 miles (96,000 kilometres) of the ship to nourish each of the trillions of cells in the body.

The heart is a muscular organ that is conical and hollow, with a base located above and the apex below. It is a striated muscle that works beyond our capabilities, is the size of the grip of the right hand, and weighs about 250–300 grammes. It consists of three layers: the endocardium, myocardium, and pericardium. The heart is divided into four parts: the right atrium, the right ventricle, the left atrium, and the left ventricle. Each contraction of the heart forces 2.5 ounces (74 millilitres) of blood into the bloodstream, which adds up to about 10 litres (4.7 litres) of blood every minute.

The apex cordis is located between the V and VI ribs (intercostals V), 4 cm from the sternum to the left, and the loudest heartbeat can be felt in this place. The heart is divided into four valves, each of which can only open in one direction. The tricuspid valve is located between the right atrium and right ventricle and prevents the return of blood flow to the right atrium by closing at ventricular contraction. The bicuspid valve is located between the left atrium and left ventricle and opens when blood flows from the left atrium to the left ventricles. The aortic valve is located in the aorta and opens when the left ventricle contracts and blood flows throughout the body.

The pulmonary valve is located in the pulmonary artery and opens when blood is pumped from the ventricles to the lungs. Cardiac muscle has the following characteristics: excitability, automaticity, rhythm, conductivity, and contractility. The heart can contract and contract due to stimulation from the autonomic nervous system, which is received at the Sino-Atrial (SA) Nodus in the right atrium near the entry of the vena cava. This stimulation is forwarded to the atrium and septum wall by the AV (atrioventricular) nodes, Bundle of His, Apex cordis, and Purkinje fibres. There are three periods in the movement of the heart: the contraction/systole period, the dilation/diastole period, and the rest period.

The duration of contractions is +30 seconds, while the duration of dilation or diastole is approximately 1/10th of a second. At rest, the heart will close 70–80 times per minute and move blood into the aorta as much as 60–70 cc. During activity, the heart rate can reach 150 beats per minute with a pump power of 20–25 litres per minute. Heart sounds are sounds caused by the process of opening and closing heart valves due to vibrations in the heart and large blood vessels. The first heart sound (S1) is caused by the closing of the atrioventricular valves and the contraction of the heart muscles.

The second heart sound (S2) is caused by the closing of the semilunar valves and the contraction of the heart muscles. In a resting person, the heart beats about 70 times a minute and pumps 70 ml per beat. Ions have an effect on heart function, with potassium ions blocking the transmission of cardiac impulses from the atria to the ventricles, calcium ions counteracting the effects of potassium, and sodium ions affecting cardiac function. Blood circulation includes the delivery of high-pressure blood to the tissues, arterioles, capillaries, venules, and veins.

Review Questions

1. List the layers of the heart wall from the outside inward.

   Answer: The layers of the heart wall are made up of the pericardium, which has two layers, the outer parietal and the inner visceral, the middle layer of the myocardium, the muscular layer, and the innermost layer, the endocardium.

2. Describe where the heart's valves are located?
Answer: The tricuspid valve, which is between the right atrium and the right ventricle, the bicuspid valve, which is between the left atrium and the left ventricle, the aortic valve, which is between the aorta and the left ventricle, and the pulmonary valve, which is between the pulmonary artery and the right ventricle, are the locations of the heart valves.

3. Outline the heart muscle's features?
Answer: The following traits of cardiac muscle are present: excitability, or the capacity of the heart muscle to react to a stimulus, Automaticity, or the heart muscle's capacity to produce a stimulus on its own, rhythm, or the capacity to induce pulsations, conductivity, or the capacity to deliver stimuli, and contractility, or the capacity to contract in response to stimulation

4. How does the sound system of the heart function?
Answer: The mechanism of heart sounds can occur due to the closure of the heart valves. Closing of the Atrioventricular valves (Tricuspid and Bicuspid valves) produces the first heart sound, while closing of the Semilunar valves (Aortic and Pulmonary valves) causes the second heart sound.

5. How well do you understand how ions affect the heart?
Answer: The extracellular fluid's excess potassium ions cause the heart to widen and weaken, and the heart rate lowers. This is the impact of potassium ions, one of the many ions, on the heart. The transmission of cardiac impulses from the atria to the ventricles will be inhibited by a very significant excess. Calcium Ion Effect: While a deficit makes the heart sluggish, an excess of calcium ions counteracts the impact of potassium by causing the heart to contract spastically and therefore accelerating the contracting process. Effect of Sodium Ions: An excess may decrease heart activity; calcium ions are less efficient the more sodium ions are present in the extracellular fluid. Due to cardiac fibrillation (coordinated

contractions), which might result from the very low sodium ion concentration, death may result.

6. Describe the blood circulation in the human body?
Answer; Humans have two different forms of blood flow: tiny blood flow and massive blood flow. Small blood circulation occurs when the right ventricle contracts, causing blood to flow to the lungs before returning to the heart, namely the left atrium. Blood is pumped to the aorta as the left ventricle contracts, where it circulates throughout the body before returning to the heart, specifically the right atrium. A tiny circulatory system and a big circulatory system make up the human circulatory system. Small circulation, namely blood flow between the heart and lungs before returning to the heart. Blood travels through: Right ventricle --> Pulmonary artery --> Lungs --> Pulmonary vein --> Left atrium. This blood circulation is also often referred to as pulmonary circulation, because if it is abbreviated it will be like this Heart --> Lungs --> Heart. Large blood circulation, namely the circulation of blood from the heart to all organs of the body and back again to the heart. Blood travels through: left ventricle --> Aorta --> arteries --> arterioles --> capillaries --> venules--> veins --> superior vena cava and inferior vena cava --> right atrium. This blood circulation is also often referred to as systemic circulation, because if abbreviated it would be like this: Heart --> Whole body --> heart.

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CHAPTER 8
LYMPHATIC AND IMMUNE SYSTEMS

Learning Objectives:

1. Understanding the structure and function of the lymphatic and immune systems
2. Understanding the anatomy of the lymphatic systems
3. Understanding the physiology of the lymphatic systems
4. Understanding the anatomy of Immune systems
5. Understanding the physiology of Immune systems

Introduction:

The lymphatic system of the head and neck region is part of the lymphatic system throughout the body, which anatomically consists of lymphatic organs, lymph ducts or vessels, and lymph nodes (or lymph glands) (Munir M., 2000; Ross J., 2009; Guyton A. C., 1994).

The lymphatic system transports fluids called lymph. This fluid distributes cells and immune factors throughout the body. The lymphatic system also interacts with the circulatory system for the drainage of fluids from the cells and tissues of the body. The lymphatic system contains lymphocyte cells that protect the body from various antigens (Ferrer R., 2022). The body is divided into lymph nodes (lymphotomies), where each lymphoma is a specific drainage area for a particular group of lymph nodes. (Feltman & Petterborg, 2023).

Knowledge of lymphatic drainage from various organs is important in diagnosing and treating various diseases, including cancer, because of the physical proximity of the lymphatic system to body tissues, which allows it to carry cancer cells to various organs of the body in a process called metastasis. Even if the lymph nodes are lymphatics and cannot destroy cancer cells, they will become secondary tumour sites. (Ferrer R., 2020)

Under normal conditions, the lymph nodes cannot be palpated. Infection or cancer in an area is drained by lymph vessels to the nodes so that they can be palpated. A certain pathological reaction of the immune system can cause manifestations in the form of anatomical changes, according to the location of the pathological reaction. Almost all forms of inflammation and malignancy in the head and neck region manifest through the head and neck lymph nodes. Therefore, the anatomy of the lymphatic system in the head and neck area is important to understand (Lucioni, M. 2007).

The purpose of presenting this reference is to help understand the anatomy and physiology of the lymphatic system in the head and neck region so that it can become a solid basis for making a diagnosis, planning treatment, and estimating the prognosis of diseases or disorders affecting the head and neck area.

Topic 1: Lymphatic System Anatomy

Broadly speaking the lymphatic system of the body can be divided into the conduction system, lymphoid tissue and lymphoid organs (Figure 8.1). The conducting system transports lymph and consists of tubular vessels namely lymph capillaries, lymph vessels and thoracic duct. Almost all body tissues have lymph vessels or channels that drain fluid from the interstitial spaces (Guyton, 1994).

The definition of lymphatic tissue (or what is often called lymphoid tissue) is reticular connective tissue infiltrated by lymphocytes. This lymphoid tissue is widely distributed throughout the body either as lymphoid organs or as a dense, diffuse collection of lymphocytes. Lymphoid organs are masses or groups of lymphoid tissue surrounded by a connective tissue capsule or covered by epithelium (Ferrer R., 2020; Vanderbilt, 2002).

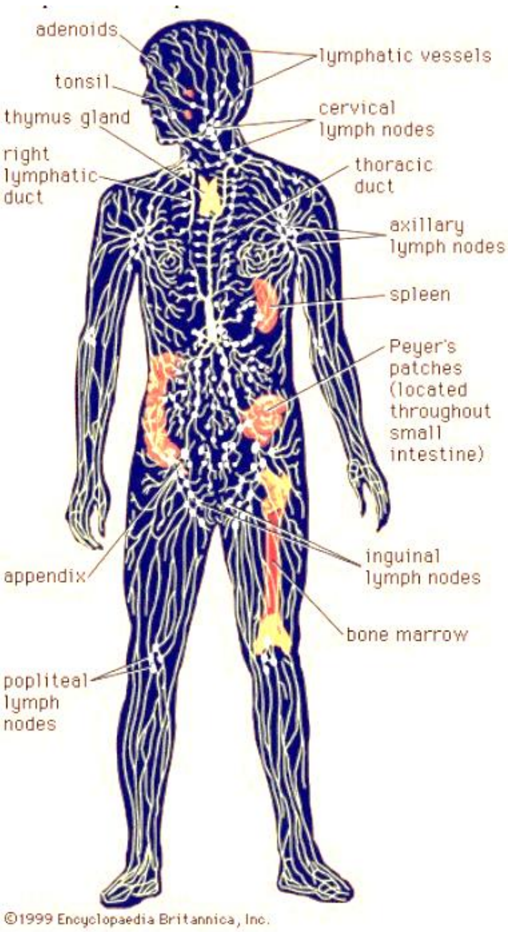

Figure 8.1. Lymphatic System of The Body and Major Lymph Node Groups (Guyton, 1994)

The lymph vessels become bigger and closer to the veins as they go deeper. Lymph vessels contain valves that stop backflow, much as veins do. There is no alternative mechanism to re-absorb protein that has been removed from the interstitial space. The design of the lymph capillaries makes it possible for protein to enter them without any issues. The closing margins of the capillary may expand inward to generate tiny valves that open into the capillaries because there is just a single layer of endothelial cells arrayed like shingles on a roof at the capillary's end (fig. 8.2). Regular contractions of the smooth muscle lining the lymph arteries' walls aid lymph drainage into the thoracic duct (Ross, 2009).

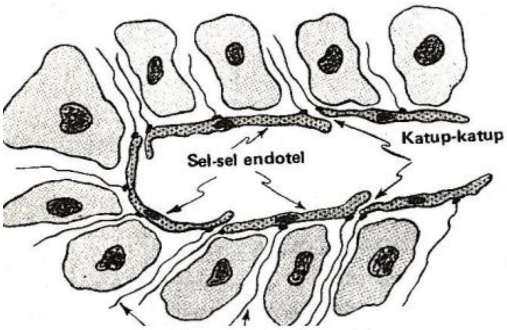

Figure 2. Special Structure of Lymph Capillaries (Guyton, 1994)

Lymphoid tissue. The lymphoid nodes and nodules that make up lymphoid tissue come in different sizes and locations. Nodules range in size from a few microns to several millimetres, whereas nodes are often bigger, measuring 10–20 mm long, and do not contain a capsule. These lymphoid nodes, also known as lymph nodes or lymph nodes, are numerous and range in size from the size of a pinhead to a bean seed. They are dispersed throughout the human body. Throughout the course of a person's existence, the size of these glands may rise or decrease, but any gland that is injured or killed will not grow back. The immune system of the body, lymphoid tissue's role is to fight infections and filter lymph fluid (or lymph fluid). Ross (2009) and Baratawidjaja (2004).

Depending on where they are situated, the majority of these lymphoid nodes are concentrated in certain areas, such as the lips, neck, forearms, armpits, and between the thighs. Organized mucosal lymphoid tissue includes solitary lymphoid follicles, the pharynx, Peyer's patches in the small intestine, and the tonsils.

Lymphoid organs are divided into the following groups based on the stages of growth and maturation of the lymphocytes they contain: 1) Primary or central lymphoid organs, such as the thymus gland and bursa of Fabricius, which assist in producing virgin lymphocytes from immature progenitor cells; these lymphocytes are required for T and B cells to develop, specialize, and proliferate into lymphocytes that can identify antigens; 2) The secondary or peripheral lymphoid organs, which are where antibodies are mostly produced, guide lymphocytes to detect antigens, collect and store antigens, and support the growth and transformation of lymphocytes that are sensitive to certain antigens (Baratawidjaja, 2004; Ross 2009).

The principal secondary lymphoid organs of the immune system include the skin, or skin-associated lymphoid tissue (SALT), mucosal-associated lymphoid tissue (MALT), gut-associated lymphoid tissue (GALT), lymph glands, and spleen. Afferent lymphatic vessels are found only in lymph nodes whereas efferent lymphatic vessels may be found in all lymphoid organs. The connective tissue projections from the fibrous capsule into the lymphoid nodes via the cortex and branching into the medulla that surround lymphoid nodules are known as trabeculae. They divide the lymphoid nodal cortex into incomplete compartments known as lymphoid follicles.

The solid lymphocyte and macrophage aggregates that make up lymphoid nodules are separated by lymphoid sinuses. The medulla is a lumpy mass at the middle. 4,9 From a location known as the hilum, efferent arteries emerge from the nodes (Fig. 8.3) (Darling, 2000).

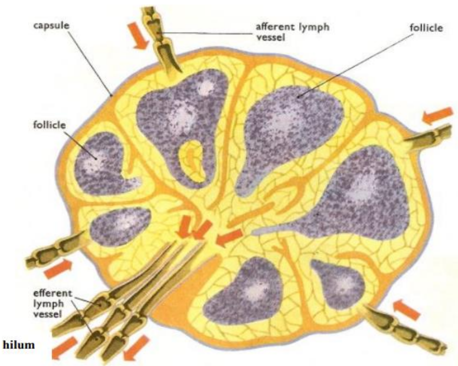

Figure 8.3. Cross Section of a Lymph Node (Darling, 2000)

Topic 2: Lymphatic System Physiology.

The lymphatic system includes the tonsils, spleen, thymus, and other lymphatic organs. The lymphatic system runs parallel to the venous system. While the venous system is in charge of returning blood to the heart and transporting minute molecular components from connective tissue, the lymphatic system is in charge of moving large molecular compounds and fluids from tissues. Molecular compounds with molecular weights of less than 200 include gas, salt, sugar, water, and sugar. Among the huge molecular compounds are all kinds of protein molecules, which have molecular weights ranging from 70 thousand to 130 thousand. Among the burdens that lymph may carry are proteins, immobilised cells, cell fragments, waste metabolites, bacteria, viruses, animated substances, more fluid, and fat.

Based on size and function, the lymphatic system may be broken down into four sections.

1. Lymph capillaries

   The interstitial fluid is emptied by the action of lymph capillaries (lymph creation). Lymph capillaries, which are adjacent to blood capillaries and blanket the body like a net of valveless channels, are present. Since lymph capillaries lack valves, flow occurs in all directions and may be manipulated during treatment to focus on certain therapeutic targets. Endothelial cells, basement membrane, and anchor filaments make up lymphatic capillaries. Endothelial cells that are stacked enable interstitial fluid to enter, which leads to the development of lymph. According to the requirements of the interstitial fluid, lymph capillaries may open and contract.

2. Pre-collector

   The pre-collector serves as a bridge between capillaries and lymphatic collectors from a functional perspective. The pre-collector, which is attached to the lymph capillaries, draws interstitial fluid into the collector by acting like both a capillary and a collector while having smooth muscle cells and valves in certain areas.

3. Collectors and lymphatic trunks

a. The diameter of collectors, or active transport vessels, is 0.1-2 mm. Lymphatic collections and veins share an internal valve that gives them their identical histological characteristics. The passive nature of the lymph valves guarantees that lymph flow is directed toward the centre and prevents backflow. The distance between the two valves is around three to ten times the diameter of the vessel. As a result, the collector has valved every 0.6-2 cm and the thoracic duct has valves every 6-10 cm. The area between the two valves is known as the lymphangion. Depending on the geography, there are three types of collectors:

   1) The observation region is related to the cutaneous vein subcutaneously and surface collectors in the subcutaneous fat tissue that roughen the skin. Each collector is parallel to the ground and joined to the others by the anastomosis of several branches. Lymph may be directed to other veins when one collector is stopped, reducing oedema.
   2) Interfacial collectors in the extremities have a larger diameter than surface vessels. This collection strengthens muscles, ligaments, and joints.
   3) The organ arteries and the intestine collector are parallel.

Each valve on a lymphatic segment only opens in one direction, which establishes the lymph flow's direction and avoids backflow. The ring-shaped smooth muscle in lymphatic veins enables the segments to react to pressure and external stimuli and provide instructions for opening the valves. As a result, the mechanoreceptors in lymphatic vessels are what ultimately control the pulse frequency and flow rate of lymphatic fluid. skeletal muscle movement, arterial pulse, the change in thoracic pressure when breathing, intestinal peristalsis, and a manual lymphatic scan are all examples of stimuli.

The lymphangion contracts on its own, 3–7 times per minute, in the absence of external stimulation. Depending on the impact of stimuli, the lymphatic veins' pulse rate ranges between 1 and 30 times per minute. Stretching the interior lymphatic vessels has the most pulsing impact.

b. The biggest lymphatic vessels are the lymphatic trunks. The extremities and trunk areas that are closest to the viscera (truncus quadrants) get lymph from these core lymphatic veins. It leaves the trunk close to the heart, entering the venous circulation.
   1) Lymphatic trunks of the lower body: it travels via the right and left lumbar regions, connects the gastro-intestinal trunk, and then enters the thoracic duct from the lower extremities, quadrants of the relevant trunks, and the pelvis.
   2) Lymphatic trunks of the upper body, on the left, consisting of the jugular trunk, subclavius trunk, and bronchomediastinalis trunk. On the right, the three main trunks unite to form the lymphatic ducts dextra.

Another pathway for fluid to enter the bloodstream as a transudate is the lymphatic system, where it subsequently contributes to the immunological response of the organism. Generally speaking, lymphatics serve three purposes, including (Farrer, 2020)

a. Raising the amount of tissue fluid and the interstitial fluid pressure while maintaining a low protein content in the interstitial fluid to ensure that blood proteins filtered by the capillaries are kept in the tissues. The lymph pump pumps interstitial fluid into the lymph capillaries, which transport the accumulated extra protein, as a result of the increased pressure. The dynamics of fluid exchange in the capillaries will become irregular in a matter of hours if this system is not working, which would result in death.
b. Transport of fat and chyle (chyle) to the circulatory system and absorption of fatty acids.
c. Production of immune cells, including lymphocytes, monocytes, and plasma cells, which are cells that make

antibodies. When lymphocytes are initially exposed to foreign antigens (viruses, bacteria, or fungus), lymphoid nodes set up the environment so that lymphocytes may be activated to perform immunological activities.

The body's lymphatic system draining. Right and left drainage zones are two distinct and unequal drainage areas that make up lymph drainage. Normally, the lymph flow won't go through the drainage channel's other side. Each region's structures transport the lymph to its final destination, the circulatory system. Lymph from the right side of the head, neck, right arm, and right upper quadrant of the body is received by the right side of the drainage region.

These sites will produce lymph flow into the right lymph duct, which will discharge lymph into the bloodstream through the right subclavian vein. Lymph from the left side of the head, neck, left arm, left upper quadrant of the torso, lower body, and both legs is carried through the left drainage region. Lymph that is rising from the lower body is briefly stored in the cilia of the cisterna. The left lymph duct empties lymph into the circulatory system through the subclavian vein after being reached by the lymph from the thoracic duct (fig. 8.4).

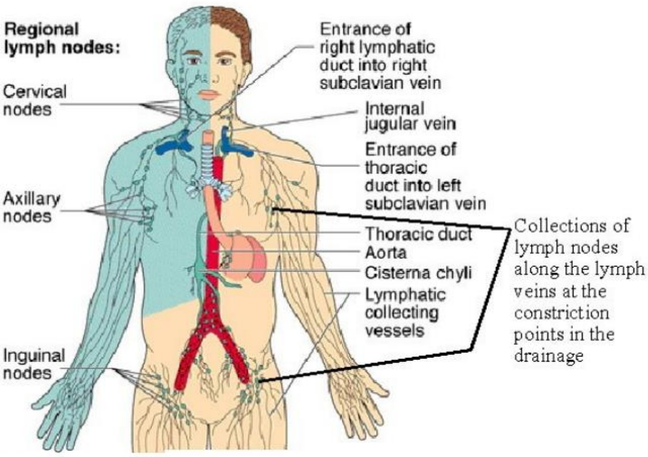

Figure 8. 4. Lymph Flow Drainage (Ross, 2009)

Formation of lymph fluid. The nutrient-rich arterial blood plasma from which lymph, also known as lymph fluid, is derived. The blood flow slows down at the capillary ends, allowing the plasma to escape into a tissue fluid known as intercellular or interstitial fluid. This tissue fluid transports the hormones, nutrients, and oxygen required by cells (Figure 8.5). 90% of the tissue fluid returns the by-products of cellular metabolism to the capillaries where they are converted to plasma before making their way back into the venous circulation. The remaining 10% of tissue fluid is lymph fluid. If the interstitial fluid's function is to transport the nutrients that cells need, lymph's function is to transport metabolic waste for disposal. Highly permeable lymph capillaries gather tissue proteins and fluids. Lymph continues to circulate, dissolving proteins from and between cells, resulting in the fluid's transformation from clear to protein-rich. After then, lymph capillaries combine to create bigger lymphatic vessels with a vein-like configuration. Although there is no pump in the lymphatic channels, the lymph still flows, hastening the venous return to plasma.

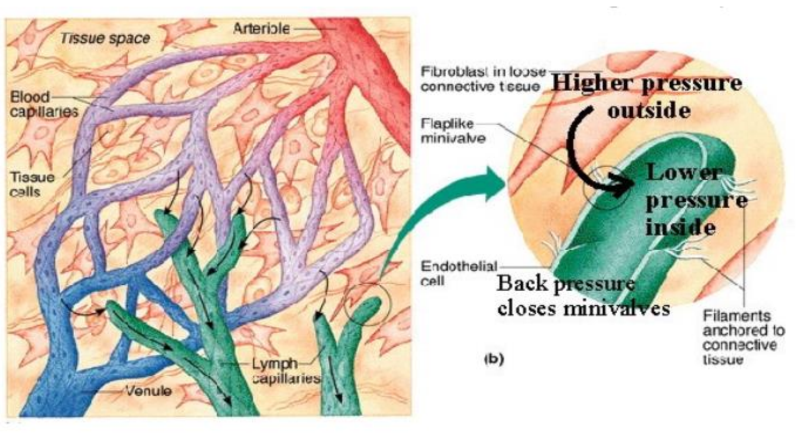

Figure 8.5. Mechanism of Formation of Lymph Fluid (Ross, 2009)

Summary

The conduction system, lymphoid tissue, and lymphoid organs make up the body's lymphatic system. Lymph capillaries, lymph vessels, and the thoracic duct are tubular vessels that make up the conducting system, which transports lymph. Infiltrated by lymphocytes, lymphoid tissue is reticular connective tissue that is widely dispersed throughout the body as lymphoid organs or as a dense mass of lymphocytes. Lymphoid organs are collections or masses of lymphoid tissue that are enveloped in an epithelium or a connective tissue capsule.

Lymphoid tissue is made up of nodes and nodules of various sizes and locations. Nodes are frequently larger and do not have a capsule, whereas nodules range in size from a few microns to several millimetres. They are found everywhere over the human body and are very important to the immune system. Secondary or peripheral lymphoid organs direct lymphocytes to find, gather, and store antigens, whereas primary or central lymphoid organs create virgin lymphocytes from immature progenitor cells. The epidermis, mucosal-associated lymphoid tissue, gut-associated lymphoid tissue, lymph glands, and spleen are examples of secondary lymphoid organs. Efferent lymphatic vessels can be found in all lymphoid organs, whereas afferent lymphatic vessels are only present in lymph nodes.

Large molecules and fluids are moved out of tissues through the lymphatic system, which connects to the venous system. It comprises the lymphatic organs such as the tonsils, spleen, thymus, and others. Blood capillaries are close by lymph capillaries, which produce lymph to drain interstitial fluid. Endothelial cells, basement membrane, and anchor filaments make up these capillaries, which allow interstitial fluid to circulate and provide for specialized medical care.

The pre-collector draws interstitial fluid into the collector by acting as a functional link between capillaries and lymphatic collectors. The pre-collector has smooth muscle cells and valves in certain locations and functions as both a capillary and a collector.

The lymphangion is a ring-shaped smooth muscle in lymphatic veins that responds to pressure and outside stimuli. It is located between the two valves. Depending on the effects of stimuli, the lymphangion contracts on its own 3–7 times each minute.

The lymphatic trunks, which carry lymph from the main lymphatic veins to the extremities and trunk regions closest to the viscera, are the biggest lymphatic vessels. These trunks link to the gastrointestinal trunk and enter the thoracic duct as they pass through the lower body. The jugular trunk, subclavius trunk, and bronchomediastinalis trunk are the three primary trunks of the upper body. The three main trunks combine to produce the ducts dextra. In conclusion, the lymphatic system is in charge of moving big molecules from tissues and fluids, mostly via lymph capillaries, pre-collectors, and lymphatic trunks.

Fluids must enter the circulation through the lymphatic system in order to support the organism's immune response. It performs three functions: transferring fat and chyle to the circulatory system, boosting tissue fluid and interstitial fluid pressure while maintaining low protein content, and creating immune cells such lymphocytes, monocytes, and plasma cells. Right-sided lymph from the body is received by and released into the right subclavian vein via the right and left drainage zones of the lymphatic system. The left drainage area carries lymph from the left side of the body, while the cilia of the cisterna temporarily store fluid from the lower body. The lymph from the thoracic duct enters the left lymph duct and exits into the circulatory system through the subclavian vein.

Intercellular or interstitial fluid, which is a source of nutrient-rich arterial blood plasma, is used to create lymph fluid. The by-products of cellular metabolism are returned to the capillaries by 90% of tissue fluid, where they are transformed into plasma before returning to the venous circulation. Lymph fluid makes up the remaining 10% of tissue fluid. Proteins from and between cells are dissolved by lymph capillaries, which collect tissue proteins and fluids. This process turns the fluid from clear to protein-rich. Although there is no pump in the lymphatic channels, the lymph still flows, accelerating the venous return to plasma. Lymph capillaries join to form bigger lymphatic vessels with a vein-like shape.

Review Questions

1. Where does the lymph fluid come from?
   A. Blood
   B. Blood plasma
   C. Intracellular fluid
   D. Liquid interstitial
   E. Everything is wrong
   Answer: C

2. What are the lymphatic vessels that open into the venous system called?
   A. Aorta
   B. Lymphatic capillaries
   C. Lymphatic vessels
   D. thoracic duct
   E. Everything is wrong
   Answer: B

3. Movement of lymph fluid occurs because, unless:
   A. Pumping of smooth muscle in lymphatic vessels
   B. Skeletal muscle pumping
   C. Sucking the chest cavity on expiration
   D. Muscle
   E. Everything is correct
   Answer: A

4. Edema caused by fluid ingress on:
   A. Intracellular space
   B. Extracellular space
   C. (A) and (B) are correct
   D. (A) and (B) are incorrect

5. Lymph glands are found, among others:
   A. Top of head
   B. Fold the thighs
   C. Legs
   D. Everything is correct
   E. Everything is incorrect
   Answer: B

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CHAPTER 9
DIGESTIVE SYSTEM

Learning Objectives:

1. Understanding the structure of the digestive system
2. Recognizing how the digestive system works

Introduction:

Eating is a fundamental human behaviour that is necessary for energy, maintenance, survival, as well as being the centre of social interaction and cultural identity. The food we eat cannot be used directly for energy or to build tissue structures. Basically, it is the digestive system (digestive system) which is the line of breakdown to break down food into small molecules such as amino acids and monosaccharides so that they can be absorbed and transported into cells. The digestive system functions to process food, extract nutrients from food, and eliminate residual substances. This is done through several stages, namely ingestion, mechanical processes, digestion, secretion, absorption, compaction, and defecation (Saladin et al., 2018; Martini et al., 2018; Eckel, 2018).

This chapter discusses the digestive system which consists of the digestive tract and the digestive glands. The digestive tract from the oral (proximal) to the anal (distal) includes the oral cavity, pharynx, oesophagus, ventricle, duodenum, jejunum, ileum, cecum, appendix vermiformis, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, anal canal, and anus. The digestive glands include the salivary glands, liver, gallbladder bladder, exocrine part of the pancreas, and intestinal glands.

This chapter discusses the digestive system, which consists of the tractus. Digestivus and Glandula digestoria (digestive glands). The tractus digestivus from oral (proximal) to anal (distal) includes the cavitas oris, pharynx, oesophagus, ventriculus, duodenum, jejunum, ileum, cecum, appendix vermiformis, colon ascendens, colon transversum, colon descendants, colon sigmoideum, rectum, canalis analis, and anus. Glandula digestoria includes glandula salivarius, hepar, vesica fellea, pancreatic pars exocrine, and glandula intestinalis.

Some aspects of clinical anatomy related to the digestory system are also discussed briefly as enrichment material. The digestorial system is a system that does not stand alone but is related to other systems. Other systems related to the digestive system are the cardiovascular system, lymphatic system, nervous system, and musculoskeletal system. This system is discussed on its own outside of the chapter. Knowledge of the abdominal walls, surface anatomy, peritoneum, and cavitas peritonii can be acquired on separate topics outside of this chapter. In addition, students will find it easier to study other courses related to systemic digestion, both in normal (physiological) and abnormal conditions (patologis).

Gastrointestinal System

The digestive system, also known as the gastrointestinal system, is a group of internal organs that receives food, breaks it down into nutrients and energy, absorbs those nutrients into the bloodstream, and excretes the parts of the food that cannot be digested or are left over from those processes from the body. It extends from the mouth to the anus. The mouth, throat, oesophagus, stomach, small intestine, colon, rectum, and anus make up the digestive system. The pancreas, liver, and bile cells are examples of extra digestive organs that are a part of the digestive system. According to the sequence of the human gastrointestinal system from the mouth to the abdomen as detailed beginning with the digesting system and its activities, its explanation, and the human gastrointestinal system.

1. Mouth

   Food and liquids may enter the mouth since it is an open cavity. The digestive system may be entered via the mouth. The mucous membrane that lines the interior of the mouth. The taste buds, which are located on the surface of the tongue, detect flavour. The four basic flavours of taste are sweet, sour, salty, and bitter. The incisors on the front teeth chop food into smaller, more easily digestible bits while the molars on the rear teeth eat it. The digestive process starts when the saliva produced by the salivary glands coats the meal components with digestion enzymes. Additionally, saliva includes antibodies and enzymes that directly kill bacteria by dissolving their proteins, such as lysozyme. The enzyme amylase (ptyalin), which breaks down polysaccharides (starch) into disaccharides, is found in the salivary glands. According to Anderson (1999), Syaifuddin (2012), and Pearce (2007), swallowing begins deliberately and continues automatically. Here is the mouth's anatomy for female students: Take note of the components in the mouth (Figure 9.1).

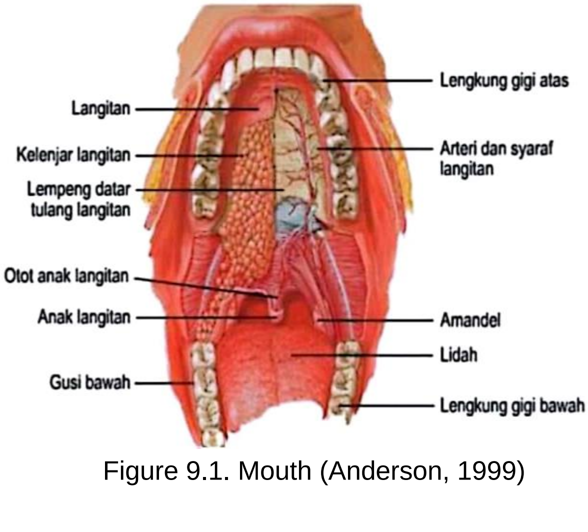

Figure 9.1. Mouth (Anderson, 1999)

The tongue is a mass of striated muscle that is covered with a mucous membrane. Muscle fibres are bundled together and cross over one another in three different planes; connective tissue often separates them. The mucous membrane of the tongue's underside is smooth, while its dorsal surface is uneven and covered with many tiny protrusions known as papillae. The tongue's papillae are protrusions of the lamina propria and oral epithelium, each of which is assumed to have a unique structure and function. The tongue has four different kinds of papillae, which are as follows:

a. Papillae filiformis

   The surface of the tongue is covered with thin, very numerous, chronically projecting filiform papillae. Taste receptors (taste buds) are not present in the epithelium.

b. Papillae fungiformis

   Fungiform papillae are shaped like mushrooms because they have broad top surfaces and slender stems. Taste buds are dispersed on the top surface of these papillae, unevenly positioned amongst the many filiform papillae.

c. Papillae foliate

   The foliate papillae are placed along the rear lateral border of the tongue as extremely many projections. There are a lot of soy nipples in these papillae.

d. Papillae circumvallate

   Large papillae with a flat surface that protrudes over other papillae are known as papillae circumvallate. The "V" region on the back of the tongue is covered with Papillae circumvallate. Numerous serous (von Ebner) and mucous glands deposit their contents into the deep grooves that encircle each papilla's edge. As a result of this trench-like configuration, fluid may continuously flow across the many taste receptors that line the sides of these papillae. This secretory flow is crucial for clearing debris from the area surrounding the taste receptors so that they can take in and process fresh sensory input. Small mucous and serous glands are dispersed across the walls of the other oral cavities, such as the epiglottis, throat, palate, and so on, to react to taste stimulation in addition to the serous glands associated with this kind of papillae (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007).

2. The Throat/Pharynx

   The throat, also known as the pharynx, connects the oesophagus to the mouth cavity. Tonsils, or lymph glands, which contain many lymphocyte glands and provide a defence against infection, are located within the pharyngeal arch. The state of the pharynx is linked to the nasal cavity up front by a hole known as the choana, and the state is connected to the oral cavity via a hole known as the isthmus faucium. The neck is divided into the following three sections:

   a. Superior Section

      The nasopharynx is the name of this region. The pharynx and the eardrum space are connected by a tube that the nasopharynx opens.

   b. Section on media

      The mouth and this portion share the same height. The oropharynx is the term for the medial portion. The forward boundary of this segment ends at the tongue's base.

   c. Inferior Section

      The larynx and this region both measure the same height. The oropharynx and larynx are connected by the inferior portion, which is known as the larynx gopharynx.

3. Oesophagus

   The oesophagus is a muscular tube in vertebrates through which food passes from the mouth into the stomach. Often also called the oesophagus (from the Greek). Oesophageal length ±20 cm and width ±2 cm. This organ serves to connect the mouth with the stomach. Food travels through the oesophagus using the process of peristalsis. Oesophageal peristalsis includes widening, narrowing, wavy, and squeezing movements so that food is pushed into the stomach. In the oesophagus, food substances do not experience digestion. The oesophagus meets the pharynx at the 6th vertebra of the spine. According to histology, the oesophagus is divided into three parts, namely the superior part (mostly skeletal muscle), the middle part (a mixture of skeletal and smooth muscle), and the inferior part (mainly consisting of smooth muscle) (Anderson, 1999; Syaifuddin, 2012, Pearce, 2007).

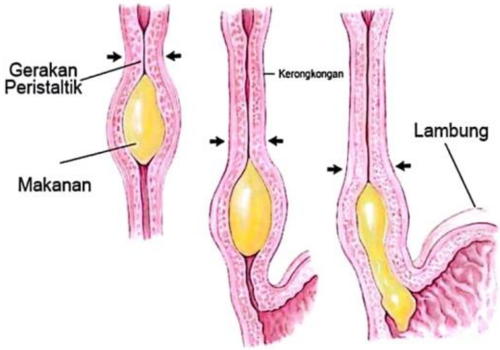

Figure 9. 2. Oesophagus (Anderson, 1999)

4. Gaster

   Gaster is a large, muscular, hollow organ with a donkey-cage-like form. Three areas make up the stomach, and they are as follows:

   a. Cardiac, or the oesophagus, is the first section of the stomach to receive food from the oesophagus.
   b. Fundus, the portion of the stomach in the centre where food is digested chemically with the assistance of enzymes.
   c. Pylorus, the last section of the stomach that serves as an exit for food into the small intestine.

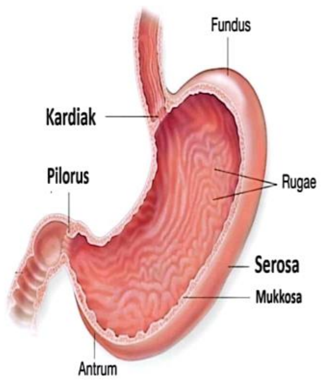

Figure 9.3. Gaster (Sloane, 2012)

5. Small intestine

The digestive tract's section between the stomach and the large intestine is known as the small intestine. Blood vessels that carry chemicals absorbed into the liver through the portal vein are abundant in the gut wall. Mucus and water are expelled from the intestinal wall, which lubricates the intestinal contents and aids in dissolving food particles that have been partially digested. Small quantities of enzymes that breakdown protein, sugar, and fat are also released from the gut wall (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

The small intestine's lining is made up of the serosa layer (outer side), the serosal layer (inner side), the circular muscle layer (musculus circular), and the mucosal layer (musculus longitudinal). The duodenum, empty intestine (jejunum), and intestinal absorption (ileum) make up the small intestine.

a. The duodenum.

The small intestine's duodenum joins the empty intestine (jejunum), which is located after the stomach, to the small intestine. Twelve fingers are what the Latin word duodenal digitorum, from whence the word duodenum derives, signifies. The duodenum, which begins at the bulb duodenale and ends at the ligament of Treitz, is the smallest portion of the small intestine. The peritoneal membrane does not entirely enclose the retroperitoneal organ known as the duodenum. The pH of the duodenum is typically about nine. There are two ducts from the pancreatic and gallbladder in the duodenum. The duodenum, the first segment of the small intestine, receives food from the stomach. Through the pyloric sphincter, food that the small intestine can digest reaches the duodenum. The duodenum will notify the stomach to cease taking in food if it is full.

b. Jejunum

Between the duodenum (also spelled duodenum) and the ileum (also spelled ileum), in the small intestine, lies the jejunum (also spelled jejunum). The word "jejunum" comes from the English adjective "jejune," which meaning "hungry" in the present day. Jejunums, which means "empty" in Latin, is where its original meaning was from. The total small intestine of an adult is 2 to 8 meters long, of which 1-2 meters are the empty gut. A mesentery holds the absorptive intestine and the empty gut in place inside the body. A mucous membrane covers the inside of the empty intestine, while intestinal projections (villi) extend the gut's surface. By having fewer Brunner's glands than the duodenum, it may be differentiated histologically. It may be distinguished from intestinal absorption histologically by the absence of goblet cells and Peyer's plaques. Macroscopically, it might be challenging to tell the empty gut from the absorption intestine.

c. Ileum

The small intestine's last section is the ileum. The ileum, which is between two and four meters long and situated between the duodenum and the jejunum in the human digestive system, is followed by the appendix. The ileum serves to absorb vitamin B12 and bile salts and has a pH between 7 and 8 (neutral or slightly alkaline) (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007).

6. Colon

The small intestine has an appendix, which serves as an extra intestine, while the big intestine continues that small intestine. The ascending, transverse, and descending portions make up the three sections that make up the large intestine. There is no digestion in the big intestine. E. coli bacteria will assist in the decomposition of all remaining food, yielding vitamin K. A rectum that eliminates leftover food into the anus is located at the end of the large intestine. This organ's primary job is to extract water from excrement.

The large intestine's abundance of bacteria aids in the digestion of certain substances and the absorption of nutrients. Additionally, the large gut bacteria produce critical chemicals like vitamin K. These microbes are necessary for the gut to operate normally. The bacteria in the large intestine may be affected by several illnesses and drugs. As a consequence, inflammation takes place, which may lead to the discharge of mucus and water as well as diarrhoea.

According to anatomical terminology, the appendix, also known as the cecum (Latin: caucus, blind), is a sac that is related to intestinal absorption and the ascending colonic portion of the large intestine. An extra organ in the appendix is the appendix, or appendix. Appendicitis, or inflammation of the appendix, is the medical term for an infection of this organ. Peritonitis (infection of the abdominal cavity) may result from severe appendicitis, which can cause the appendix to rupture and produce pus in the abdominal cavity.

The appendix, also known as the vermiform appendix or just the appendix in English, is the caecum's connecting tube's blind end. The cecum gives rise to the appendix during the embryonic period. The worm's tassel is usually approximately 10 cm long in adults but may be as long as 20 cm. The appendix is usually in the same place, although its tip may sometimes be found at a different place, either retrocecal or in the abdomen (pelvis), even if it is still plainly in the peritoneum. Some individuals think the appendix is a vestigial organ that serves no use, whereas others think it has a role in the lymphatic system. Appendectomy is the medical term for the procedure to remove the appendix (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

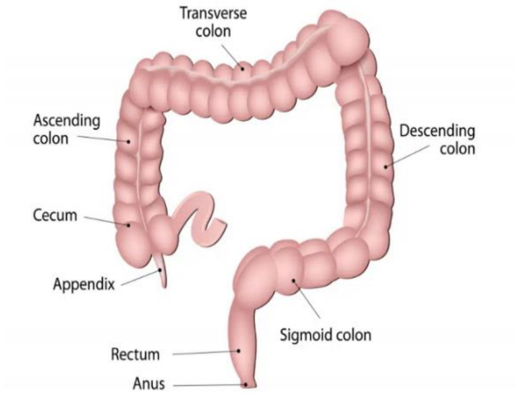

Figure 9.4. Colon
(*Google Source* 2023: Adobe Stock, Licensed to TeachMeSeries Ltd)

7. Rectum (Anus)

The large intestine's end (after the sigmoid colon), where the rectum (Latin: *regere*, "to straighten, to set") starts, meets the anus. This organ serves as a spot where wastes are temporarily stored. Because faeces are held further up, in the descending colon, the rectum is often empty. The desire to urinate (BAB) develops if the descending colon is full and faeces reaches the rectum. The neurological system is triggered by the enlargement of the rectal wall brought on by the build-up of material in the rectum, which results in the need to urinate. Material is often returned to the large intestine if faeces is absent, where water absorption is then restarted. Constipation and hardening of the stool will happen if defecation is delayed for a long time. The ability to regulate one's muscles is necessary for postponing bowel motions in adults and older children, but it is difficult for newborns and younger children to resist this impulse (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

The anus is the exit point for waste from the body at the conclusion of the digestive system. The skin and the remaining portion of the intestine make up the majority of the anus. The sphincter muscles control the anus's opening and closure. The primary function of the anus is defecation, or bowel defecation, which removes faeces from the body. The pancreas, liver, and gallbladder are examples of extra-digestive organs that are a part of the digestive system.

8. The Pancreas

The pancreas is an organ of the digestive system that primarily produces hormones like insulin as well as digestive enzymes. The pancreas and duodenum have a tight relationship and are situated at the back of the stomach (duodenum). Acini, which generate digestive enzymes, and pancreatic islets, which create hormones, are the two primary tissues that make up the pancreas.

The pancreas distributes hormones into the blood and digesting enzymes into the duodenum. Proteins, carbs, and lipids will all be digested by the pancreas's enzymes. Proteins are released in an inactive state after being broken down by proteolytic enzymes into a form that the body can utilise. Only until it has entered the digestive system will this enzyme become active. Large quantities of sodium bicarbonate are also released by the pancreas, which protects the duodenum by dissolving stomach acid (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

9. The Liver

Being the biggest organ in the body, the liver serves several purposes, some of which are connected to digestion. Hepar, the Greek word for liver, is often the first letter in medical phrases referring to the liver. The body uses this organ for a number of purposes, including drug neutralization, plasma protein synthesis, glycogen storage, and metabolism. Bile, another substance produced by the liver, is vital for digestion.

Food nutrients are absorbed into the gut wall's abundance of capillaries, which are tiny blood vessels. These capillaries release blood into veins that connect to bigger veins and ultimately form the portal vein, which enters the liver. In the liver, where incoming blood is processed, the portal vein is split into tiny veins. The liver works quickly to complete this process, after which the blood enters the general circulation after being enhanced with nutrients (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

10. Gallbladder

    The gallbladder is a pear-shaped organ that can store about 50 ml of bile that the body needs for the digestive process. In humans, the gallbladder is about 7-10 cm long and has a dark green colour, not because of the colour of the tissue, but rather because of the colour of the bile it contains. This organ is connected to the liver and duodenum via the bile duct. Bile has 2 important functions, namely helping digestion and absorption of fat, and playing a role in removing certain wastes from the body, especially haemoglobin (Hb) which comes from the destruction of red blood cells and excess cholesterol. (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

Digestive Glands

The digestion of food in the digestive tract is assisted by enzymes. Digestive enzymes are produced by the digestive glands. Here are the digestive glands on man.

1. Parotid Gland (salivary gland)

   The salivary glands are located beneath the tongue, on each side of the lower jaw, on the right and left of the pharynx, and on either side of the ear. Saliva is produced by the salivary glands. Saliva production is influenced by psychological factors that picture certain meals and reflexes triggered by food entering the mouth. The salivary amylase enzyme, ptyalin, is present in saliva.

Mammals have salivary glands, which are exocrine glands, meaning they have their own ducts and generate saliva. Amylase, an enzyme that converts carbs into maltose, is also secreted by this gland. In humans, this gland is located below the tongue. Dehydration, heartburn, or a sickness may all affect saliva production (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

2. Submandibular Gland

   A pair of glands called the submandibular glands are situated in the lower jaw, above the digastric muscle. Its secretory output, which is a combination of serous and mucous, travels via Wharton's duct and enters the mouth. Despite being smaller than the parotid glands, these glands account for around 70% of the oral cavity's saliva production.

   The submandibular gland is a tubularian gland with branches. The mucosal cells and seromucous make up the secretory portion. Protein secretory granules with mediocre amyloid activity are seen in seromucous cells. The lysozyme enzyme, whose primary function is to dismantle the bacterial wall, is present in and secreted by the cells of the submandibular and sublingual glands.

3. Sublingual Gland

   A pair of glands called the sublingual glands are situated below the tongue, next to the submandibular glands. These glands are the departure points for around 5% of the saliva that enters the mouth cavity. The sublingual gland is a tubuloacinary gland with branches.

4. Gaster Gland

   Hydrochloric acid (HCl), renin enzymes, and pepsin enzymes are all produced by glands in the stomach. Pepsinogen, which is activated by stomach acid, yields the enzyme pepsin. The response that occurs when food enters the stomach and the hormone gastrin secreted by the stomach wall both have an impact on the production or release of gastric acid. Stomach wall irritation may result from too much stomach acid production.

5. The Liver

The biggest gland in the body, the liver (Greek: *ἡ ha*, *hēpar*), is situated on the right side of the abdominal cavity, immediately below the diaphragm. The liver is also listed as a method of excretion based on its activities. This is due to the liver's role in assisting kidney function, which includes the breakdown of a number of harmful substances and the production of ammonia, urea, and uric acid by using nitrogen from amino acids. by a hazardous substance known as the liver detoxification process.

Parenchymal and non-parenchymal cells make form the lobes of the liver. Hepatocytes, which are parenchymal cells and make up around 80% of the liver's volume, are responsible for the majority of the organ's activities. The sinusoidal lobes contain 40% of the liver's cells. Hepatocytes are endodermal cells that mesenchymal tissue constantly stimulates throughout embryogenesis until they differentiate into parenchymal cells. As a catalyst for endodermal cell proliferation and hepatocyte differentiation, albumin mRNA transcription increased during this time.

Hepatocytes carry out a variety of duties that the liver does. No other organ, artificial organ, or piece of machinery has yet been discovered that can perform all the tasks of the liver. Liver dialysis is a therapy option for individuals with liver failure that may replace some of the functions of the liver.

The liver, which functions as a gland, generates up to 12 litres of bile per day. Old red blood cell hemoglobin is converted into bile, a bitter-tasting, greenish liquid that is retained in the gallbladder or expelled into the duodenum. The pigments bilirubin and biliverdin as well as mineral salts, bile salts, and cholesterol are all found in bile. Activating lipase, assisting with fat absorption in the gut, and converting chemicals that are water-insoluble into substances that are water-soluble are all benefits of bile production. If the liver's bile duct is clogged, bile enters the bloodstream and causes the patient's skin to become yellow. According to Anderson (1999); Syaifuddin (2012); Pearce (2007); and Sherwood (2001), such a person has jaundice.

6. Pancreas Gland

The pancreatic gland is situated close to the stomach in the abdominal cavity. Amylase, trypsinogen, lipase, and $NaHCO_3$ are the digestive enzymes produced by the pancreas and released into the duodenum. The hormone secretin affects the pancreas' ability to secrete enzymes.

When food reaches the duodenum, the hormone secretin is created. Endocrine and exocrine glands are found in the pancreas. The exocrine glands, which are made up of grape-like clusters of secretory cells that form sacs (acini), are the body's main structural components. The pancreas contains islets of Langerhans, which make up the endocrine glands. The pancreas' exocrine glands secrete. Pancreatic enzymes, produced by acinus cells

a. Trypsinogen, chymotrypsinogen, and procarboxypeptidase are examples of proteolytic enzymes. Trypsinogen is an inert form that, after being released into the duodenal lumen, is turned into trypsin by enterokinase in the small intestine. Chemotrypsinogen and procarboxypeptidase are subsequently changed into chymotrypsin and carboxypeptidase by trypsin. These proteolytic enzymes all attack peptide bonds in distinctive ways. An amalgam of amino acids and short peptide chains is the final product. Polysaccharides are transformed into the disaccharide maltose by pancreatic amylase. Since amylase doesn't damage the secretory cells, it is secreted in an active state. Triglycerides are broken down into absorbable fat molecules called monoglycerides and free fatty acids by pancreatic lipase. Steatorrhea (excess fat in the stool) may result from significant maldigestion of fat caused by pancreatic enzyme deficiency.

b. Alkaline is diluted by pancreatic duct lining cells. $NaHCO_3$ is prevalent in this alkaline liquid. Its purpose is to neutralize the enzyme-produced acidic chyme from the stomach. pH levels that are neutral or slightly alkaline are ideal for the pancreas to function (Anderson, 1999; Syaifuddin, 2012; Pearce, 2007; Sherwood, 2001).

Summary

The digestive system, also referred to as the gastrointestinal system, is a collection of bodily organs that receives food, breaks it down into nutrients and energy, absorbs those nutrients into the bloodstream, and excretes the parts of the food that cannot be digested or are waste products from those processes. It encompasses the mouth, throat, oesophagus, stomach, small intestine, colon, rectum, and anus, and it stretches from the mouth to the anus.

Because the mouth is an open orifice, food and liquids may enter the digestive system via it. Taste buds pick up tastes on the smooth mucous membrane that coats the inside of the mouth. The molars on the back teeth consume the food that the incisors on the front teeth slice into smaller, more readily digestible pieces. The salivary glands' production of saliva coats the meal's components with digestive enzymes, which triggers the beginning of the digestive process. Polysaccharides (starch) are broken down into disaccharides by the enzyme amylase (ptyalin).

The tongue has four distinct types of papillae: filiformis, fungiformis, foliate, and circumvallate. It is a mass of striated muscle coated with mucous membrane. The tongue contains four distinct papillae types: circumvallate, foliate, fungiformis, and filiformis. The pharynx, sometimes referred to as the pharynx, joins the mouth cavity with the oesophagus. Lymph glands called tonsils are found in the pharyngeal arch. The pharynx is linked to the oral cavity by the isthmus faucium and the nasal cavity in front via the choana.

In vertebrates, the oesophagus is a muscular tube that allows food to go from the mouth to the stomach. It produces peristalsis, which includes wavy, expanding, and squeezing actions to drive food into the stomach, and connects the mouth with the stomach. The oesophagus is split into three sections that meet the pharynx at the sixth vertebra of the spine: the superior section, which is mostly made up of skeletal muscle, the middle section, which is made up of both skeletal and smooth muscle, and the inferior section, which is primarily made up of smooth muscle.

The stomach is a large, muscular, hollow organ that resembles a donkey cage. The oesophagus, fundus, and pylorus, which acts as an entrance for food into the small intestine, make up this structure. The digestive tract's portion between the stomach and the large intestine is known as the small intestine. The gut wall is full with blood vessels that transport substances into the liver through the portal vein. Intestinal mucus and water are released, lubricating the intestinal contents and helping to dissolve partly digested food particles. Additionally, small amounts of digestive enzymes for protein, sugar, and fat breakdown are released from the gut wall.

The serosa layer (outer side), serosal layer (inner side), circular muscle layer (musculus circular), and mucosal layer (musculus longitudinal) make up the small intestine's lining. The small intestine is made up of the duodenum, the jejunum (empty gut), and the ileum (intestinal absorption). Food is taken into the duodenum from the stomach, which then alerts the stomach when it is full. Between the duodenum and the ileum, the jejunum absorbs bile salts and vitamin B12 and has a pH of 7 to 8.

The large intestine continues the small intestine whereas the small intestine contains an appendix that acts as an additional intestine. The big intestine's profusion of bacteria helps the body digest certain substances and absorb nutrients. In order for the gut to function correctly, important substances like vitamin K must be produced by the big gut bacteria. The appendix, sometimes referred to as the cecum, is a sac connected to intestinal absorption and the large intestine's ascending colon. It is an additional organ in the appendix that has the potential to inflame the surrounding tissue and lead to peritonitis, an infection of the abdominal cavity. Although the appendix is often in the same location, its tip may sometimes be discovered in a different location, such as the retrocecrum or the abdomen (pelvis).

In conclusion, the Gaster is a sophisticated organ with several functions that is essential to the digestive system. Understanding the many parts of the small intestine and its function in the digestive system is crucial due to its complexity. The large intestine's terminus, the rectum (anus), is where wastes are momentarily held. As the place where waste leaves the body, it is essential for bowel motions. Defecation, the process by which faeces are expelled from the body, is mostly carried out through the anus. At the rear of the stomach, the pancreas produces both hormones and digestive enzymes. In addition to digesting enzymes in the duodenum, it distributes hormones throughout the circulation.

The liver, the biggest organ in the body, has a number of functions, including metabolism, glycogen storage, plasma protein synthesis, and drug neutralization. The liver produces bile, which is essential for digestion. The capillaries of the gut wall absorb nutrients from food, releasing blood into veins that eventually link to larger veins to create the portal vein, which reaches the liver. The blood enters the general circulation after being enriched with nutrients as the liver works swiftly to finish this process.

A pear-shaped structure called the gallbladder holds the approximately 50 cc of bile required for digestion. The bile duct connects it to the liver and duodenum. Bile has two crucial roles in the body: it aids in fat digestion and absorption and eliminates waste products, mainly haemoglobin (Hb), from the system.

The digestion of food in the digestive system is greatly aided by the digestive glands. The exocrine salivary glands are situated underneath the tongue and generate saliva. The enzyme ptyalin, which they release, turns carbohydrates into maltose. Around 70% of the saliva produced by the oral cavity is produced by the submandibular glands, which are located in the lower jaw. Around 5% of the saliva that enters the oral cavity leaves via the sublingual glands, which are located under the tongue.

Hydrogen chloride (HCl), renin enzymes, and pepsin enzymes are all produced by the gastric glands. The reaction to food entering the stomach and the hormone gastrin secreted by the stomach wall have an effect on how much gastric acid is produced or released. Too much stomach acid production might cause inflammation of the stomach wall.

The liver, the biggest gland in the body, is located just below the diaphragm on the right side of the abdominal cavity. In addition to creating ammonia, urea, and uric acid, it is in charge of helping the kidneys operate. The bulk of the liver's functions are carried out by hepatocytes, which account for around 80% of the organ's volume. For those with liver failure, liver dialysis is a treatment option that might take over some of the activities of the liver.

In the abdominal cavity, the pancreatic gland is located adjacent to the stomach. It generates gastrointestinal enzymes such trypsinogen, lipase, amylase, and $NaHCO_3$. The secretion of enzymes by the pancreas is impacted by the hormone secretin. The pancreas contains both endocrine and exocrine glands, with exocrine glands serving as the body's major structural elements. Trypsinogen, chymotrypsinogen, and procarboxypeptidase are some of the pancreatic enzymes. These enzymes destroy peptide bonds in unique ways, resulting in a mixture of short peptide chains and amino acids. Polysaccharides are converted to maltose by pancreatic amylase, whilst glycerides are broken down into monoglycerides and free fatty acids by lipase. Steatorrhea may be brought on by severe maldigestion of fat brought on by a lack of pancreatic enzymes. Pancreatic duct lining cells dilute the alkaline liquid, which is mostly composed of $NaHCO_3$. The pancreas performs best at pH values that are neutral or slightly alkaline.

Review Questions

1. Please explain what the function of the tongue is in the oral cavity!
   Answer: The functions of the tongue in the oral cavity are: mastication (chewing), deglutition (swallowing), and taste (speaking).
2. Please describe the 3 pairs of salivary glands found in the oral cavity!
   Answer: The three pairs of salivary glands found in the oral cavity are: Parotid Glandula is the largest gland found in the mouth and has a channel called Stensen, Sub Maxillary gland is the second largest gland with the channel is called Wharton's, and the Sub Lingualis gland is the smallest gland which is a collection of glands with two ducts.
3. What do you know about the function of the small intestine?
   Answer: The function of the small intestine is: most (85%) digestion and absorption, perfecting the digestion of maltose into glucose, peptones into polypeptides/amino acids and fats into glycerine and fatty acids.
4. Please describe the parts of the colon?
   Answer: The parts of the colon are: ascending colon (right), transverse colon, descending colon (left) and sigmoid.
5. What do you know about pancreas?
   Answer: The pancreas is an organ in the digestive system that has two main functions, namely to produce digestive enzymes and several important hormones such as insulin. The pancreas is located in the posterior part of the stomach and is closely related to the duodenum (duodenum). The pancreas consists of 2 basic tissues, namely: acini, which produce digestive enzymes and pancreatic islets, which produce hormones.
6. Explain what the function of bile is!
   Answer: has 2 important functions, namely: Helps digestion and absorption of fat and plays a role in removing certain wastes from the body, especially hemoglobin (Hb) which

comes from the destruction of red blood cells and excess cholesterol.

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CHAPTER 10
ENDOCRINE SYSTEM

Learning Objectives:

Understanding Kind of endocrine gland, endocrine gland function, mechanism of action of hormones and mechanism of action of enzymes

Introduction:

The endocrine system is a group of glands that create hormones to control functions including metabolism, mood, sleep, reproduction, and sexual function. The Greek word *endo*, which means "secret" in the sense of "crinis," is where the English term "endocrine" originates. In addition to processing and excreting items required for use elsewhere in the body, this gland eliminates substances from the blood (White, Duncan, & Baumle, 2013).

Every hormone generated by these glands is designated against certain networks and organs before it circulates throughout the body. When hormone levels are either too high or too low, disease results. Hormones are chemical compounds that a single cell or a group of cells produce into bodily fluids and which have a physiological regulatory influence on cells in another body. The hormone system regulates a variety of bodily metabolic processes, including the speed at which chemical reactions occur inside cells, the movement of materials across the cell membrane, and other elements of cell metabolism including growth and secretion.

Some of this hormone's effects may happen instantly, while others take a few days to manifest and can endure for many weeks, months, or even years. There are several linkages between the hormonal system and the neurological system. For instance, the medullary adrenal and pituitary glands are two glands that nearly exclusively discharge their hormones in response to proper nerve stimulation. Instead, the majority of the other endocrine glands are primarily controlled by hormones released by the pituitary gland.

1. Kind of endocrine gland and function

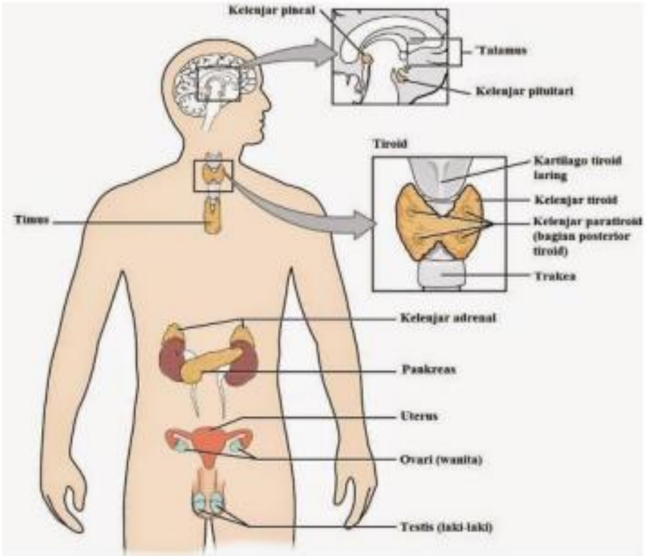

Figure 10.1. Kind of Endocrine Gland (Tortora & Derricson, 2014)

a. Pituitary Gland

Alternatively referred to as the pituitary gland, The pituitary (or hypophyseal) stalk connects the hypothalamus to the sella turcica, the hollow bone at the base of the brain, where there is a little gland with a diameter of approximately 1 centimetre and a weight of 0.5 to 1 gram. from the corner looking out. The anterior pituitary, also known as the adenohypophysis, and the posterior pituitary, sometimes known as the neurohypophysis, are the two physiologically distinct portions of the pituitary gland. The pars intermedia, a tiny, comparatively avascular region between these two portions, is essentially non-existent in humans but considerably bigger and more functioning in several lower species of animals.

1) Anterior
   - Most cells and tissues in the body expand as a result of growth hormone.
   - Adrenocorticotropin: stimulates the release of adrenocortical hormones from the adrenal cortex.
   - Thyroxine and triiodothyronine are secreted by the thyroid gland in response to thyroid stimulating hormone.
   - Before ovulation, follicles in the ovaries expand, and sperm production in the testes is increased by follicle stimulating hormone.
   - The hormone lutein plays a crucial part in the ovulation process. It also triggers the release of testosterone from the testes and female sex hormones from the ovaries.
   - Milk production and breast growth are encouraged by prolactin.
2) Posterior
   - The antidiuretic hormone (also known as vasopressin), which induces the kidneys to retain water, raises the body's water content. When present in large amounts, it also elevates blood pressure and narrows blood vessels all throughout the body.
   - Oxytocin causes the uterus to contract during labour and aids in the baby's expulsion. It also causes the myoepithelial cells in the breast to contract, extracting milk when the infant sucks from the breast.

b. Adrenal Cortex

At the superior poles of both kidneys are the two adrenal glands, which each weigh around 4 grams. The medulla adrenals and the adrenal cortex are the two separate components that make up each gland. The 20% of the gland that makes up the adrenal medulla functions as a part of the sympathetic nervous system and secretes the stimulating chemicals epinephrine and norepinephrine to promote sympathetic activation. Next, these hormones will have a result that is quite similar to that produced by directly stimulating the sympathetic nerves all throughout the body.

1. Cortisol regulates the metabolism of proteins, carbohydrates, and fats via a number of metabolic processes.
2. Aldosterone increases potassium excretion while decreasing sodium excretion via the kidneys, increasing both the quantity of sodium in the body and the amount of potassium.

c. Thyroid Gland

Thyroxine and triiodothyronine, also known as T4 and T3, are two important hormones secreted by the thyroid gland, which is situated immediately below each side of the larynx and is anterior to the trachea. These hormones have a substantial impact on the body's metabolic rate. Additionally, this gland releases calcitonin, which is crucial for the metabolism of calcium. When thyroid secretion is completely absent, the basal metabolic rate often falls by 40–50 percent below normal, and when thyroid secretion is too high, the basal metabolic rate may rise by up to 60–100 percent. thyroid gland discharges mostly controlled by the anterior pituitary.

1. Thyroxine and triiodothyronine speed up chemical reactions in practically all body cells, raising metabolic rate throughout the body.
2. The promotion of calcium deposition in bones by calciumonin results in a decrease in the amount of calcium in extracellular fluid.

d. Pancreas and Langerhans Islets

The human pancreas may have one to two million islands. Each 0.3 millimetre-diameter Langerhans Island has small capillaries that hold the hormones that these cells release. The three main cell types identified in Langerhans islets are alpha, beta, and delta. The physical characteristics and staining of these three cell types can be used to distinguish them. The majority of the cells in the centre of each islet are beta cells, which make up about 60% of all cells and secrete insulin. In relation to 25% of all cells, glucagon is released by alpha cells. The somatostatin-releasing delta cells make up 10% of all cells. Additionally, the islets of Langerhans contain at least one more cell type known as PP cells that produce polypeptides, which are hormones with unidentified activities, in the pancreas in very small amounts.

Insulin speeds up the influx of glucose into all of the body's cells, which in turn regulates how quickly nearly all carbohydrates are broken down.

Glucagon: It increases the liver's ability to produce and release glucose and permits it to move through bodily fluids.

e. Ovaries

One such reproductive organ in women is the ovary, which has the ability to generate cells, eggs, and hormones. The left and right ovaries are found on humans. The ovary is oval-shaped and measures about 4 cm long, 3 cm broad, and about 2 cm in diameter.

The ovary often has a smooth, uneven surface and a reddish grey tint.

1) Estrogen: encourages the growth of breasts, numerous secondary sex traits, and female sex organs.
2) Progesterone: increases the development of the breast's secretory system and boosts the release of "uterine fluid" from the uterine endometrial glands.

f. Testicles

The 900 coils of seminiferous tubules in the testes, which have an average length of more than 5 metres each and are where sperm are formed, make up the testes. Male genitalia growth is stimulated by the hormone testosterone, which also encourages the secondary development of male sexual traits.

g. Parathyroid glands

The endocrine glands known as parathyroid glands produce the hormone parathyroid. Humans have four parathyroid glands, which are typically placed in the neck. Because it is situated behind the thyroid gland, this gland is known as the parathyroid. This gland produces the hormone parathyroid, which regulates the amount of calcium in the blood. The production of this gland won't stop till a person is 30 years old. By controlling calcium absorption from the intestine, renal excretion of calcium, and bone release of calcium, parathormone controls the concentration of calcium ions in the extracellular fluid.

h. Placenta

The placenta, or what is frequently referred to as the placenta, is an organ that develops in the womb during pregnancy. An organ that is crucial to the growth and development of the foetus is the placenta. The placenta's primary job is to exchange metabolic products and nourishment between the mother and the foetus. The human placenta weighs about 470 grammes and has an average diameter of 15 to 22 cm. This organ's centre is typically 2.5 to 5 cm thick. The umbilical cord is also a part of the placenta. Blood vessels create the umbilical cord.

- Human Chorionic Gonadotropin encourages the corpus luteum's development and its production of oestrogen and progesterone.
- Oestrogen encourages the growth of some foetal tissue as well as the mother's and vaginal organs.
- Progesterone aids in the specific development of the uterine endometrium during the later stages of implantation of an ovum that has already undergone fertilisation, and it may also enhance the growth of some of the foetus' tissues and organs. It also aids in the development of the mother's breast's secretory system.

- Human somatomammotropin may promote the development of the mother's breasts and stimulate the growth of some foetal tissue.

2. **Enzyme and hormone mechanisms of action**

The majority of the hormone's activities are brought about by two crucial general mechanisms:

Numerous other intracellular processes are activated when the cyclic AMP system (3,5-adenosine monophosphate) in the following cell is activated. The majority of hormones firstly affect cells by way of the cyclic compound 3,5-adenosine monophosphate (cyclic AMP). The hormone will function in the cell as a result of the cyclic AMP material. Therefore, the intermediate form of that intracellular hormone is cyclic AMP. The second messenger for the hormone mediator is another name for this substance. The stimulating hormone comes first. Adrenocorticotropin, TSH, LH, FSN, ADH/vasopressin, parathyroid hormone, glucagon, catecholamines, and secretin are a few hormones that employ AMP in a cyclical manner.

The 'specific' receptors for the stimulating hormone are initially connected to the hormone, and they are found on the target cell membrane's surface. Which hormone impacts the target cell is determined by the unique characteristics of these receptors. The interaction of the hormone with the membrane receptor results in the activation of the enzyme protein adenyl cyclase. Additionally found in the membrane, this enzyme binds either directly or extremely firmly to the receptor protein. Adenyl cyclase, on the other hand, are the majority of the enzymes; they protrude into the cytoplasm from the inner surface of the membrane and, upon activation, convert the majority of the cytoplasmic ATP into cyclic AMP.

Once the cell has produced this cyclic AMP, it will then activate another enzyme. It turns out that this AMP cycle normally causes a number of enzymes to become active. As a result, in this instance, one enzyme is activated first, then another enzyme, which in turn activates another enzyme, which in turn activates a third enzyme, and so on. The significance of this method is that it only requires a small number of molecules to cause adenyl cyclase in the activated cell membrane to activate numerous other enzyme molecules. Additionally, under these conditions, the majority of the third enzyme molecule can be activated a few more times.

In this way, despite the fact that the hormone's effect on the cell's surface is little, it turns out that the hormone was nevertheless able to initiate an extremely acute activating force within the cell. The type of the intracellular structure—some cells contain a sequence of enzymes, and these cells also have other enzymes—determines the precise work that takes place in response to the cyclic AMP that occurs inside target cells. Consequently, different functions take place in different target cells; among these roles are:

1) start the intracellular synthesis of particular molecules,
2) either causes the muscle to contract or relax,
3) start the cellular secretion process,
4) alter the permeability of cells, etc.

Thus, cyclic AMP-stimulated thyroid cells produce thyroxine from triiodothyronine, whereas the same cyclic AMP material in adrenocortical cells results in the release of adrenocortical steroid hormones; in contrast, this cyclic substance AMP has a different effect on the epithelial cells of the renal tubules, increasing the tubules' permeability to water.

The function of "calmodulin" and calcium ions as a secondary messenger system. The entry of calcium ions into the cell triggers the operation of a second courier system. The opening of calcium channels in the membrane may occur as a result of an electrical phenomena, or calcium channels may also open as a result of receptor contacts in the membrane. Calcium ions bind to the protein calmodulin as they enter the cell. This protein has four distinct calcium sites, and if calcium has been coupled to three or more of these sites, calmodulin is activated, which has many effects on the cell that are similar to AMP's cyclic functioning. For instance, the binding will activate numerous other enzymes that help the enzymes that were already activated by the preceding cyclic AMP, making it a further contributing component for the intracellular metabolism reaction. Calmodulin's activation of myosin kinase, which would later operate directly on the myosin present in smooth muscle and finally lead to smooth muscle contraction, is one of its unique actions.

All body cells typically contain between 10-7 and 10-8 millimoles of calcium ions per litre, however this is insufficient to activate the calmodulin system. However, it is sufficient to create a connection so that calmodulin can function inside the cell when the calcium ion concentration rises to between 10-6 and 10-5 millimoles per litre. The change in the number of ions is almost exactly reflected in this amount. Troponin C is activated by calcium, which skeletal muscles require, and its activation results in the contraction of the skeletal muscles. In this instance, it's noteworthy to note how closely the structure and function of the protein in troponin C resemble those of other calmodulins (or second messengers) that are present inside the cell. There are two of these intermediary materials:

1) Cyclic guanosine monophosphate, which functions similarly to AMP's cyclic nucleotide, contains more guanine base than adenine and can activate a variety of enzyme configurations.
2) In addition to being produced in response to hormones, inositol triphosphate attaches to a particular receptor found on cell membranes and continues to have the ability to activate enzymes.

Finally, it's possible that a lot of prostaglandins serve as messengers. These two substances are a collection of lipid bonds that are widely distributed among the body's cells and are very intimately associated to one another. Numerous cells are thought to be regulated by prostaglandins, albeit the majority of these actions still require additional study to be confirmed.

The many second messenger systems within the cell mean that each messenger can control distinct cell processes, enabling various methods for cells to function. Activate the gene in the cell, which results in the intracellular production of proteins and the appearance of particular cell functions.

Summary

The endocrine system is a collection of glands that produce hormones to regulate bodily processes including metabolism, mood, sleep, and sexual function. Hormones are chemical substances produced by cells or clusters of cells that have an impact on the physiological regulation of cells in another body. The hormone system controls a number of physiological metabolic processes, including the rate of intracellular chemical reactions, the flow of substances across cell membranes, and other aspects of cell metabolism, such as growth and secretion.

The hormone system and the nervous system are connected in a number of ways. Pituitary and medullary adrenal glands are two glands that release hormones in response to appropriate nerve stimulation. The pituitary gland's hormones play a vital role in controlling the majority of other endocrine glands. The sella turcica, the hollow bone at the base of the brain, is connected to the hypothalamus via the pituitary gland, also referred to as the hypophyseal stalk. The anterior pituitary (adenohypophysis) and the posterior pituitary (neurohypophysis) are its two physiologically separate sections.

The posterior pituitary, also known as the neurohypophysis, promotes milk production and breast expansion whereas the anterior pituitary increases the release of adrenocortical hormones from the adrenal cortex. Vasopressin, an antidiuretic hormone, causes the kidneys to retain water, increases blood pressure, and constricts blood vessels all throughout the body. During childbirth,

oxytocin induces the uterus to contract and assists in the baby's exit.

The medulla adrenals and adrenal cortex are positioned in the adrenal cortex, which is situated at the superior poles of both kidneys. Epinephrine and norepinephrine, which control the metabolism of proteins, carbohydrates, and lipids, are secreted by the adrenal glands. Two significant hormones released by the thyroid gland are thyroxine and triiodothyronine, often referred to as T4 and T3, respectively. These hormones release calcitonin, which is essential for the metabolism of calcium, and have a substantial influence on the body's metabolic rate.

In conclusion, the endocrine system is critical in the regulation of several biological processes, such as metabolism, mood, sleep, reproduction, and sexual function. Hormones, such as those produced by the pituitary gland, are essential for preserving equilibrium and general health. One to two million Langerhans Islands, each measuring 0.3 millimetres in diameter, make up the human pancreas. These islands contain tiny capillaries that store the hormones that these cells secrete. Alpha, beta, and delta are the three primary cell types found in Langerhans islets. Delta cells make up 10% of all cells, alpha cells produce glucagon, and beta cells account for 60% of all cells. Additionally, polypeptide-producing PP cells, which are hormones with unidentified functions, are seen in the islets.

Women's ovaries, which produce cells, eggs, and hormones, are reproductive organs. The left and right ovaries are oval-shaped, have smooth, uneven surfaces, and are greyish-reddish in colour. The hormones estrogen and progesterone promote the development of female sex organs, secondary sex characteristics, and breast size. Male genitalia growth and male sexual characteristics are stimulated by the 900 coils of seminiferous tubules that make up the testes. The hormone parathyroid, which controls blood calcium levels, is produced by parathyroid glands, which are situated beneath the thyroid gland. Until a person is 30 years old, this gland continues to produce. Calcium absorption, renal excretion, and bone calcium release are all regulated by parathormone.

The exchange of nutrients and metabolic by-products between the mother and the fetus occurs via the placenta, an organ that is essential to the fetus' growth and development. The typical human placenta weighs 470 kilos and is 15 to 22 cm in diameter. Progesterone helps with the development of the uterine endometrium during implantation and the development of the mother's breast's secretory system, whereas human chorionic gonadotropin promotes the development of the corpus luteum and the generation of oestrogen and progesterone. Somatomammotropin may encourage the growth of certain fetal tissue as well as the development of the mother's breasts.

The cyclic AMP system (3,5-adenosine monophosphate) in the subsequent cell is principally responsible for hormone activation. The cyclic molecule, which is the intermediate form of the intracellular hormone, is what largely activates the hormones. The initial messenger for the hormone mediator is the stimulating hormone, which includes adrenocorticotropin, TSH, LH, FSN, ADH/vasopressin, parathyroid hormone, glucagon, catecholamines, and secretin. The target cell's response to the hormone depends on the receptors for the stimulating hormone, each of which has distinct properties. The enzyme protein adenyl cyclase is activated as a consequence of the hormone's interaction with the membrane receptor. The majority of the cytoplasmic ATP is converted into cyclic AMP by this enzyme once it binds to the receptor protein.

Multiple enzymes are often activated simultaneously by the AMP cycle; one enzyme is activated first, then another, which activates another enzyme, and so on. The hormone may start an acute activation force inside the cell by repeatedly doing this procedure. The secondary messenger system of "calmodulin" and calcium ions plays a critical role in the operation of the cell. A second messenger system, which may be triggered by calcium ions or receptor interactions, is started when calcium ions enter the cell. Muscle contraction results via calmodulin's activation of myosin kinase, which subsequently interacts directly with myosin in smooth muscle.

Similar in structure and operation to other calmodulins as inositol triphosphate and cyclic guanosine monophosphate. Within the cell, prostaglandins, a group of lipid bonds, are also regarded as messengers. Each messenger may regulate a particular cell process, giving cells the ability to act in a variety of ways. In conclusion, the cyclic AMP system and other cell messenger systems play a major role in the activation of hormones. These systems make it possible for diverse cell processes to be regulated as well as enabled.

Review Questions

1. Describe what the terms "appendix" and "endocrine glands" mean!

   Answer: Endocrine glands, sometimes known as blind glands, release hormone-like compounds into the blood, which circulates throughout the body's tissues
2. How well do you understand hormones?

   Answer: A gland or organ releases hormones into the circulation, which have an impact on cell function. Numerous processes that control life are regulated by hormones. They are molecules that one cell or a group of cells emit into body fluids, and they can have an impact on how other cells' physiology is regulated.
3. Describe how the endocrine system works!

   Answer: The endocrine glands have the following functions: they make hormones that enter the bloodstream and are required by specific body tissues; they regulate metabolism and oxidation; they stimulate tissue growth; they increase glucose absorption in the small intestine; and they have an impact on how fat, protein, carbohydrates, vitamins, minerals, and water are metabolised.
4. The pituitary gland is known as the "Master of Gland" for a reason.

Answer: Because it regulates the operations of the majority of the other endocrine glands, the pituitary is known as the Master of Gland.

5. What hormones does the thyroid gland produce?

   Answer: Triiodothyronine (T3), thyroxine (T4), and a small amount of calcitonin are the three hormone kinds that the thyroid gland generates. The follicle produces the hormones T3 and T4, while the parafollicular produces calcitonin. Iodine, which is derived through food and beverages, serves as the building block for the creation of these hormones. Iodine that has been eaten will be transformed into iodine ions (iodide), which actively penetrate glandular cells and require ATP as an energy source.

6. What is your knowledge of the Suprarenal Gland's Cortex and Medulla Sections?

   Answer: Aldosterone, a mineralocorticoid hormone, is produced by the adrenal cortex of the zona glomerulosa to promote Na reabsorption and K secretion. The hormone cortisol (glucocorticoid), which increases blood glucose at the expense of protein and fat storage and aids in stress adaption, is produced by the adrenal cortex of the zona fasciculate and zona reticularis. Dehydroiandosterone, an androgen hormone that contributes to both women's sex drive and the growth spurt during puberty, is also produced by it. Epinephrine and norepinephrine, which are generated in the adrenal medulla region, boost the sympathetic nervous system and aid in stress adaption and blood pressure control.

7. Describe the function of the pancreas' Islets of Langerhans beta cells!

   Answer: The hormone insulin, which helps lower blood sugar levels and functions physiologically in opposition to glucose, is made by beta cells in the islets of Langerhans.

8. How does insulin function?

   Answer: How insulin decreases blood sugar levels, namely the several ways it does so Particularly in skeletal muscle fibres, where the presence of insulin receptors on the target cell surface determines whether glucose enters cells, insulin speeds up the transport of glucose from the blood into cells. Additionally, insulin promotes lipogenesis, which is the process by which glucose or other nutrients are converted into fatty acids, speeds up the conversion of glucose into glycogen, lowers glycogenolysis and gluconeogenesis, and aids in promoting protein synthesis.

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CHAPTER 11
URINARY SYSTEM

Learning Objectives:

Recognising the urinary system's composition and operation

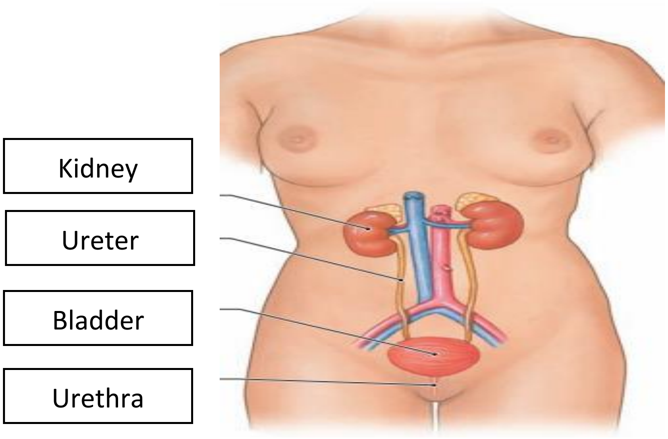
Introduction:

The act of filtering blood through the urinary system removes substances from the blood that the body does not need and absorbs those that are still needed by the body. Unused substances are dissolved in water and eliminated through the urinary system. You will learn about the anatomy and physiology of the urinary system in this chapter, starting with an overview of the kidneys, ureters, bladder, and urethra. It is hoped that after reading this material, you will be able to appreciate the significance of the urinary and digestive systems. Waste is removed by the urinary system. The urinary regulatory system regulates the body's ability to produce urine, regulate its flow to the bladder, and release it through the urinary tract.

Anatomy of Urinary System

1. Kidney

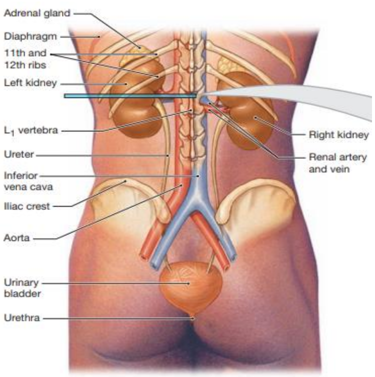
   The kidney, ureter, bladder, and urethra are all parts of the urinary system. Adult kidneys measure around 10 cm (4 inches) length, 5.5 cm (2.2 inches) long, and 3 cm (1.2 inches) thick. They are reddish-brown in colour. The average kidney weighs 150 g (5.25 oz). The kidneys are situated in a retroperitoneal position on the vertebral column between vertebrae T12 and L3. The left kidney is slightly superior to the right kidney, which is slightly inferior due to the right lobe of the liver. The adrenal gland is found on the superior surface of each kidney.



Picture 11.1. The Anatomy of Kidney

The Connective Tissue Layers in the Kidney:

a. The outer layer of the fibrous capsule is made up of collagen fibres.
b. The fibrous capsule is encased in a thick layer of adipose tissue called perinephric fat.
c. The collagen fibres of the renal fascia extend through the perinephric fat to this layer from the fibrous capsule.



Picture 11.2. Posterior View

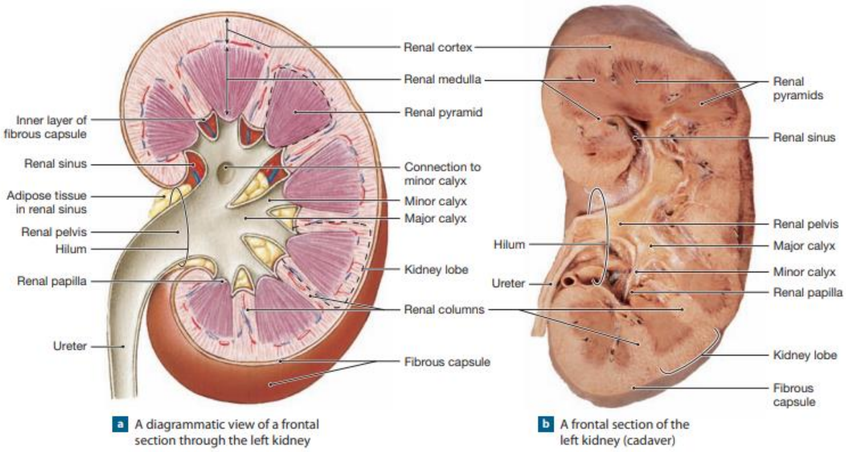
The Connective Tissue Layers in Each Kidney

a. The outer layer of the fibrous capsule is made up of collagen fibres.
b. The fibrous capsule is encased in a thick layer of adipose tissue called perinephric fat.
c. The collagen fibres of the renal fascia extend through the perinephric fat to this layer from the fibrous capsule.

1. *The Structure of Kidney*

The renal artery, renal nerves, and the renal vein all enter and leave the body through the hilum, which also serves as the exit point for the ureter. The fibrous cap that covers the outside of the kidneys is known as the renal sinus, which maintains the locations of the ureter, renal blood vessels, and nerves.

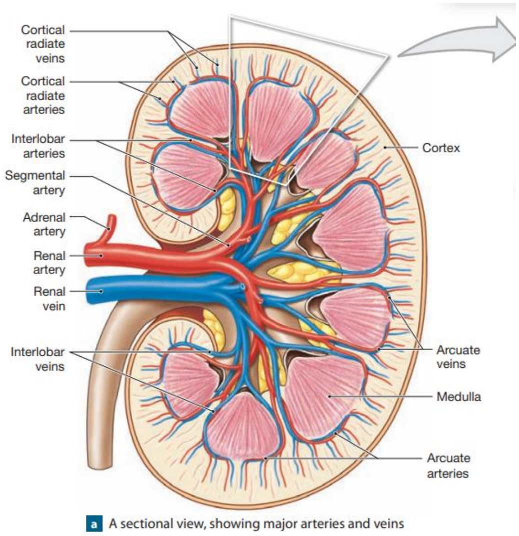
The outer layer of the kidney is called the renal cortex, and it is granular and reddish brown in colour. Six to eight renal pyramids (triangular structures) make up the renal medulla. The renal pyramid is made up of the lobes of a kidney. The kidney lobes are where urine is made. The duct that excretes urine into a cup-shaped vessel within each papilla is known as a minor calyx; four to five minor calyces join to form a major calyx; and two or three calyces combine to form the renal pelvis. The ureter, which drains the kidney, is attached to the renal pelvis. The nephrons are minute tubular organelles. There are 1.25 million nephrons in each kidney.



Picture 11.3. The Structure of Kidney

2. *The Blood Supply of The Kidneys*

   20–25% of the entire cardiac output is directed to the kidneys, which get roughly 1200 ml of blood every minute. A renal artery is a blood vessel that develops along the abdominal aorta's lateral surface, not far from the superior mesenteric artery. Blood is supplied by the renal artery to the segmental arteries, which in turn divide into interlobar arteries and extend through the columns separating the renal pyramids. The arcuate arteries are supplied by the interlobar arteries. The kidney's cortex and medulla are separated from one another by the arcuate arteries. Cortical radiating artery branches are known as afferent arterioles. The nephrons' capillaries are supplied with blood by these channels. Following their passage, the blood enters a system of venules and tiny veins, sometimes known as cortical radiate veins or interlobular veins. These veins then discharge into the renal vein and the interlobar vein.



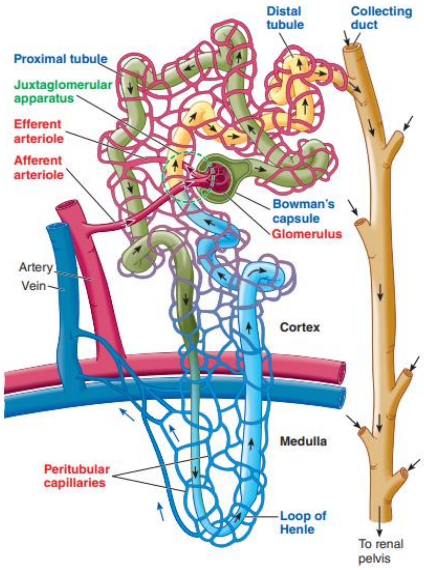
Picture 11.4. The Blood Supply of Kidney

The kidneys and ureters are innervated by the renal nerves. At the hilum, a renal nerve enters each kidney. The sympathetic innervations influence blood flow and blood pressure, which alter urine production, and increase renin release, which reduces water and salt loss by promoting reabsorption.

3. The Nephron

The nephron is the tiniest component of a kidney or a component of a system. A renal corpuscle and a renal tubule make up each nephron. The glomerular (Bowman's) capsule, a cup-shaped chamber with a diameter of about 200 m, and a capillary network known as the glomerulus make up the spherical corpus renal. The renal corpuscle is where the renal tubule starts. A 50 mm (1.97 in) or longer tubular passageway exists there.

The afferent arteriole is where the blood enters. Blood is sent to the glomerulus, where it is removed in an efferent arteriole. It enters the peritubular capillaries, a network of capillaries. The blood is returned to the venous system through these capillaries, which develop into tiny venules.



Picture 11.5. A Part of Nephron

Nefron's vascular system is composed of the afferent arteriole, which transports blood to the glomerulus, the glomerulus, which is made up of capillaries, and the tubular component. The efferent arteriole nourishes the renal tissue with blood from the glomerulus and peritubular capillaries and participates in exchanges with the fluid in the tubular lumen.

Tubular Component of Nefron (a) Bowman's capsule collects the glomerular filtrate; (b) Proximal tubule: uncontrolled reabsorption and secretion of certain substances occur here; (c) Loop of Henle of long-looped nephrons: establishes an osmotic gradient in the renal medulla that is important in the ability of the kidney to produce urine of varying concentrations; (d) Dis Combining a vascular and tubular component, the juxtaglomerular apparatus creates chemicals that regulate kidney function.

Basic Mechanisms that Produce Urine

a. Filtration

Water and solutes are pushed into the capsular space by the blood pressure across the glomerular capillaries' wall. The water molecules around the solute molecules are what transport them through the filtration membrane.

b. Reabsorption

After the filtrate has exited the renal corpuscle, water and solutes are removed from the filtrate by moving past the tubular epithelium and into the kidney. The majority of reabsorbed substances are nutrients that the body can utilise. Reabsorption is a selective process, whereas filtering is entirely dependent on size. Simple diffusion or the function of carrier proteins in the tubular epithelium are both involved in reabsorption. The peritubular fluid's reabsorbed materials eventually re-enter the circulation. Through osmosis, water is passively reabsorbed.

c. Secretion

Secretion is the movement of solutes past the tubular epithelium and into the tubular fluid from the peritubular fluid. Filtration cannot remove all of the dissolved elements from the plasma; thus, secretion is required. The plasma concentration of unwanted compounds can be further reduced by tubular secretion, which eliminates substances from the blood. It offers a filtration mechanism as a fallback. Many chemicals, including many medications, are prepared for excretion primarily by secretion.

Tabel 10.1. Normal Laboratory Values for Solutes in Plasma and Urine

Solute	Plasma	Urine
Ions (mEq/L)		
Sodium (Na+)	135-145	40-220
Potassium (K+)	3.5-5.0	25-100
Chloride (Cl-)	100-108	110-250
Bicarbonate (HCO3-)	20-28	1-9

Solute	Plasma	Urine
Metabolites and Nutrients (mg/dl)		
Glucose	70-110	0.009
Lipids	450-1000	0.002
Amino Acids	40	0.188
Proteins	6-8	0.000
Nitrogenous Wastes (mg/dl)		
Urea	8-25	1800
Creatinine	0.6-1.5	150
Uric Acid	2-6	40
Ammonia	<0.1	60

Source: Daniels & Nicoll (2012)

4. The Glomerular Filtration
   Passage through a filtration membrane is a necessary step in the glomerular filtration process. Remember that there are three parts to this membrane: the thick layer, the filtration slits, and the capillary endothelium. Glomerular capillaries are fenestrated capillaries with pores that have a diameter of between 60 and 100 nm (0.06 and 0.1 m). These openings are too big to obstruct the diffusion of solutes, even those the size of plasma proteins, but they are too small to allow blood cells to pass through. Only little plasma proteins, nutrients, and ions can pass through the thick layer because it is more selective. The finest of all are the filtration slits. There are only 6–9 nm between them. The majority of tiny plasma proteins cannot pass through these gaps because they are too small.
5. Factors Controlling Glomerular Filtration
   a. The blood pressure in the glomerular capillaries is known as the glomerular hydrostatic pressure (GHP). Water and solute molecules are frequently forced out of the plasma and into the filtrate by this pressure. The efferent arteriole is smaller in diameter than the afferent arteriole, and the GHP, which averages 50 mm Hg, is much higher than capillary pressures elsewhere in the systemic circuit.

b. Filtration is opposed by the blood colloid osmotic pressure (BCOP), which has a tendency to suck water from the filter and into the plasma. The BCOP is roughly 25 mm Hg along the whole length of the glomerular capillary bed.
c. The net pressure operating across the glomerular capillaries is known as the net filtration pressure (NFP). It stands for the total of the colloid osmotic pressures and hydrostatic pressures. The net filtration pressure is roughly 10 mm Hg under typical conditions. This is the typical pressure pushing water and other dissolved materials into the capsular space from glomerular capillaries.
d. GHP is opposed by capsular hydrostatic pressure (CsHP). The resistance of the filtrate already presents in the nephron that must be pushed towards the renal pelvis causes CsHP, which has a tendency to push water and solutes out of the filtrate and into the plasma. The net hydrostatic pressure (NHP), which separates GHP and CsHP, is the difference.
e. Because very few, if any, plasma proteins penetrate the capsular area, the colloid osmotic pressure of the capsular colloid is typically zero.

6. Control of the Glomerular Filtration

Glomerular filtration, a crucial component of kidney function, is governed by three different mechanisms: 1) autoregulation, 2) hormonal regulation, and 3) autonomic regulation (the sympathetic division of the autonomic nervous system).

a. The autoregulation of Glomerular Filtration Rate (GFR)

In addition to regulating local blood pressure and blood flow, it maintains a sufficient GFR. The afferent arterioles, efferent arterioles, and glomerular capillaries vary as a result of an increase or drop in blood pressure, which helps to maintain GFR. The GFR is stabilised by the regulatory systems when the systemic blood pressure falls.

When the systemic BP rises, the GFR likewise stays mostly unchanged. The smooth muscle cells respond by contracting when the walls of afferent arterioles are stretched by an increase in renal blood pressure. Afferent arterioles' diameter is reduced, which reduces glomerular blood flow and maintains the GFR within normal ranges.

b. Hormonal Regulation of GFR

The natriuretic peptides (ANP and BNP) and hormones of the renin-angiotensin-aldosterone system control the GFR. The juxtaglomerular complex (JGC) releases renin in response to three triggers. These include: (1) a drop in blood volume, a drop in systemic pressures, or a blockage in the renal artery or one of its branches that causes a drop in blood pressure at the glomerulus; (2) stimulation of juxtaglomerular cells by sympathetic innervation; or (3) a drop in the osmotic concentration of the tubular fluid at the macula densa. A general description of how the GFR is affected by the renin-angiotensin-aldosterone system. The juxtaglomerular complex releases renin in response to a decline in GFR. Angiotensinogen, an inert protein, is transformed into angiotensin I by renin. Angiotensin-converting enzyme (ACE) converts dormant angiotensin I to active angiotensin II. The lungs' capillaries are where this conversion primarily occurs. The CNS, adrenal glands, and nephron are all affected by angiotensin II. Angiotensin II causes a fleeting but potent vasoconstriction of arterioles and precapillary sphincters in peripheral capillary beds, raising arterial pressures all over the body. A rise in systemic blood volume, blood pressure, and the restoration of normal GFR are the combined effects. The GFR automatically rises with an increase in blood volume. This rise encourages fluid losses that aid in restoring normal blood volume. Hormonal variables further raise the GFR and hasten urine fluid loss if the blood volume increase is significant. When the heart's walls are stretched by an increase in blood flow or blood pressure, the heart releases natriuretic peptides. Atrial natriuretic peptide (ANP) is released by the atria, and brain natriuretic peptide (BNP) is released by the ventricles.

c. Autonomic Regulation of the GFR

Sympathetic postganglionic fibres make up the majority of the kidneys' autonomic innervation. (It is unknown how the small number of parasympathetic fibres affect renal function.) Direct impact of sympathetic stimulation on GFR. Afferent arterioles have a strong vasoconstriction as a result, which lowers the GFR and reduces filtrate generation. In this approach, the local regulatory systems that work to stabilise the GFR are overridden by the sympathetic activation brought on by an abrupt drop in blood pressure or a heart attack. The sympathetic tone and crises subside, and the filtration rate progressively returns to normal. Blood flow to the kidneys is frequently impacted when the sympathetic division modifies regional patterns of blood circulation.

For instance, warm weather causes the superficial arteries to enlarge, diverting blood from the kidneys. The result is a brief decrease in glomerular filtration. During intense exertion, the effect is most noticeable. Kidney perfusion steadily declines when the blood flow to your skin and skeletal muscles increases. Autoregulation at the municipal level may attempt to thwart these changes, with varying degrees of success.

d. Reabsorption and Secretion at the Proximal Contortus Tubulus (PCT)

Normally, 60 to 70 percent of the filtrate volume produced in the renal corpuscle is reabsorbable by the cells of the proximal convoluted tubule. The reabsorbed materials diffuse into the peritubular capillaries, enter the peritubular fluid, and then swiftly return to the circulation.

The PCT serves five main purposes:

a. Taking Up Organic Nutrients

The PCT normally reabsorbs more than 99 percent of the glucose, amino acids, and other organic substances in the fluid before the tubular fluid enters the nephron loop.

Cotransport and assisted transport are also used in this reabsorption.

b. Ion Active Reabsorption

In addition to sodium, potassium, and bicarbonate ions, the PCT also actively transports magnesium, phosphate, and sulphate ions. Although each of the relevant ion pumps is independently controlled, amounts of circulating ions or hormones may have an impact. Angiotensin II, for instance, promotes Na^+ reabsorption along the PCT. About 90% of the bicarbonate ions in tubular fluid are indirectly recaptured by the PCT by absorbing carbon dioxide. Bicarbonate is crucial for maintaining the pH of the blood.

c. Absorptive Water Reaction

The solute concentrations inside and outside of the tubules are directly impacted by the reabsorptive processes. The osmotic content of the filtrate entering the PCT is identical to that of the peritubular fluid around it. The solute content of tubular fluid falls as reabsorption progresses, whereas the solute concentration of peritubular fluid and nearby capillaries increases. The water is subsequently drawn into the peritubular fluid through osmosis from the tubular fluid. This mechanism causes the reabsorption of around 108 litres of water every day along the PCT.

d. Ions' Passive Reabsorption

The concentration of other solutes in the tubular fluid rises above that in the peritubular fluid when active reabsorption of ions occurs and water leaves the tubular fluid by osmosis. These solutes passively diffuse across the tubular cells and into the peritubular fluid if the tubular cells are susceptible to them. This may cause urea, chloride ions, and lipid-soluble substances to diffuse outside the PCT. Such dispersion encourages more water reabsorption by osmosis and further lowers the solute content of the tubular fluid.

e. Secretion

Along the PCT, hydrogen ions are also actively secreted. We shall explore secretory mechanisms when we discuss the DCT because the PCT and DCT (Distal Contortus Tubule) produce similar chemicals and the DCT performs relatively little reabsorption.

7. Reabsorption and Secretion at the DCT

As we've just seen, as tubular fluid moves from the capsular region to the distal convoluted tubule, its volume and content undergo significant changes. Just 15 to 20% of the initial filtrate volume makes it to the DCT. The electrolyte and organic waste concentrations in the incoming tubular fluid no longer resemble those in blood plasma. The last modifications to the solute composition and volume of the tubular fluid are made by selective reabsorption or secretion, primarily along the DCT. Recovery at the DCT The tubular cells actively move Na+ and CI out of the tubular fluid over the majority of the DCT. Additionally, ion pumps that reabsorb tubular Na+ in exchange for another cation (often K+) are present in tubular cells along the distal parts of the DCT. The adrenal cortex secretes the hormone aldosterone, which regulates the ion pump and Na+ channels. This hormone promotes sodium channel and sodium ion pump production and integration in plasma membranes along the DCT and collecting duct. The quantity of sodium ions lost in urine is decreased as a result. However, potassium ion loss is linked to sodium ion conservation. Therefore, prolonged aldosterone stimulation might result in hypokalaemia, a hazardous drop in plasma K+ concentration. The natriuretic peptides (ANP and BNP) compete with aldosterone for secretion and block its effects on the DCT and collecting system. The main location for Ca2+ reabsorption is the DCT. This mechanism is controlled by the amounts of calcitriol and parathyroid hormone in the blood.

8. Secretion at the DCT

There are still some potentially harmful compounds in the blood that enters the peritubular capillaries that did not pass through the glomerular filtration barrier. The majority of the time, these chemicals' concentrations are too low to have any negative physiological effects. The peritubular fluid will, however, disperse any ions or substances present in the peritubular capillaries. The tubular cells may take these compounds from the peritubular fluid and secrete them into the tubular fluid if those concentrations rise too high. According to changes in the concentration of K+ and H+ in the peritubular fluid, the rate of K+ and H+ secretion either increases or decreases. The rate of secretion increases with their content in the peritubular fluid. Because the amounts of potassium and hydrogen ions in physiological fluids must be kept within specific ranges, they demand special consideration. Tubular cells exchange excess potassium ions in bodily fluids for sodium ions in the tubular fluid. In exchange for sodium ions from the tubular fluid, potassium ions are taken out of the peritubular fluid. Through potassium leak channels at the apical surfaces of the tubular cells, these potassium ions diffuse into the DCT lumen.

9. Secretion of hydrogen ions.

The release of hydrogen ions is connected to sodium absorption as well. Both processes rely on the carbonic anhydrase enzyme to produce carbonic acid. By sodium-linked countertransport, hydrogen ions produced by the breakdown of carbonic acid are secreted in the tubular fluid in place of Na+. The peritubular fluid receives the bicarbonate ions after they have diffused into it. There, they aid in preventing alterations to plasma pH. While raising the blood's pH, hydrogen ion secretion acids the tubular fluid. When the pH of the blood falls, hydrogen ion secretion increases. This may occur in cases of lactic acidosis, which may appear after strenuous exercise of the muscles, or ketoacidosis, which may appear in cases of famine or diabetes mellitus. p. 956 The kidneys' production of HCO3 and elimination of H+ both contribute significantly to the regulation of blood pH. Aldosterone promotes H+ secretion because one of the secretory routes is aldosterone-sensitive. Alkalosis, or an unusually high blood pH, can result from prolonged aldosterone stimulation.

10. Reabsorption and Secretion along the Collecting System
    Through the concentration gradient in the medulla, the collecting ducts take tubular fluid from several nephrons and transport it to the renal sinus. There are two mechanisms that control the average quantity of water and solute loss in the collecting system: Aldosterone, which regulates sodium ion pumps along the majority of the DCT and the proximal part of the collecting system, is responsible. The natriuretic peptides work against these effects, as we have already mentioned. The permeability of the DCT and collecting system to water is controlled by ADH. The effects of the natriuretic peptides on aldosterone secretion and action, as well as their suppression of ADH secretion, can significantly increase urinary water losses.
11. Reabsorption in the Collecting System
    The following is how the collecting system reabsorbs sodium ions, bicarbonate ions, and urea: sodium ion absorption Aldosterone-sensitive ion pumps in the collecting system switch out Na+ in tubular fluid for K+ in peritubular fluid. Absorption of bicarbonate. In the peritubular fluid, chloride ions are reabsorbed in exchange for bicarbonate ions. Resorption of urea. The amount of urea in the tubular fluid entering the collecting duct is relatively considerable. Although the fluid entering the papillary duct typically has a similar osmotic content to the interstitial fluid of the medulla—roughly 1200 mOsm/L—it has a significantly higher quantity of urea. As a result, in the deepest part of the medulla, urea has a

tendency to diffuse from the tubular fluid and into the peritubular fluid.

12. Secretion in the Collecting System

By secreting hydrogen or bicarbonate ions, the collecting system is crucial for regulating the pH of bodily fluids. Carrier proteins pump hydrogen ions into the tubular fluid and reabsorb bicarbonate ions to assist restore a normal pH if the peritubular fluid's pH drops. The collecting system pumps hydrogen ions into the peritubular fluid and secretes bicarbonate ions if the pH of the fluid rises, which is a far less frequent occurrence. In the end, the body gets hydrogen ions that lower pH while losing a buffer.

The Makeup of Regular Urine

As we've seen, the glomeruli create 180 litres of filtrate per day, and more than 99 percent of it is reabsorbed. It is never eliminated at the renal pelvis. Urine's composition and concentration are two connected but separate characteristics. The filtration, reabsorption, and secretion processes of the nephrons are reflected in the composition of urine. Some chemicals (like urea) move along the nephron but are neither actively expelled nor reabsorbed. Organic nutrients, on the other hand, are entirely reabsorbed. Other chemicals, like creatinine, are actively secreted into the tubular fluid but are ignored by filtration.

The types and quantities of chemicals expelled in urine are determined by filtration, reabsorption, and secretion. Water moves osmotically through the walls of the tubules and collecting ducts, determining the concentration of these chemicals in a particular urine sample. You can generate a little volume of concentrated urine or a large volume of dilute pee and yet excrete the same amount of dissolved chemicals since the content and concentration of urine fluctuate independently. Due to this, medical professionals interested in a thorough evaluation of renal function frequently analyse 24-hour urine production rather than a single urine sample.

The Ureter

The ureters are two muscular tubes that go approximately 30 cm (12 inches) from the kidneys to the urine bladder. The renal pelvis' funnel-like form is where each ureter starts. The anterior surfaces of the psoas major muscles are crossed by the ureters as they extend inferiorly and medially. The retroperitoneal ureters are securely fastened to the back abdominal wall. Because the reproductive organs change in shape, size, and location between men and women, so do the ureters' routes. The base of the male urinary bladder is located between the pubic symphysis and the rectum. The base of the urinary bladder is located anterior to the vagina and inferior to the uterus in females. Without going into the peritoneal cavity, the ureters pierce the posterior wall of the urine bladder. They make an oblique cut in the bladder wall. Instead of being spherical, the ureteral apertures are slit-like. When the urinary bladder contracts, this form aids in preventing the backflow of urine towards the ureter and kidneys.

The ureters' histology A transitional epithelium and the lamina propria that surround it make up the inner mucosa of each ureter. The middle muscular layer is composed of longitudinal and circular bands of smooth muscle. The outer connective tissue layer is continuous with the fibrous capsule and peritoneum. A peristaltic contraction starts at the renal pelvis every 30 seconds or so. Urine is pushed towards the bladder as it travels along the ureter.

13. The Urinary Bladder

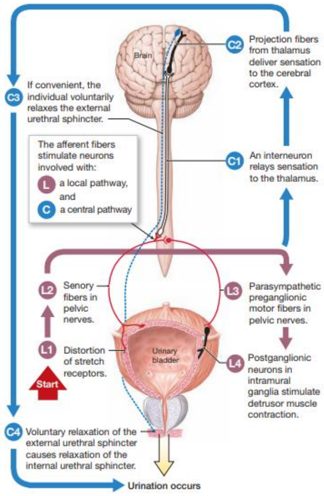
The muscular, hollow urinary bladder acts as a temporary holding tank for pee. The urine bladder's size varies depending on how distended it is. One litre of pee can fit in a full urinary bladder. Histology of the bladder of the urinary layers of mucosa, submucosa, and muscularis line the urinary bladder wall. The circular layer between the inner and outer longitudinal smooth muscle layers makes up the muscularis layer. These layers work together to create the strong detrusor muscle of the urine bladder. When this muscle contracts, the urinary bladder is compressed and pee is released into the urethra.

14. The Urethra

    Urine is transported to the outside of the body by the urethra, which extends from the urinary bladder's neck. Male and female urethrae are different in length and purpose. The urethra in males runs from the urinary bladder's neck to the tip of the penis. This separation could be 18 to 20 cm (7-8 in). The prostatic urethra, membranous urethra, and spongy urethra are the three sections that make up the male urethra. Through the middle of the prostate gland, the prostatic urethra travels. The urogenital diaphragm, the muscular pelvic floor, is penetrated by a brief piece of the membrane urethra. The external hole, also known as the external urethral orifice, near the tip of the penis is where the penile urethra, also known as the spongy urethra, begins. The urethra in females is highly condensed. The distance from the bladder to the vestibule is 3-5 cm (1-2 in.). The anterior vaginal wall is not far from the external urethral aperture. The external urethral sphincter is a circular ring of skeletal muscle that is present in both sexes when the urethra passes through the urogenital diaphragm. The skeletal band serves as a valve. The perineal branch of the pudendal nerve allows for voluntary regulation of the external urethral sphincter. To allow micturition, this sphincter must be consciously relaxed because it has a resting muscular tone.

15. The Micturition Reflex and Urination

    As we've seen, the peristaltic contractions of the ureters allow urine to enter the bladder. The micturition reflex controls how and when you urinate. Stretch receptors in the bladder wall are activated as the bladder fills with urine. The pelvic nerves' afferent fibres send impulses to the sacral spinal cord. The sacral spinal cord's parasympathetic motor neurons are made more efficient by the increased activity in the fibres, which also excites interneurons that transmit sensations to the thalamus and, later, the cerebral cortex via projection fibres. You consequently become conscious of the fluid pressure in your bladder. Normally, the need to urinate strikes when your bladder has 200 mL or less of urine in it. When parasympathetic preganglionic motor neurons receive enough stimulation from stretch receptors, the micturition reflex starts. Within an hour, a further rise in bladder volume triggers the cycle to repeat. Stretch receptor stimulation rises with each increase in urine volume, intensifying the feeling. The bladder contractions brought on by the micturition reflex may create enough pressure after the volume hits 500 mL to push open the internal urethral sphincter. The external urethral sphincter relaxes in response to this opening. Despite voluntary resistance or probable inconvenience, urination happens. Less than 10 mL of pee are typically left in the bladder at the end of a regular micturition. Because the required corticospinal connections have not yet developed, infants are unable to voluntarily control their urine. Therefore, "toilet training" before the age of two frequently entails teaching the parent to predict when the reflex will occur rather than teaching the kid to exercise conscious control.



The Micturition Reflex

Summary

The kidney, ureter, bladder, and urethra are all parts of the urinary system. Adult kidneys weigh 150 g and are reddish-brown in hue. They are located between vertebrae T12 and L3 on the spinal column in a retroperitoneal location. Each kidney's upper surface has an adrenal gland. The fibrous capsule's outer layer, which is composed of collagen fibres, perinephric fat, and the renal fascia, is one of the layers of connective tissue that make up the kidney.

The hilum, which also acts as the ureter's outlet, is where the renal artery, renal nerves, and renal vein all enter and depart the body. The exterior of the kidneys is covered by the renal sinus, which preserves the positions of the ureter, renal blood arteries, and nerves. The outer layer of the kidney is known as the renal cortex, which is granular and reddish brown.

The renal artery supplies the segmental arteries, which separate into interlobar arteries and go through the columns separating the renal pyramids, with 20–25% of the cardiac output. The nephrons' capillaries are fed with blood by the arcuate arteries, which divide the kidney's cortex and medulla.

The renal nerves, which affect blood pressure and blood flow, innervate the kidneys and ureters. Blood flow and pressure are affected by sympathetic innervations, which also change urine output and increase renin release, which prevents water and salt loss by encouraging reabsorption.

The nephron, which consists of a renal corpuscle and a renal tubule, is the smallest part of a kidney. The renal corpuscle serves as the beginning point for the spherical corpus renal, which is made up of the glomerular capsule and glomerulus. Blood enters by the afferent arteriole and travels to the glomerulus, where it is eliminated by the efferent arteriole. Blood enters the peritubular capillaries, a network of capillaries, and exits via these capillaries, which grow into microscopic venules, to return to the venous system.

The afferent arteriole, which carries blood to the glomerulus, the glomerulus, and the tubular component make up the nephron's vascular system. The efferent arteriole engages in exchanges with the fluid in the tubular lumen and supplies the renal tissue with blood from the glomerulus and peritubular capillaries.

Filtering, reabsorption, and secretion are the fundamental systems that generate urine. By applying blood pressure across the glomerular capillaries' wall, filtration forces water and solutes into the capsular space. Filtering is size-dependent, while reabsorption is selective. While secretion transports solutes from the peritubular fluid through the tubular epithelium and into the tubular fluid, reabsorption is a selective process.

Glomerular filtration, which has holes between 60 and 100 nm, is an essential phase in the glomerular filtration process. Blood pressure, colloid osmotic pressure, net filtration pressure, and capsular hydrostatic pressure are some of the variables that affect glomerular filtration. While the capsular colloid is normally 0 owing to the resistance of the filtrate already present in the nephron, the net hydrostatic pressure (NHP) separates GHP and CsHP.

One of the most important aspects of kidney function is glomerular filtration, which is controlled by three mechanisms:

autoregulation, hormonal regulation, and autonomic regulation. The control of local blood pressure and blood flow allows for the autoregulation of the GFR, which contributes to the maintenance of a healthy GFR. A rise or decrease in blood pressure causes changes in the afferent arterioles, efferent arterioles, and glomerular capillaries, which aids in maintaining GFR. The GFR mostly remains unaltered as the systemic blood pressure decreases. When the walls of afferent arterioles are stretched due to an increase in renal blood pressure, smooth muscle cells react by contracting. The diameter of afferent arterioles is decreased, which lowers glomerular blood flow and keeps the GFR within normal limits.

The natriuretic peptides (ANP and BNP) and hormones of the renin-angiotensin-aldosterone system regulate the GFR hormonally. Three factors can cause the juxtaglomerular complex (JGC) to release renin: (1) a decrease in blood volume, (2) a decrease in systemic pressures, (3) a decrease in blood pressure at the glomerulus due to a blockage in the renal artery or one of its branches; and (2) stimulation of the juxtaglomerular cells by sympathetic innervation. Angiotensin II increases arterial pressure throughout the body by briefly but significantly constricting peripheral capillary beds' arterioles and precapillary sphincters.

Through sympathetic postganglionic fibres, which have an immediate effect on GFR, the GFR is autonomously regulated. This causes a significant vasoconstriction in afferent arterioles, which decreases the GFR and lessens filtrate production. The sympathetic division alters local blood flow patterns, such as when warm weather causes the superficial arteries to widen and redirect blood away from the kidneys. Increased blood flow to the skin and skeletal muscles causes a steady reduction in kidney perfusion.

Taking Up Organic Nutrients, Ion Active Reabsorption, Absorptive Water Reaction, and Secretion are the five primary functions of reabsorption and secretion at the Proximal Contortus Tubulus (PCT). Similar substances are produced by the PCT and DCT (Distal Contortus Tubule), and minimal reabsorption is done.

Only 15 to 20% of the original filtrate volume makes it to the distal convoluted tubule (DCT), where it undergoes major volume and content modifications during reabsorption and secretion. The entering tubular fluid no longer has electrolyte or organic waste concentrations similar to blood plasma. The final adjustments to the solute volume and composition of the tubular fluid are accomplished predominantly along the DCT by selective reabsorption or secretion.

Tubular cells aggressively move Na+ and CI out of the fluid across the bulk of the DCT during recovery. Along the distal sections of the DCT, tubular cells include ion pumps that reabsorb tubular Na+ in exchange for another cation (typically K+). The hormone aldosterone, which controls the Na+ channels and ion pump, is secreted by the adrenal cortex. This hormone promotes the development and integration of sodium channels and sodium ion pumps in plasma membranes along the DCT and collecting duct. As a consequence, less sodium ions are excreted in the urine. However, chronic aldosterone stimulation may cause hypokalaemia, a dangerous reduction in plasma K+ concentration, since potassium ion loss is connected to sodium ion conservation.

Blood-borne substances that might be hazardous are secreted at the DCT and penetrate the peritubular capillaries. If their concentrations increase too much, tubular cells may absorb these substances from the peritubular fluid and secrete them into the tubular fluid. The amount of K+ and H+ in the peritubular fluid affects how quickly they are secreted.

The concentration gradient in the medulla, which regulates the typical amount of water and solute loss in the collecting system, is involved in reabsorption and secretion along the collecting system. These effects are counteracted by natriuretic peptides, and ADH regulates how permeable the DCT and collecting system are to water. Urinary water losses may dramatically rise as a result of natriuretic peptide effects on aldosterone production and activity as well as their reduction of ADH secretion.

By secreting hydrogen or bicarbonate ions, the collecting system is a key player in controlling the pH of physiological fluids. In order to maintain a constant pH in the peritubular fluid, carrier proteins pump bicarbonate ions and hydrogen ions into the fluid. As a buffer is lost, the body receives hydrogen ions that cause pH to decrease.

Regular urine has a certain composition and concentration, which are related yet distinct. The urine's chemical makeup reflects the nephrons' filtration, reabsorption, and secretion activities. Some substances, such as urea, circulate inside the nephron without being actively ejected or reabsorbed. While some molecules, like creatinine, are actively released into the tubular fluid but are not filtered, organic nutrients are completely reabsorbed.

Filtration, reabsorption, and secretion all have a role in determining the kinds and amounts of chemicals released in urine. The concentration of these compounds in a specific urine sample is determined by the osmotically moving water that passes through the walls of the tubules and collecting ducts. Instead of just one urine sample, medical experts interested in a full assessment of renal function often look at 24-hour urine production.

The muscular, hollow urinary bladder known as the urethra is responsible for carrying urine from the body to the outside. The male urethra extends from the neck of the urine bladder to the tip of the penis, whereas the female urethra serves a distinct length and function. An elastic ring of skeletal muscle called the external urethral sphincter acts as a valve. The external urethral sphincter, which has to be voluntarily relaxed to permit micturition, may be controlled via the pudendal nerve's perineal branch.

Urine entry into the bladder is controlled by the micturition reflex. As the bladder fills with pee, stretch receptors in the bladder wall are engaged, and the afferent fibres of the pelvic nerves deliver signals to the sacral spinal cord. By stimulating interneurons that provide sensations to the thalamus and cerebral cortex through projection fibres, the sacral spinal cord's parasympathetic motor neurons become more effective. Typically, the urge to pee occurs when the bladder has 200 mL or less of urine.

Before the kid is two years old, toilet training often entails educating the parent to anticipate when the reflex will happen rather than teaching the child to exert conscious control.

Review Questions

1. List the urinary system's organs!
   Answer: The kidneys, which are urinary organs that produce urine, the ureters, which act as channels to carry urine from the kidneys to the bladder (vesica urinaria), the bladder (vesica urinaria), which acts to collect urine before it is excreted, and the urethra, which is the tube from the bladder to the exit, are the organs that make up the urinary system.
2. Describe your knowledge of renal function!
   Answer: The amount and make-up of the extracellular fluid are mostly kept within normal bounds by the kidney. The excretory function and the non-excretory function are the two primary purposes of the kidney. Maintaining plasma osmolality at 285 milliosmole and plasma electrolyte levels within acceptable ranges are among the roles of excretion. urea, uric acid, and creatinine are excreted while the plasma pH is kept at roughly 7.4. Renin production, which is crucial for controlling blood pressure, erythropoietin production, which stimulates the creation of red blood cells in the bone marrow, vitamin D metabolism into its active form, insulin degradation, and prostaglandin production are examples of non-excretory processes.
3. Describe the compounds that the kidneys filter!
   Answer: The volume of filtrate produced each minute is known as the glomerular filtration rate, or GFR. Because the main filtrate has a plasma-like composition with the exception of the absence of protein, the glomerular filtration procedure is known as glomerular ultrafiltration.

4. What are your understandings of active and passive transport in the reabsorption and secretion processes?

   Answer: The three categories of filtrate—substances the kidneys remove—are: non-electrolytes, such as glucose, amino acids, and products of protein metabolism like urea, uric acid, and creatinine; and electrolytes, such as sodium (Na+), potassium (K+), calcium (Ca++), magnesium (Mg++), bicarbohydrate (HCO3-), chloride (Cl-), and phosphate (HPO4-). Active transport is defined as the movement of a substance in the presence of an electrochemical difference, such as a difference in electric potential, chemical potential, or both. Energy is required for this procedure. The movement of a substance during passive transport is determined by the electrochemical differences that are present. Energy is not required to move the material during the process.
5. Describe your knowledge of the bladder!

   Answer: The bladder is a muscular sac that deflates that is situated behind the symphysis pubis. Two ureteral apertures and one urethral opening make up the three openings of the bladder. The bladder has two jobs: to hold urine until it is time for it to exit the body and to use the urethra to push urine out of the body.

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CHAPTER 12
NERVOUS SYSTEM

Learning Objectives:

Understanding the structure and function of the nervous system

Introduction

The words neurology and logos are derived from each other. The words "neuro" and "logos" both mean “sciences”. The field of study known as neurology focuses on nerves. For nerve cells (neurons) to communicate with one another, the nervous system combines electrical and chemical impulses. Millions of neurons, also known as nerve cells, make up the nervous system. Neurons are designed with the ability to send and transmit messages (impulses) that take the shape of stimuli or reactions. The three basic components of each nerve cell (neuron) are the nerve cell body, the dendrites, and the axons (Meutia et al., 2021; Nurhastuti & Iswari, 2018).

A. Anatomy Nervous System

Yulia (2020) describes the nervous system as being separated into:

1. The Central Nervous System (CNS) consists of:
    a. Brain: cerebrum and cerebellum
    b. Brainstem: medulla oblongata
    c. Spinal cord: spinal cord
2. The peripheral nervous system consists of
    a. Cranial nerves 12 pairs (N 1 – N XII)

b. Spinal nerves 31 pairs (C1-8, T1-12, L1-5, S1-5, coccygeus 1 pair)
   1) body's own nerve system
   2) system of the autonomic nervous
   3) The information from sensory receptors, such as pain, fullness, heart rate, and respiration, is sent via visceral/sensory afferent fibres.
   4) The visceral/motor efferent system transmits information from the central nervous system to the muscles and glands.

Nerve Cells (Neurons)

The nervous system is composed of billions of highly specialized cells called nerve cells (neurons). function to trigger and conduct electrical impulses. Nerve cells are units with basic and functional properties of the nervous system, including excitability (being ready to respond when stimulated). Each neuron is composed of a cell body, dendrites, and axons (neurites).

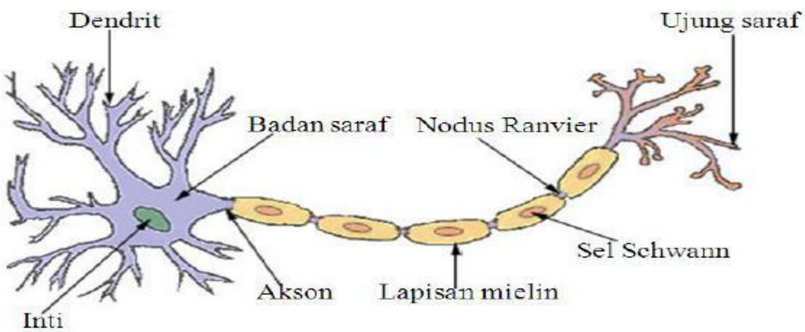

Figure 12.1. Nerve Cells. Source: (https://vlm.ub.ac.id/pluginfile.php/41035/mod_resource/content/1/SISTEM%20SARAF.pdf)

1. Nervous Body
   Is the region of the nerve cell that is made up of the granular, gray cytoplasm and nucleus (cell nucleus). It also includes the

cell membrane, cytoplasm, neurofibrils, and nucleolus (child nucleus).

a. Core (Nucleus)
   Is the soma, or centre, of the cell, where the chromosomes are found. DNA chains make the chromosomes. Although chromosomes do not directly perform any particular tasks, they do have the ability to create or produce a certain set of proteins.
b. Cytoplasm
   On the inside of the neuron, there is a clear jelly-like liquid that contains many organs, such as ribosomes, golgi bodies, and mitochondria that are involved in protein synthesis.
c. Neurofibrils, namely neurofilaments and neurotubules
d. Surrounding the neurons with a cell membrane. The membrane, which consists of two layers of lipid molecules, is semi-permeable (it may choose which substances can enter and which ones can exit).

2. Dendrites
   It is a cell body fibre with brief extensions. A branch-like structure, resembling a tree, makes up the structure of dendrites. Receiving impulses (excitements) from receptors is the job of the dendrites. The nerve cell body was then reached by the impulse.
3. Axon or Neurite
   The axon is only a few micrometres in diameter but can grow to a length of 1-2 meters from the cell body, which has a long and largely unbranched extension. In order to get impulses from the cell body to the effectors (muscles and glands), the axon functions as an impulse carrier. There are little balls filled with chemicals at the end of the axon. These substances serotonin, endorphins, noradrenaline, and norepinephrine are referred to as neurotransmitters.

4. Layer Myelin
   The axons, which are encircled by Schwan cells, are shielded by a fatty sheath. Oligodendrocytes, a type of supporting cell, create myelin sheaths.
5. Nodes of Ranvier
   Can nerve impulses be accelerated or amplified by the portion of the axon that is not covered by a healthy myelin sheath?

CENTRAL NERVOUS SYSTEM (CNS)

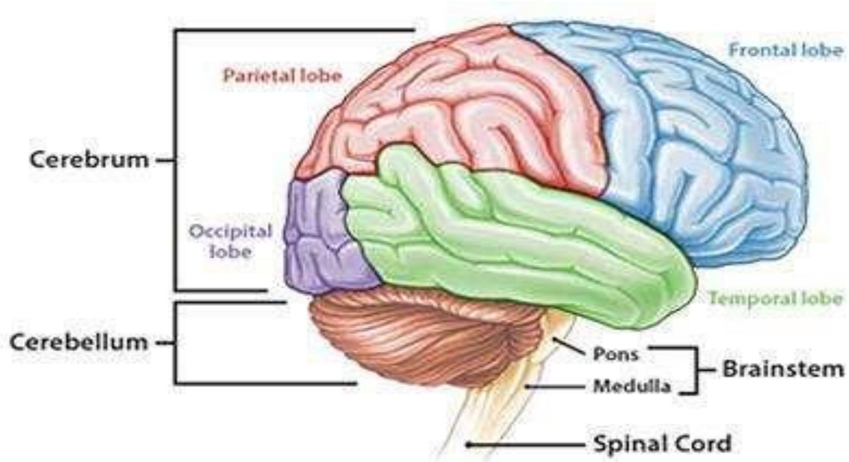

Figure 12.2. Parts of the Brain. Source: (Tjita, 2020)

Four lobes (parts) make up the human brain, including:

1. The centre of thought is held within the frontal lobe (front), which is situated on the forehead.
2. The hearing and language centres are located in the temporal lobe (side), which is at the temples.
3. The occipital lobe (back), which controls central vision, is located in the back of the head.
4. The parietal lobe (the region between the front and back), which controls touch and movement, is located on the crown.

Big Brain (*Cerebrum*)

1. Cortex of the brain's structure

   Serves to recognize and interpret sensory impulses that are required to experience or be aware of specific sensations, such as taste. For as long as people are alive, memories are stored as a result of sensory experiences.

2. Subcortical Structure
   a. By planning and coordinating simple movements, fluid or skilful movements, and body postures, the basal ganglia provide motor activities.
   b. The hypothalamus plays a role in motivation, fear, anger, and sexual behaviour.
   c. The pituitary gland produces a multitude of hormones that function as a regulatory mechanism, regulating the secretion of all other endocrine organs.

3. Cerebral Cortex
   a. Controls the muscles and bones on the sides of the body that move voluntarily. Contralateral
   b. The thalamus, which conveys sensory signals from the skin, joint muscles, and tendons on the collateral side, contains receptors for radiation nerve fibres and recipients of general sensations in the primary sensory cortex.
   c. ocular visual cortex
   d. Cortex of the auditory system
   e. Area responsive to smell
   f. Area of association: high-level mental activity, such as conversing, writing, etc. a connection between the sensory and the motor

Brain Stem (*Brainstem = Truncus Cerebri*)

The spinal cord is attached to the bottom portion of the brain. transmit electrical impulses sent to and received from the cerebral canal and the pathways in some areas of the middle brain. Numerous vital functions of life, including breathing, heart rate, digestion of food, and waste excretion, are controlled by the brainstem.

O *not* Small (*Cerebellum)*

The functions of the cerebellum in general are:

1. regulating posture-related behaviours and attitudes (coordinating muscular contractions for flawless movement execution)
2. maintains posture and muscle strength while regulating and coordinating skeletal muscle activation.
3. The following are additional ways that the cerebellum affects balance and how it processes visual information and the coordination of bodily movements:
   a. Centre for consciously coordinating movement
   b. Position control centre for the body's balancing centre

Medulla Oblongata

placed between the spinal cord and the brainstem, or cord. located in front of the cerebellum, directly following the brain. Become aware of the spinal cord. The medulla is made up of grey nerve cell bodies, while the cortex is made up of white neurites and dendrites. The medulla oblongata serves as a hub for controlling breathing rhythm, breathing movements, heart rate, blood pressure, vessel constriction and dilatation, tool movement digesting, peristalsis, salivary secretion, swallowing, coughing, sneezing, and belching.

Spinal cord

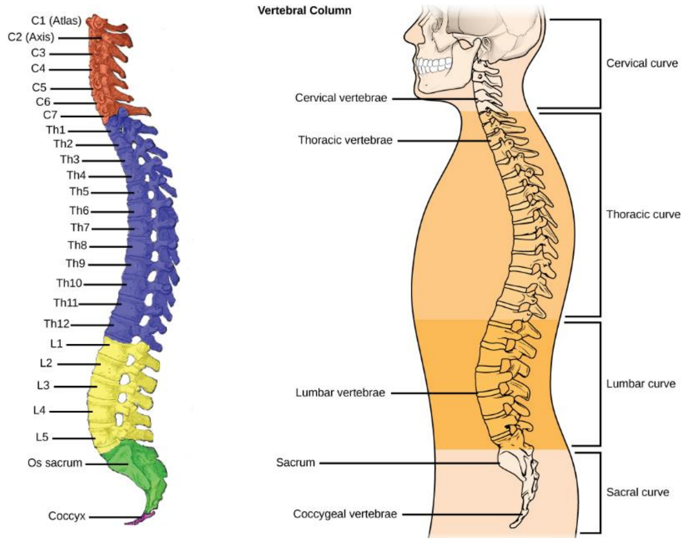

Figure 12.3. Spinal cord. Source: (Lumen, 2022)

The medulla oblongata extends in a caudal direction into the spinal cord. The cervical vertebral horn I marks the beginning of the vertebral canal, which rises all the way to the lumbar vertebral horns I and II. The following nerves leave the spinal cord:

1. The cervical portion leaves 8 pairs of spinal nerves
2. The thoracic portion leaves 12 pairs of spinal nerves
3. The lumbar region leaves 5 pairs of spinal nerves
4. The sacral portion leaves 5 pairs of spinal nerves
5. The coccyx leaves 1 pair of spinal nerves.

Peripheral Nervous System

The peripheral nervous system can be classified into two groups based on type, namely:

1. Efferent nerves, also known as sensory nerve fibres, are responsible for conveying impulses to the CNS effectors (muscles and glands) in order for them to respond to stimuli.

2. Sensory nerve fibres are a group of neurons that transfer impulses from receptors to the central nervous system.

   It is separated into two components according to how it serves, namely:

   a. Consciousness affects how the Somatic Nervous System (SSS) functions.
   b. The body's unconscious tissues and organs are controlled by the autonomic nervous system (ANS)

   The peripheral nervous system is split into cranial nerves, spinal nerves, each pair, and ganglia depending on where it originates.

   a. All the nerves that protrude from the brain's dorsal surface are referred to as cranial nerves.
   b. All the nerves that leave the spine on each side are known as spinal nerves.

   A group of nerve cell bodies called ganglia are located outside the central nervous system and together constitute nerve nodes.

Cranial Nerves

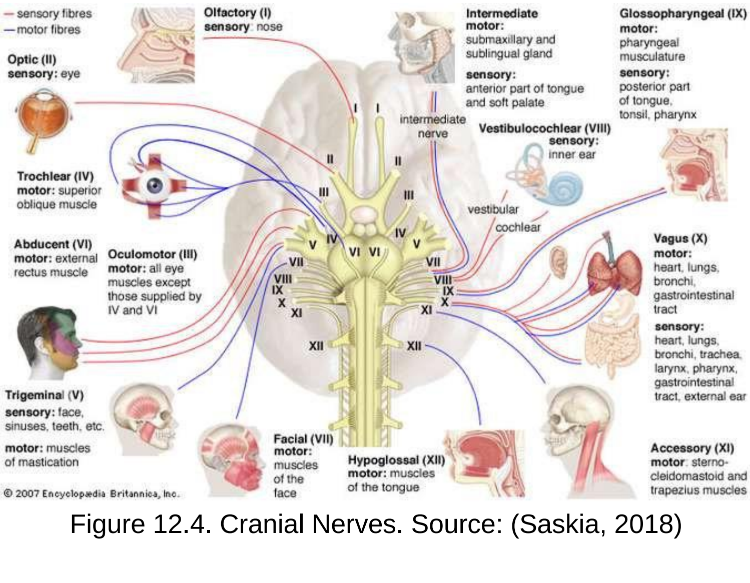

Figure 12.4. Cranial Nerves. Source: (Saskia, 2018)

1. functions of olfactory nerves (olfactory sensory);
2. Functions of the optic nerve (optic sensory) include vision and balance.
3. The oculomotor nerve (also known as the oculomotor sensory nerve) controls pupil size, eye movement, and vision focus.
4. The purpose of the trochal nerve (trochlear sensory) is to control eye movement;
5. Trigeminal nerve (sensory): serves as a face sensory and for chewing;
6. The abducent sensory (abducens) nerve controls how the eye moves;
7. The facial nerve (Facial) controls taste perception and facial expressive movement;
8. The sensory vestibulocochlear nerve is responsible for balance and hearing;
9. The pharynx's mobility, taste, and saliva secretion are all controlled by the glossopharyngeal nerve;
10. Functions of the vagus nerve (for movement and secretion);
11. The head, shoulders, throat, and larynx are all moved by the accessory nerve (accessory);
12. The function of the hypoglossal nerve (hypoglossal) is to control tongue movement.

Nerve Plexus

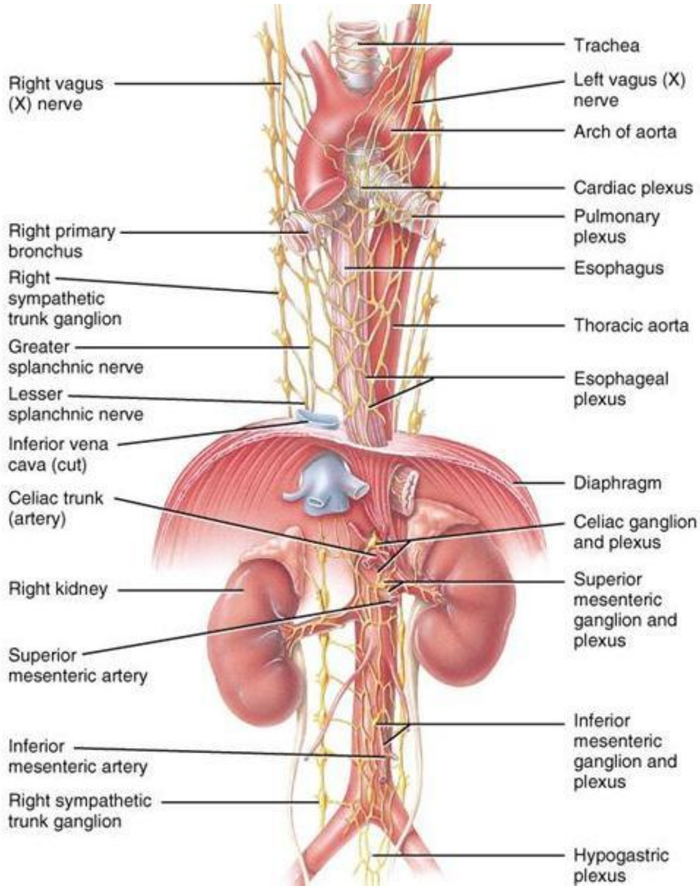

Figure 12.5. Nerve Plexus. Source: (Sihombing, 2020)

Major nerve plexuses

1. Cardiac plexus
2. Pulmonary plexus
3. Oesophageal plexus
4. Celiac ganglion and plexus
5. Superior mesenteric ganglion and plexus
6. Interior mesenteric ganglion and plexus
7. Hypogastric mesenteric ganglion and plexus

Therefore, Nervous System

These nerves are responsible for gathering data from the body's senses. SSS is divided into three categories, including:

1. The transfer of a number of mechanisms in bodily tissue stimulates mechano-receptive somatic senses. Includes the following groups of touch, pressure, and pressure sensors that control the relative position and the rate of movement of different bodily parts:
   a. Body surface sensation is referred to as eteroreception.
   b. Proprioceptive sensation: The tension in the muscles, tendons, and tendon at the bottom of the foot that is related to the physical state of the body.
   c. Sensation coming from the internal organs' visceral body and originating in the tissues is known as a visceral sensation. The fascia mostly consists of pressure, vibration, and deep pain that extends as far as the bone.
2. Heat and cold are sensed by the thermoreceptor.
3. Any factor that destroys tissue can cause the pain sense to be activated. Pain feelings are complex because they combine sentiments and sensations.

Autonomous Nervous System (Autonomous)

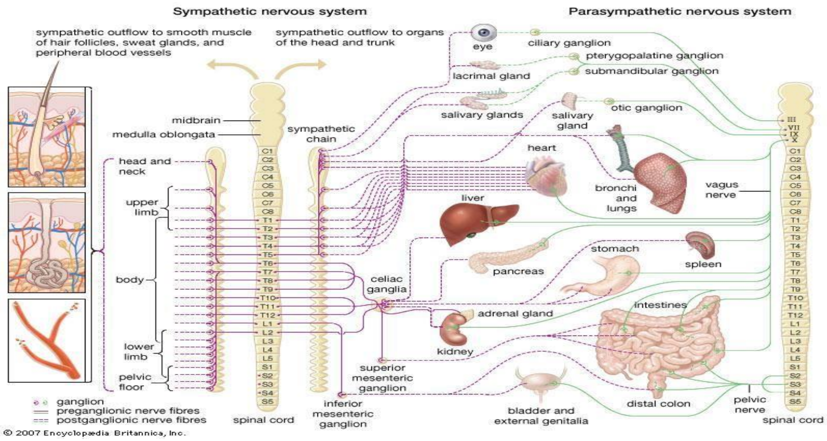

Figure 12.7. Sympathetic and Parasympathetic Nerves. Source: (Sihombing, 2020)

The two components of the autonomic nervous system are separated based on how they perform:

1. Parasympathetic System
2. Sympathetic System

In general, autonomic nerves control motility and secretion in the skin, blood vessels, and visceral organs through promoting the activity of smooth muscles and exocrine glands. Through urination, enuresis, and faeces, they also control and sustain vegetative life.

Systems work in opposite ways (antagonists).

Sympathies Nerves:

1. increases heart rate
2. lowers the rate of digestion
3. increases erection
4. reducing the artery's diameter
5. expands pupil size
6. enlarging bladder and contracting bronchi

Parasympathetic Nervous:

1. slows the heart rate.
2. Speeds up the digestive process
3. Inhibits erection
4. Enlarge the diameter of the arteries.
5. Shrinking pupils
6. The bronchus enlarges and constricts the bladder

B. Physiology

The central nervous system (CNS) and every other component of the body are connected via fibres. Skin stimulation causes impulses to be created, which are then sent along axon fibres into the spinal cord by sensory neuron cells in the nerve nodes close to the spinal cord. Impulses carry information or messages about the collected stimuli, which are sent to the brain to be processed internally. The motor neuron cells in the central nervous system are also informed about the type of stimulus that was received. The axons of motor neuron cells carry impulses that innervate the locomotor muscles in the limbs. Additionally, directives consciously issued to move the extremities and its components can generate impulses.

Neurons are divided into three categories based on their shape and function: sensory neurons, motor neurons, and interneurons.

1. Sensory S neurons
   is a type of neuron in which the cell bodies of the individual neurons are grouped together to form ganglions (plural: ganglia). Unlike the neurites, which are connected to the dendrites of other neurons, the dendrites of other neurons are associated with their neurites. Sensory neurons have the job of carrying nerve impulses (excitation) from receptors to the brain and spinal cord. Other names for sensory neurons include sensory neurons.
2. Neuron Motoric
   are neurons whose job it is to send signals from the central nervous system to the glands and muscles that will carry out the body's reaction. Activating neurons is another name for motor neurons.
3. Interneurons
   Interneurons, also known as neuronal adjustors, connect motor neurons and sensory neurons in the brain and spinal cord. The neurons that transmit impulses from sensory or other interneurons are known as interneurons. Connector neurons are another name for interneurons.

Mechanism of Conducting Nerve Impulses

1. By means of the plasma membrane
   Only some ions can actively move across the plasma membrane of other neurons, protecting the cytoplasmic fluid inside. The plasma membrane of neurons is semipermeable and functional. when neurons are at rest and receiving no stimulation. The liquid outside the plasma membrane is electrically charged (+), whereas the cytoplasm inside is

electrically charged (-). Polarization or resting potential is the name of this condition.

2. Synapses

   The neurites' ends branch, and the branches' tips are connected to other nerve cells. Increasing size is referred to as a synaptic hump (knob). Attached neurites with dendrites, or cell walls, are found at the synapse. An action potential occurs in the dendrite when an impulse reaches the synaptic head, where it is turned into an impulse by the nerve cells it contacts. If the synaptic head receives the impulse, the synaptic head will be created by a neurotransmitter (for example, acetylcholine). Acetylcholine is then converted by the choline esterase enzyme into acetate and choline, rendering it instantly inactive.

Motor impulse

Axons (nerve fibres in the white matter of the spinal cord) travel from the pyramidal cells in the motor region (in the cortex) to dendrites (motor nerve cells in the anterior horn of the medulla spinalis), which then connect to the anterior radicle motor fibres in muscle. In order for the body to respond to stimulation, motor neurons transmit impulses from the central nervous system to muscles or glands. The central nervous system contains the cell bodies of motor neurons. The association nerve's axon can be very long, but its dendrites are extremely short and connected to it.

Sensory impulses

Conducting impulses from receptors to the brain (encephalon) and spinal cord (spinal cord) are the primary duties of sensory nerve cells. sense nerves' axons that connect to their related nerves (intermediates) originating from epidermal nerve endings, traveling through nerve fibres (dendron), to sensory cells in the posterior root ganglion through axons into the spinal cord, and then ascending to the nucleus in the medulla oblongata and onto the brain.

The main function of the nervous system

1. Afferent sensory pathways allow the body to receive information (stimulation) from both inside and outside the body.
2. connects the Central Nervous System and Peripheral Nervous System to exchange information.
3. The brain and spinal cord both work together to process information in order to produce the response.
4. Deliver solutions swiftly to the body's organs via motor neurons (the motor efferent Pathway).

Physiological Reflexes

1. Corneal reflex: apply cotton to the limbus of the cornea and anticipate an eyeblink.
2. Scratching the pharynx with a spatula causes the patient to vomit.
3. Pupillary miosis will happen when the eye is lit from the side.
4. abdominal wall contractions will happen if you scratch the abdominal wall in the direction of the umbilical.
5. Cremaster reflex: if the scrotum is the same side up or tight, the inner thigh should be scratched from top to bottom.
6. Anal reflex: When the anal skin is scratched, the anal sphincter muscle contracts.

Summary

The study of nerves, which use electrical and chemical signals to communicate with one another, is known as neurology. Millions of nerve cells that are made to send and transfer signals make up the nervous system. The nerve cell body, dendrites, and axons are the three fundamental parts of every nerve cell. The Central Nervous System (CNS), which comprises of the brain, brainstem, spinal cord, peripheral nervous system, and autonomic nervous system, is one segment of the nervous system.

Highly specialized cells called neurones produce and carry out electrical impulses. Axons, dendrites, and the cell body make up

each component of a neuron. The cytoplasm, cytoplasm, neurofibrils, and nucleolus make up the nervous body. Cell body fibres called dendrites are slender extensions that receive impulses from receptors. At the end of axons, or nerves, which serve as impulse transporters, are tiny balls loaded with chemicals. The axons are shielded by the myelin layer from injury by oligodendrocytes and Schwan cells.

Nerve impulses may be accelerated or amplified by Nodes of Ranvier. The body's reaction to stimuli is regulated by the central nervous system (CNS), which also manages the nervous system's operations.

The frontal lobe, temporal lobe, occipital lobe, and parietal lobe are the four lobes that make up the human brain. While the temporal lobe is in charge of hearing and language, the frontal lobe is in charge of cognition. The motivation, fear, anger, and sexual behaviour are all influenced by the hypothalamus. Hormones produced by the pituitary gland control the secretion of endocrine organs. The thalamus transmits sensory information, whereas the cerebral cortex regulates the voluntary movements of the body's muscles and bones. The region receptive to scent is the area of association, and the auditory system cortex is in charge of controlling the auditory system.

Vital processes including breathing, heart rate, digestion, and waste excretion are managed by the spinal cord, which connects to the brainstem. The cerebellum controls behaviours that influence posture; it maintains posture and muscular strength; and it has an impact on balance and coordination of body movements. Between the spinal cord and the brainstem, the medulla oblongata is in charge of regulating blood pressure, heart rate, breathing rhythm, and other body processes. The cervical vertebral horn I, which leaves many nerves, connects the spinal cord to the spinal cord.

Effective nerves, which transmit impulses to the effectors of the central nervous system (CNS), and sensory nerve fibres, which transmit impulses from receptors to the CNS, are the two categories that make up the peripheral nervous system. Consciousness and the autonomic nervous system (ANS) regulate the somatic nervous system (SSS). The system is organized into ganglia, spinal nerves, and cranial nerves, each of which performs a specific role.

The olfactory, optic, oculomotor, trochal, trigeminal, abducent, facial, glossopharyngeal, vagus, accessory, and hypoglossal nerves are all included in the list of cranial nerves. The body's senses, which are triggered by a variety of systems in biological tissue, are collected by the SSS. These senses include pain perception, visceral feeling, proprioception, and eteroreception. The body's unconscious tissues and organs are under the supervision of the autonomic nerve system (ANS).

The sympathetic and parasympathetic nerve systems make up the autonomic nervous system. While the parasympathetic system lowers the heart rate, speeds up digestion, suppresses erections, enlarges the diameter of arteries, shrinks pupils, and constricted the bladder, the sympathetic system regulates motility and secretion in the skin, blood vessels, and visceral organs.

Fibres link the central nervous system (CNS) to various parts of the body. Sensory neuron cells generate impulses in response to skin stimulation, and these impulses are then transmitted through axon fibres into the spinal cord. The brain processes the gathered data internally, and impulses contain information about those processed stimuli. The central nervous system's motor neuron cells are also aware of the kind of stimulus being received.

Sensory neurons, motor neurons, and interneurons are the three subtypes of neurons. Motor neurons provide messages from the central nervous system to glands and muscles, whereas sensory neurons deliver nerve impulses from receptors to the brain and spinal cord. In the brain and spinal cord, interneurons, often referred to as neuronal adjustors, link motor and sensory neurons.

The plasma membrane, synaptic humps, and motor impulses all play a role in the transmission of nerve impulses. The brain and spinal cord receive impulses from receptors that are carried by sensory nerve cells. Receiving information, establishing connections between the Central Nervous System and Peripheral

Nervous System, processing information, and sending information to organs are the primary duties of the nervous system.

The pharynx scratching, pupil miosis, abdominal wall contractions, cremaster reflex, and anal reflexes are examples of physiological reflexes.

Review Questions

1. Describe how the human nervous system is divided!
   Answer: The Central Nervous System (CNS) and Peripheral Nervous System (PNS) are the two components of the human nervous system. Both the Brain (Encephalon) and the Spinal Cord (Medulla Spinalis) are parts of the Central Nervous System. Conscious and unconscious (autonomous) nerves make up the peripheral nervous system, but
2. Explain what is called the spinal medulla!
   Answers: The spinal cord is an extension of the brainstem that begins at the foramen magnum and continues down through the vertebral canal to the first lumbar vertebra (L1). The spinal cord is located in its lower end position by the terminal phylum, an extension of the pia mater that is attached to the coccyx.
3. What nerves are included in the cranial nerves?
   Answer: Cranial nerves are PNS nerves that originate or terminate in the brain. There are 12 pairs of cranial nerves, all of which pass through the cranial foramina. There are two types of cranial nerves: sensory nerves (only dominated by sensory fibres) and mixed nerves (containing sensory fibres and motor fibres). The twelve pairs of cranial nerves are: Olfactory, Optic, Oculomotor, Trochlear, Trigeminal, Abducent, Facial, tracheal, Glossopharyngeal, Vagus, accessory, and Hypoglossal.
4. Describe the functions of the parts of the brain!
   Answer Instructions: The functions of the parts of the brain are: The frontal lobe, as a conscious control of skeletal muscles and intellectual processes, is useful in verbal

communication. The parietal lobe, which controls the sensation of the skin and muscles, also controls speech. The Temporal lobe interprets auditory sensation, auditory memory, and sight. The occipital lobe integrates the focusing movement of the eyes and regulates the relationship of visual images to previous experiences and conscious vision. Insular activity regulates memory and integrates other cerebral activities.

5. What do you know about the autonomic nervous system?
   Answers: The autonomic nervous system consists of motor neurons that control smooth muscle, cardiac muscle, and glands. In addition, the ANS monitors visceral organs and blood vessels with sensory neurons, which provide input information to the central nervous system. The autonomic nervous system is further divided into the sympathetic nervous system and the parasympathetic nervous system. Both of these systems can stimulate and inhibit effectors. However, the two systems work antagonistically. Each system prepares the body for different types of situations.

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CHAPTER 13
MUSCULOSKELETAL SYSTEM

Learning Objectives:

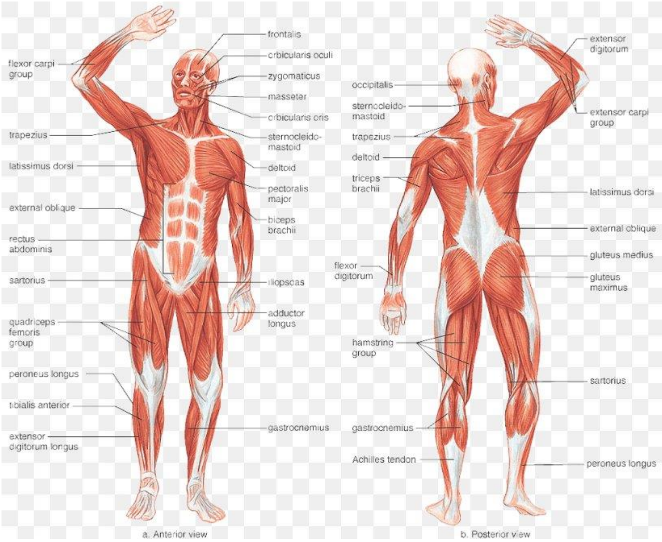
Understanding the structure and function of the sensory system

Introduction

Musculo (meaning "muscles") and skeletal (meaning "bones") make up the term "musculoskeletal." A network of muscles in the body is referred to as muscular, and the study that examines these muscles is known as myology. The skeleton, or osteo, is the structure of the bones, and osteology is the study of the science of the skeleton. In reaction to shifting surroundings, muscles (muscles) are network-functioning bodies that alter their energy chemistry and transform into work mechanics. Bones, cartilage, and joints make up the skeleton (skeletal), which adheres to muscles and enables the body to retain attitude and position. Together, the body's skeleton of muscles and bones support and move the body. Muscles move bone, which protects interior organs, but muscles are in charge of responding.

Anatomy of Musculoskeletal System

1. Muscular/Muscles

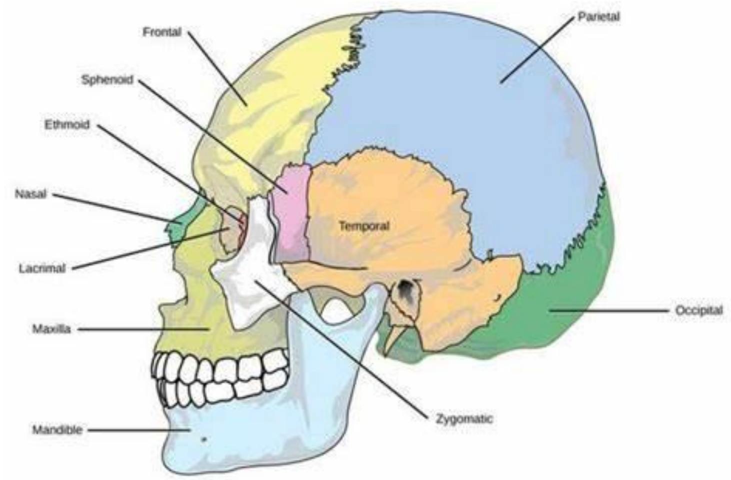


Picture 13.1. Source : Hariandja & Yulanda (2023)

2. Skeletal

a. Bone Skull

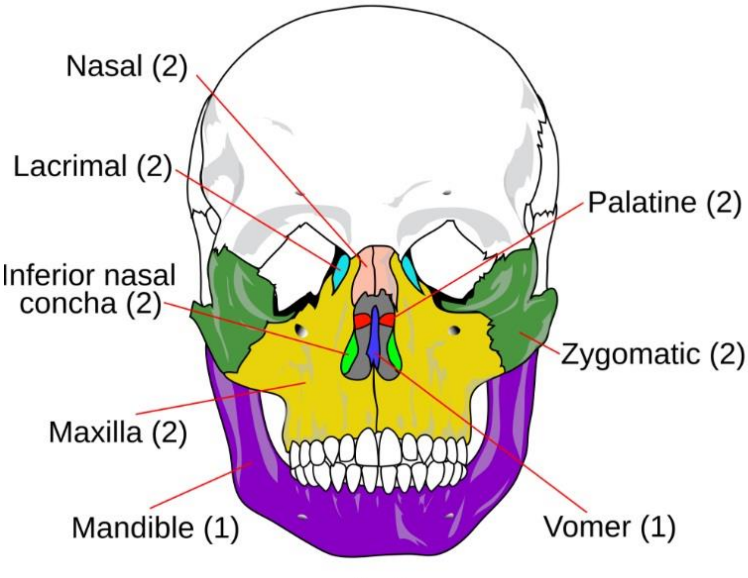
1) Bone shell head (cranium)



Picture 13.2. Source: (Lumen, 2022)

a) Bone forehead (frontal)
b) Bone fontanel (parietal)
c) Bone temples (temporalis)
d) Bone head back (occipital)
e) Bone wedge (stenoid)
f) Sieve bones (ethmoid)

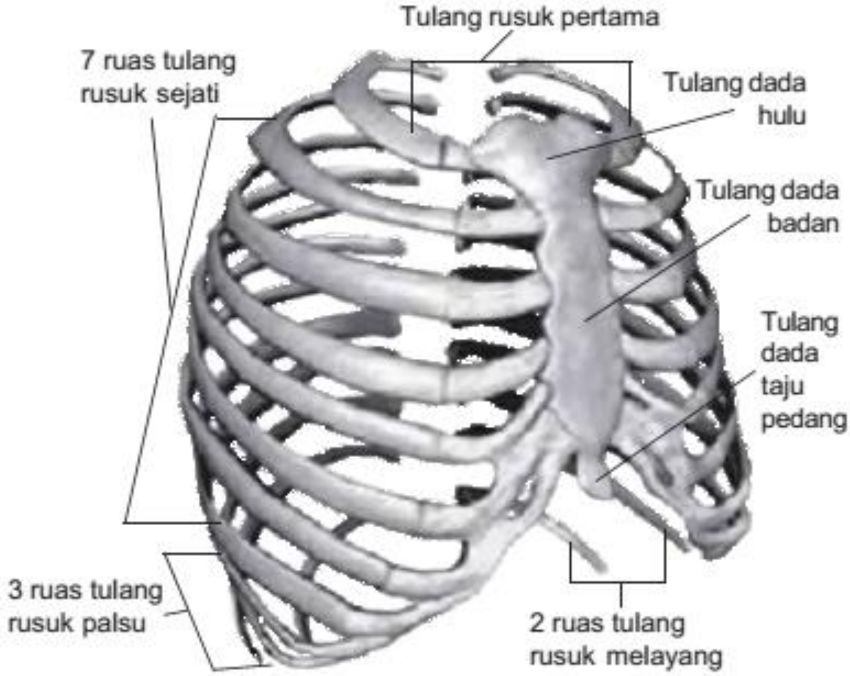
b. Bone face



Picture 13.3. Source: (Miller, 2018)

a) Bone jaw upper (maxillary)
b) Bone nose (nasalis)
c) Cheekbones (zygomatic)
d) Tear bone (lacrimal)
e) Bone palate (palatinus)
f) Bone inferior turbinate
g) Bone jaw lower (mandible)

c. Thorax

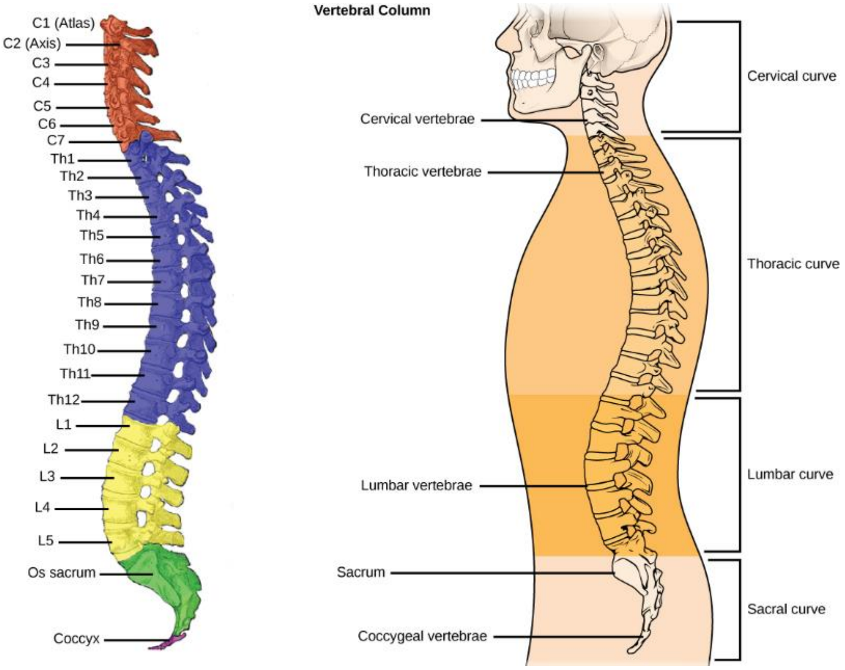


Picture 13.4. Source: (Noveawan, 2015)

1) Sternum (sternum)
   a) Upstream sternum (manubrium)
   b) Body sternum (gladiolus/corpus)
   c) Taju breastbone sword (xiphoid processus)

2) Bone ribs (costae)
   a) Bone lateral true 7 pairs
   b) Bone lateral fake 3 pairs
   c) Bone lateral floated 2 pairs

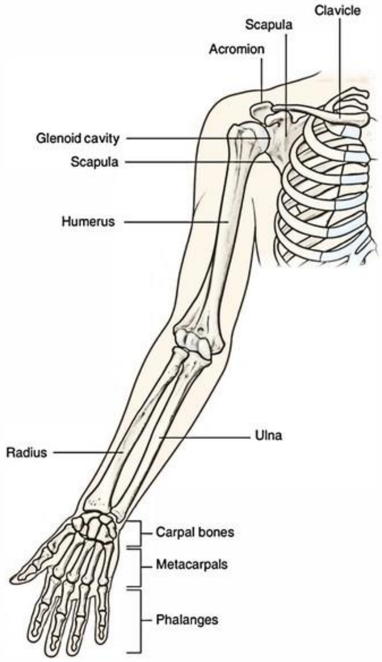
d. Bone Back (Vertebrae)



Picture 13.5. Source : (Lumen, 2022)

1) Cervical/neck bone 7 vertebrae
2) Bone thoracalis/back 12 segments
3) Bone lumbar/waist 5 segments
4) Bone sacral/groin 5 segments
5) Bone coccygeus/tail

e. Order Upper Appendicular



Picture 13.6. Source: (Earthslab, 2019)

1) Shoulder bone
   a) Clavicle (bone collarbone)
   b) Scapula (bone shoulder blade)
2) Bone arm
   a) Bone arm above: humerus (bone base arm)
   b) Bone arm below: radius (bone radius) and ulna (ulna)
3) Bone hand
   a) Bone wrist hand (carpus/carpals): scaphoid, lunate, triquetrum, fisiform and terrapezium, trapezoid, capitatum, hamate
   b) Bone palm hand (metacarpal)
   c) Bone finger hands (phalanges)

f. Order Lower Appendicular

Picture 13.7.

1) Coxae bones (innominate / bones hips)
   a) Ileum (intestinal bone)
   b) Ischium (sitting bone)
   c) Pubis (bone genitals)
2) Bone extremity lower
   a) Bone thigh (femur)
   b) Bone shell knee (patella)
   c) Bone calf (fibula)
   d) Bone dry (tibia)
3) Leg bones (tarsus)
   a) Bone ankles (tarsals): calcaneus, talus, cuboid, navicular, cuneiform
   b) Bone feet (metatarsals)
   c) Bone toes (phalanges)

Physiology Anatomy of Musculoskeletal System

1. **Muscular/Muscles**

   The ability to do Work mechanics with road contraction and relaxation cells, or the fibre, is possessed by network muscle. The cytoplasmic structural filament that makes up a cell's muscle causes the cell to extend and shorten. A luminous chemical underpinning for muscle contraction lies below the mechanism that underlies muscle contraction, which is just an explicit motion mechanic (Sari, 2018).

   a. **Function**

      1) Movement

         The internal organs of the body have muscles attached to them that move to cause movement in the bones.

      2) Crutch body and defend posture

         When in position, standing or sitting against gravity, muscles support the frame and preserve body moment.

      3) Production hot

         In order to maintain a normal body temperature, muscle contraction generates heat metabolically.

   b. **Features**

      1) Contractility

         Fibre muscle tensing and contracting, which may or may not involve muscular shortening.

      2) Excitability

         Fibre muscle tensing and contracting, which may or may not involve muscular shortening.

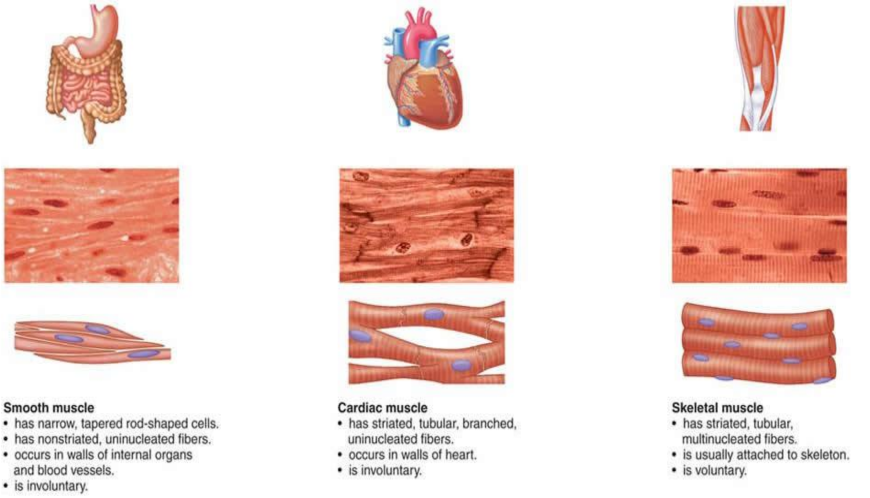
      3) Extensibility

         If nerve impulses are used to excite fibre muscles, they will react strongly.

      4) Elasticity

         Fibre muscle has unique capabilities. Overcome a long muscle period of relaxation for stiff muscles.

c. Types



Picture 13.8.

1) Muscle structure

   The striated, voluntary, and skeleton-attached muscular framework. Fibre is a very long, cylindrical muscle with a length that can reach up to 30 cm and a thickness that ranges from 10 microns to 100 microns. Numerous nuclei are grouped in portions along the peripheral axis of each fibre. Strong and swift contractions are experienced. The following are the structures of the tiny muscular skeleton:

   a) Myofibers, also referred to as muscle fibres, are the long, cylinder-shaped fibres that make up the muscle skeleton and are grouped in bundles.
   b) Every muscle fibre is in fact a cell with many nuclei on the edge.
   c) Full sarcoplasm refers to the cytoplasm of a muscle cell and contains a variety of organelles, most of which are in the form of long cylinders known as myofibrils.
   d) Different myofibril sizes, which are rough and include the protein myosin, and smooth proteins, which contain the protein actin, make up myofibrils.

2) Supple muscle
A muscle is a smooth muscle. Unwilling and striated. muscle type This can be found in the blood of the respiratory, digestive, reproductive, urinary, and systemic circulation tubes as well as on the walls of hollow organs like the biological bladder and uterus. spindle in the form of a fiber-muscle with a nucleus in the middle. Fibre This is tiny, ranging from 20 microns (blood coat vessels) to 0.5 mm in a pregnant woman's uterus. Strong and slow contractions were experienced.
a) The sarcoplasm of microscopic muscle is made up of myofibrils made of myofilaments.
b) There are two categories of muscles: techniques based on smooth muscle and fiber-muscle stimulation in favour of tense muscles. Double-unit smooth muscle can be seen on the blood vessel walls, the airway, the respiratory system, the muscle that focuses the eyes, the lens, adjusts pupil size, and the muscle that erects the hair. The hollow organ walls, or viscera, contain layers of single-unit smooth muscle. Every fibre in a layer has the ability to contract as a single unit. Without external nerve stimulation, muscles can be activated myogenically or on their own to produce outcomes from spontaneous activity.

3) Muscular heart
The muscle heart has striae. Also known as muscle sergeant latitude involuntary. Muscle Only the heart can experience this. The heart works nonstop at all times, yet it also rests between each heartbeat. The microscopic muscular heart shares a structure with the muscle skeleton.

2. Skeletal

There are 206 bones in the body. Movement is governed by the configurations of the bones, joints, and muscle attachments on the bones. Bones are divided into four classes based on their shapes: long, short, flat, and regular bones. Many authors also distinguish type 5 bone, also referred to as sesamoid bone, which is a tiny, embedded nodular bone in the tendons. Bone-long mobility is made possible by the framework that bones give the body. Diaphysis is the name given to the bone's long, hollow rod, and epiphyses are the epiphyses' two prominent ends (Purnomo, 2019).

a. Function

1) Bones build the structure of the body, which determines the shape and size of the body.
2) A small amount of mobility is dependent on the functional body; no movement; formation joints: adjacent bones form mobile joints.
3) muscles attached: position muscles attached
4) Leverage: For a variety of tasks while moving.
5) Additionally, provide weight support. energy stand Take care of your attitude and body posture, such as standing up straight, to control face influence, pressure, and mechanics.
6) a bone-like chamber that serves as protection for delicate organs.
7) Hemopoiesis: the process of bone marrow producing blood cells.
8) Immunological function: the development of B cells in the bone marrow, which produce antibodies for the body's immune system.
9) Calcium that is stored in bones is released into the blood when the body requires it.

b. Bone Skull

1) Cavity skull

   Above the conventional dome skull, cavity skulls have smooth surfaces outside and wavy surfaces inside, depending on the shape of the brain and the position of blood veins. Base skull and punctured base kranii together make up the surface lower cavity skull. Blood arteries, nerves, and fibres can travel through several holes.

2) Bone occipital

   The foramen magnum (hole head) behind the medulla oblongata penetrates the bone occipital positioned behind and beneath the cavity cranium to reach the spinal cord. Bone that creates masses is found in the condyle skull's side foramen.

3) Parietal skeleton

   The sides and roof of the skull are formed by both of them. The outside is smooth. There are wrinkles on the surface when loading the cerebral artery. The medial meningeal artery is where the very noticeable wrinkles are located. Should the artery This spilled blood will make the network's muscles flimsy and fragile, allowing damage to extend to the sides and altering the eyes' pupils.

4) Frontal crest

   The sides and roof of the skull are formed by both of them. The outside is smooth. There are wrinkles on the surface when loading the cerebral artery. The medial meningeal artery is where the very noticeable wrinkles are located. Should the artery This spilled blood will make the network's muscles flimsy and fragile, allowing damage to extend to the sides and altering the eyes' pupils.

5) Bone

   The squama and the mastoid are the two components that make up each bone. The auditory meatus external is positioned behind the zygomaticus process, with the squama segment being part flat and soaring to up and allowing linked temporal muscles to rise. The walk-down process mastoideus, which has a spacious cavity mastoid air and space special termed the antrum tympani and coated continuous epithelium with epithelium from the cavity ear centre, is where the mastoid is placed.

6) Sutures/cranial gaps
   Bones skull be connected One each other by a connection that is not can move called sutures, except A bone face the mandible (jaw bottom). Mandible forming joints with the temporal bone is called mandibular joint. Main sutures are suture coronalis, suture sagittal and suture lamboidalis.
7) Fontanels/fontanel
   A newborn with a bone skull Not quite perfectly hardened yet. membranes that are at the corners and filled with bone in the interroom. The term for that is fontanelles. The anterior fontanel is the largest fontanel and is situated where the sutures coronalis and sagittal, which connect the frontal bone to the two parietal bones, meet. It is placed gently on a baby's head and measures 4 cm. This can contact and pulse his brain through place. Fontanels typically close at the age of 18 months. The occipital bone, which swiftly shuts after birth, connects the two parietal bones, and the posterior fontanel is situated behind them. bone that forms part of the lower sides of the left and right skulls. Each bone is made up of two parts: the squama and the mastoid. The squama segment is part flat and half soaring up, allowing the associated temporal muscles to ascend. The auditory meatus external is situated behind the zygomaticus process. The mastoid is located in the walk-down process mastoideus, which has a large cavity mastoid air and space special called the antrum tympani and is covered continuously with epithelium from the cavity ear centre.
8) Air sinuses in the skull
   The nasal cavity (nose) and the paranasal sinuses are connected by air gaps in the bone of the skull. The maxillary sinus (antrum highmore located on the left right nose in bone maxillary), the frontal sinus (lie in bone forehead, on the left right base nose above the corner eye), the ethmoidal sinus (mastoid antrum is located inside

deep temporal bone mastoid process, connected with the tympanic cavity), and the sphenoidal sinus are the four paranasal cavities that are connected with the cavity nose. Sine/space air function This helps to ease the weight of the heavy skull bones, gives the sound resonance, aids in hardening the voice during speech, produces flowing mucus in the nasal cavity, and warms and moisturises the entering air.

c. Thorax

The lowest portion of the cone is wider than the top and is arranged on bones and bones that are fragile. The 12 thoracic vertebrae in the back, the sternum of the thoracic vertebrae in front, and the 12 pairs of ribs on either side make up the arrangement bone thorax that is next to it.

d. Bone Ahead

Function without bone Increase the style mechanic structure of the bone back and straighten or support the posture structure of the bone back for a hefty body. Man may perform a variety of postures and motions between his back bones, which are connected by ligaments, muscles, and intervertebral discs. These positions and movements include standing, sitting, and running, as well as maintaining a straight posture and protecting the marrow of the backbone.

1) Cervical vertebrae

   The neck region and nape are made up of seven cervical vertebrae, or bone segments. The seven processes that make up a cervical vertebra's so-called crown process are not split and feature tubercles or bulges that are visible on the nape of the neck and are referred to as vertebral prominence.

2) Thoracic vertebrae

   The rear of the thorax, or chest, is made up of 12 thoracic vertebrae, or segments of bone, which are larger than cervical vertebrae.

3) Lumbar vertebrae

   There are five vertebrae: the lumbar or waist-shaped section of the bones. largest and most attractive vertebrae, similar to kidneys. Joints with the sacrum are referred to as lumbosacral joints in section five.

4) Sacrum

   The sacrum, often known as the bone crotch, is made up of five sacral vertebrae or segments that do not shift in maturity.

5) Coccygeus

   In adulthood, the four coccygeal vertebrae, also known as the bone tugging or bones tail, combine to form the bone coccygeus. It is immobile and is also known as a segment bone.

6) vertebral columnar arch

   The column vertebral has four curves, all of which are posterior when viewed from the side:

   a) When infants begin lifting their heads, the arch cervical region (neck curved to the front), area thoracic curved back, area lumbar curved anteriorly, area pelvic curved back, and bend cervical develop.
   b) The primary arch refers to the thoracic and pelvic arches since they both preserve the original arch that existed in the back form C during pregnancy.
   c) The arch secondary is the lumbar arch that developed when infants began to crawl, stand, walk, and support their bodies upright.

7) pelvic bracelet

   The link between the body and the members below is the bracelet pelvis, or pelvic bones. This band includes the sacrum and the bones coccygeus, which are wedged between two bones coca and are a part of the axial framework. Second joined bone cocas; same other on the place pubic symphysis

e. **Ordering the Upper Appendix**

Members of the framework include:

a) Clavicle: function establishes a connection between certain muscles acting as crutches in the arms, shoulders, and neck.
b) Scapula/shoulder blade: forms a portion behind the thoracic and then behind the shoulder bracelet.
c) The longest member of the bone is called the humerus (bone arm above; motion top).
d) Bone cubits, also known as ulna, are pipes with a rod at either end.
e) Radius: On the lateral side of the bone arm down, the pipe bone is shorter than the ulna.

f. **Order the Lower Appendix**

a) Bone hip: The big pelvis includes the os coxae. The ileum (intestinal bone), pubic bone (genital bone), and bones that make up bone coxae meet at the acetabulum. The longest bone in the body, the femur or thigh bone, has the thickest ischium and is located in the sitting bones.
b) Extensor quadriceps tendon is where the patella (shell knee) originates.
c) The major limbs' structure, the tibia (bone dry), is located beneath and medial to the fibula (bone calf).
d) Calf bone, or fibula, is situated in the lower limbs on either side.

Summary

The body is supported and moved by the muscles and skeletal system, which are made up of both. In reaction to changing environmental conditions, muscles are network-functioning bodies that change their energy chemistry and morph into work mechanics. The structure of the bones is known as the skeleton, or osteo, and the study of the skeleton's science is known as osteology. While muscles are in charge of reacting, bone is moved by muscles, protecting internal organs.

The skeletal system is made up of joints, cartilage, and bones that attach to the muscles and allow the body to maintain posture and attitude. The shoulder bones, sternum, ribs, thorax, lumbar, sacral, and tail bones are all parts of the upper appendicular system. Coxae, intestine, iliac, and genital bones make up the lower appendicular system.

Muscles can move, shape the body and support posture, and they may also produce heat. They also possess qualities including elasticity, extensibility, contractility, and excitability. Triceps, hamstrings, femurs, tarsi, and toe muscles are among the several muscle kinds.

Including muscle fibres, supple muscle, and skeletal muscle, muscle structure is a striated, voluntary, and skeleton-attached muscular framework. Myofibers, which are long, cylindrical fibres with a length of up to 30 cm and a thickness of 10 microns to 100 microns, make up the muscular skeleton. Muscle fibres, which come in a variety of organs including blood vessels, airways, respiratory systems, and hair, are made up of myofibrils of different diameters and proteins.

The only muscle that can undergo muscle contractions is the muscular heart, also known as muscle sergeant latitude involuntary. The heart beats continuously and takes a break in between each beat. Based on their forms, the 206 bones that make up the human body are separated into four categories: long, short, flat, and regular bones. The structure, functionality, and movement of the body are greatly influenced by bones.

The structure of the body is built from the bones, which also provide muscles attachment, leverage, weight support, and protection for sensitive organs. They also participate in immunology, hemopoiesis, and the release of calcium into the blood as necessary.

The cavity skull, occipital skeleton, parietal skeleton, and frontal crest make up bone skulls. The auditory meatus external and the walk-down process mastoideus establish joints with the temporal bone, and the squama and mastoid are the two constituents of each bone.

Except for the mandible, which forms joints with the temporal bone, sutures are the connectors between bones. In the interroom, fontanelles are membranes in the corners that are filled with bone. The frontal bone and the two parietal bones are connected by the anterior fontanel, which is the biggest fontanel in the body. It comfortably rests on a baby's head and shuts after 18 months. The posterior fontanel is located behind the two parietal bones, which are connected by the occipital bone. The squama and the mastoid, which are joined by air spaces, make up the two components of the skull. There are air spaces in the skull that link the nasal cavity and paranasal sinuses.

The lowest point of the cone is the thorax, which is supported by frail bones. The configuration consists of the 12 pairs of ribs on each side, the sternum of the thoracic vertebrae in front, and the 12 thoracic vertebrae in the rear. The backbone is made up of four coccygeal vertebrae, the sacrum, five lumbar vertebrae, 12 thoracic vertebrae, seven cervical vertebrae, and the vertebral columnar arch. The sacrum and the coccygeus bones are among the pelvic bones connected to the body via the pelvic bracelet.

The clavicle, scapula/shoulder blade, humerus, bone cubits, and radius are all parts of the upper appendix. The hip, tibia, and fibula are bones found in the lower appendix. Numerous elements, including posture, position, and body position, have an impact on the skeletal structure of the body.

Review Questions

1. Why is the skeleton called a passive locomotion device?

   Answer Instructions:

   Bones are referred to as passive locomotors because they are locomotors that cannot move on their own but are moved by muscles, and muscles are referred to as active locomotors because they can move on their own and move bones by means of muscle contractions.

2. Name the four functions of the skeleton in the body!

Answer Instructions:

Skeletal function:

a. The skeleton can strengthen and straighten the body.
b. If the human body is not equipped with a framework, maybe the body will not be sturdy and strong enough to support the body while standing, running, or walking. With the shape of the soles of the feet that are long, strong, and long enough, we can stand straight.
c. The skeleton determines the shape of the body.
d. With the skeleton, our bodies have a perfect and beautiful shape. Even without the existence of a skeleton, every form of the human body can be distinguished. For example, some people are tall, some are short, some have long fingers, some are short, and so on.
e. The skeleton is the place where muscles attach.
f. Without a skeleton, muscles have nowhere to attach. If the muscles have nowhere to attach, the limbs will become stiff and immobile. Muscles work by relaxing and contracting. That's where the framework cooperates with the muscles to perform a movement. For example, moving the arm is influenced by the muscles in the upper arm bone, namely the biceps and triceps.
g. The skeleton can protect the body, which is important.
h. We know that bones are the hardest part of the body. With their hard shape, the function of bones is to protect parts of the body that are quite fragile or easily injured and damaged if exposed to hard objects, such as the brain, heart, and lungs.

3. Mention four names of bones, including long bones!

Answer Instructions:

Some of the bones that include long bones are the upper arm (humerus), femur (femur), tibia (tibia), fibula (fibula), radius (radius), and ulna (ulna).

4. Describe the characteristics of cartilage and give an example!
Answer Instructions:
The definition of cartilage is a connective tissue in which the bones are tough and flexible because the substances between the bone cells contain a lot of adhesive substances and contain calcium. In adults, cartilage is replaced by bone, but not all cartilage is replaced by bone. Cartilage in adults is found in the ears, nose, and at the ends of bones, where bones connect (joints).

5. Name the bones that make up the spine!
Answer Instructions:
The spine (vertebrae) are irregular bones, forming the back of the body, which is easy to move around. There are 33 human vertebrae, i.e., the upper three are made up of 24 bones (divided into 7 cervical (neck) vertebrae, 12 thoracic (thoracic), and 5 lumbar vertebrae), 5 of which join to form the sacral, and 4 bones form the coccyx.

6. What is the connection between one bone and the other called?
A. Muscle
B. Joints
C. Order
D. Collagen
E. Network
Answer: B

7. Joints that allow free movement in almost any direction:
A. Pivots
B. Saddle
C. Diarthrosis
D. Synarthrosis
E. Amphiarthrosis
Answer: A

8. Joints that connect the bones of the skull:
   A. Pivots
   B. Saddle
   C. Diarthrosis
   D. Synarthrosis
   E. Amphiarthrosis

   Answer: E

9. The joint between the upper arm and shoulder:
   A. Pivots
   B. Plane
   C. Hinge
   D. Condylar
   E. Diarthrosis

   Answer: C

10. The joint connection between the ulna and radius that causes the palm to turn and the palm of the hand to turn is called:
   A. Swivel joint
   B. Synarthrosis
   C. Gliding Joints
   D. Flex-extension
   E. Supination and pronation

   Answer: E

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CHAPTER 14
INTEGUMENT SYSTEM

Learning Objectives:

Understanding the structure and function of the Integument system

Introduction

The word "integument" comes from the Latin word *integumentum* which means "covering". System integument is an organ system that helps animals distinguish between one another, guard against danger, and learn about their surroundings. According to Bahrudin & Muslim (2018), this is frequently the largest organ system and contains the skin, hair, feathers, scales, nails, glands, perspiration, and product (sweat or mucus). typical or skin termed. The two networks from which the integument develops—the network-growing epithelium (epidermis) and the network binder (support)—are also the sources of the dermis layer. The fiber-braided nerves in the skin are arranged in a way that feels smooth, functional, or tool-like. The body's biggest organ, the skin shields the body from pathogens, light, and material chemistry threats while also maintaining a healthy balance between the body and its surroundings. Skin serves as a sign. Look for variations in skin tone, such as those that are light, yellowish, or reddish, to get an overall sense. When there is an abnormality on the skin or a psychological disturbance (such as stress, fear, or anger) that results in a change on the skin, skin temperature increases (Syaifuddin, 2014).

A. Anatomy System Integument

1. Skin Structure

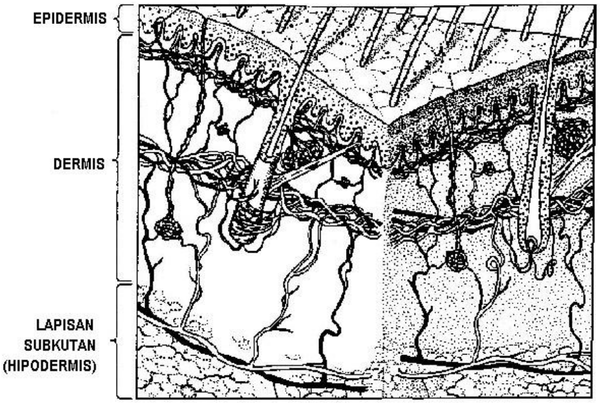

Figure 14.1. Skin Structure (Source: Kessel, 1998)

Three layers make up the skin, namely:

- Skin's epidermis
- Subcutis/hypodermian
- Stratum of the dermis

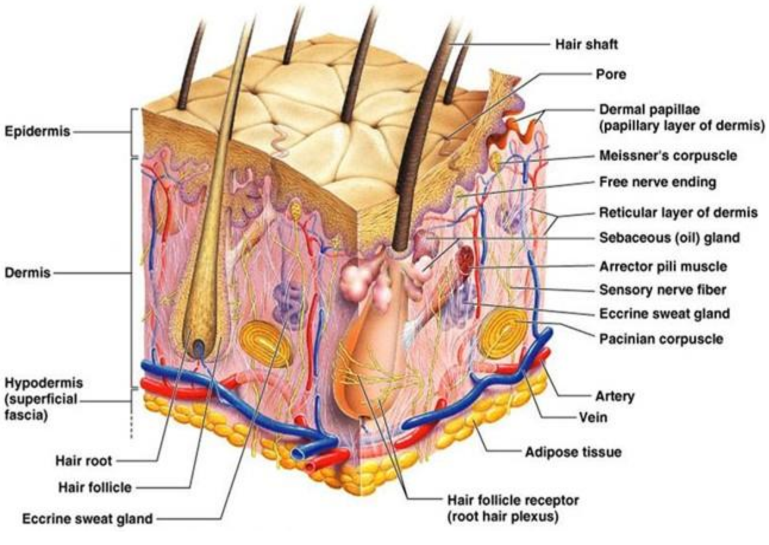

Figure 14.2. Skin Layers and Appendix (Source: Syaifuddin, 2013)

English	**Latin**	**Indonesian**
Arteries	Artery	Vessels pulse skin
Veins	Vein	Vessels come back skin
Pacinian corpuscle	Corpusculum lamellosum	Body small pacin
Eccrine sweat glands	Glandula sudorifera (glandula eccrine)	Gland sweat
Sensory nerve fibres	Nervus sensory	Nerve carrier stimulus
Arrector select muscles	Musculi arrector pili	Muscle enforcer hair
Sebaceous glands (oil)	Glandula sebacea	Gland sweat
Reticular layer of dermis	Reticular	Matting vessels hair
Free nerve ending	Dermal nerves	Nerve skin
Meissner's corpuscle	Corpusculum	Body small
Dermal papillae	Dermal papillae	Skin nipples
Pore	Porus	Pores (holes small)
Hair shafts	Scapus pili	The end of the hull
Epidermis	Epidermis	Layer skin part outside
Dermis	Dermis	Skin
Hypodermic	Hypodermis	Layer lower skin
Hair roots	Hair papilla	Hair nipples
Hair follicles	Folliculus pili	Pocket hair
Eccrine sweat glands	Glandula sudorifera (glandula eccrine)	Gland sweat
Hair follicle receptor (root hair flexus)	Plexus pili	Arch hair

2. Epidermis Layer

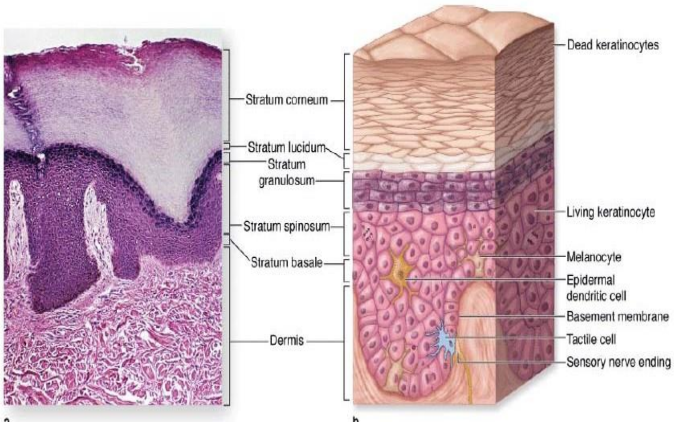

Figure 14.3. Layers of the Epidermis of the Skin (Source: Mescher, 2010)

According to Kalangi (2014) & Syaifuddin (2014) The epidermis consists of 5 layers, namely:

a. Stratum Basal (basal layer, seed layer)
b. Stratum Spinosum (taju layer)
c. Stratum Granulosum (grainy layer)
d. Stratum Lucidum (clear layer)
e. Stratum Corneum (horny layer)

3. Dermis Layer

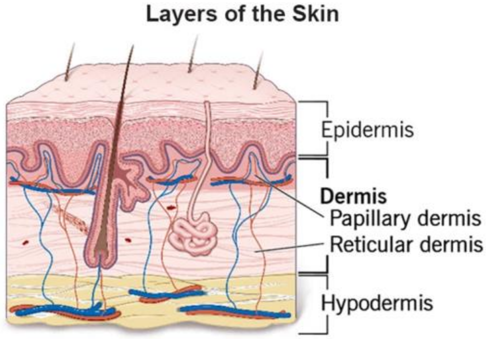

Figure 14.4. Layers of the Dermis (Source: Cleveland Clinic, 2022)

Layers in the dermis are:

a. Papillary layer
b. The reticularis stratum

4. Hair

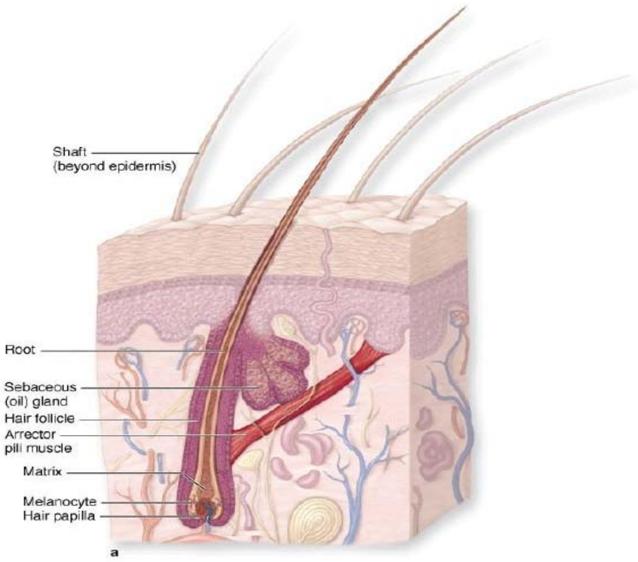

Figure 14.5. Hair Schematic (Source: Mescher, 2010)

English	Latin	Indonesian
Shafts	Scapus pili	Hair ends
Sebaceous (oil) glands	Glandula sebacea	Gland sweat
Hair follicles	Folliculus pili	Pocket hair
Arrector select muscles	Musculi arrectorpili	Muscle enforcer hair
Melanocytes	Melanocytes	Cell melanin producer
Hair papilla	Papilla pili	Hair nipples

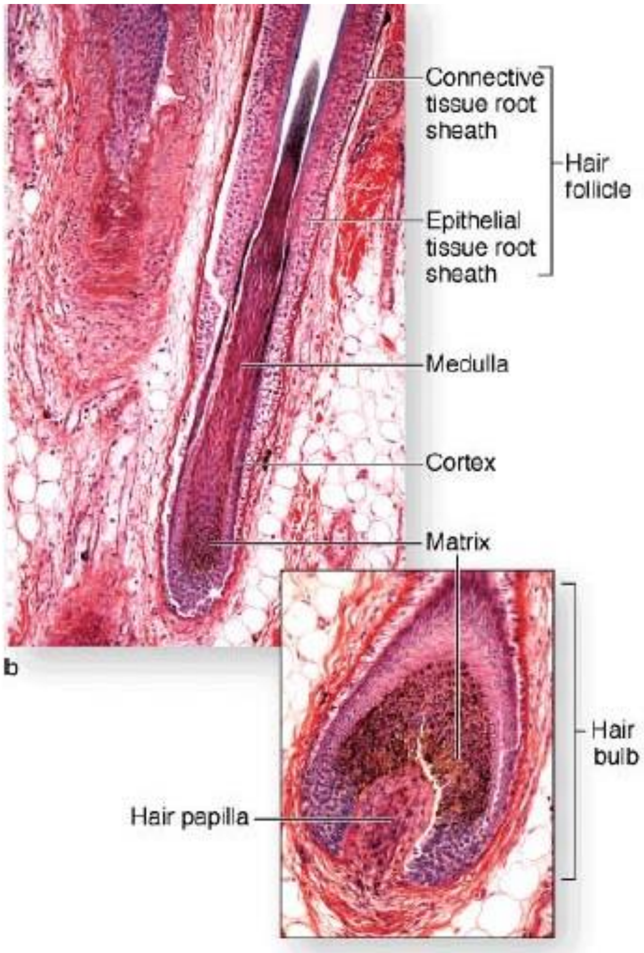

Figure 14.6. Micrograph show medulla and cortex on hair root that is cut longitudinally as well sarong hair root (Source : Mescher, 2010)

According to Kalangi (2014), hair structure consists of:

a. Follicle hair
b. Medulla hair
c. Cortex hair
d. Cuticle hair

5. Nail

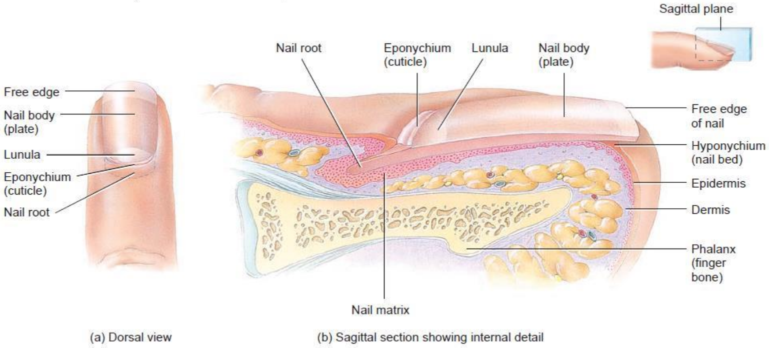

Figure 14.7. Anatomy of the Nail (Source: Siska et al., 2020)

Nail part consists of:

a. Hair root (nail root)
b. Nail body (nail plate)
c. Nail walls
d. Nail grooves
e. Eponychium
f. Hyponychium
g. Part nail proximal
h. Distal section

6. Gland sweat

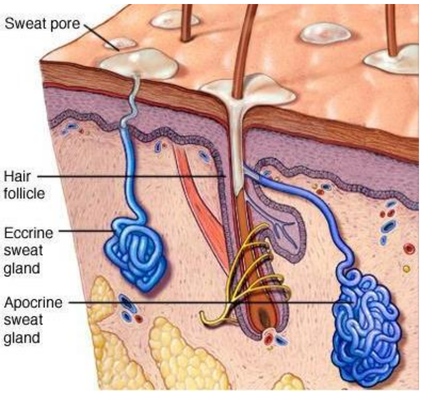

Figure 14.8. Glands Sweat (Source: Siska et al., 2020)

English	Latin	Indonesian
Sweet pore	Porus	Pores (holes small)
Eccrine sweet glands	Glandula ecrina	Gland sweat eccrine
1. Apocrine sweat glands	2. Glandula apocrine	3. Gland sweat apocrine

B. Physiology System Integument

1. Epidermis

The epidermis, which is the skin's top layer, is made up of flat layers of epithelium and horn. There are no vessels, blood vessels, or lymphatic vessels in the epidermis; it merely consists of network epithelium. Because of this, the dermis layer's capillaries are the only source of oxygen and nutrients. On this epidermis, the epithelium is structured in flat layers by several keratinocyte-containing cell layers. Cells in the basal layer that undergo mitosis continue to update this, progressively moving them to the surface epithelium. The cells divide, expand, and collect inner keratin filaments in the cytoplasm as they travel. As they get closer to the surface, cells are already dead and continue being removed. 20 to 30 days are needed to reach the surface. Structure change during travel In epidermal cells, this process is known as cytomorphosis. Changed epithelium form on a level, with potential distribution in a piece histologically upright and parallel to the skin's surface (Syaifuddin, 2014). The stratum basal, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum are the five layers that make up the epidermis.

a. Stratum Basal

This layer is the deepest and is made up of a row of cells arranged in a layer above the basement membrane that are linked to the dermis below. The cells are cylindrical or cuboid. The cell's size and basophilic cytoplasm are the key points. This is typically seen as a description of mythical cells, cell proliferation, and the function of cells in the regeneration of the epithelium. layers of cells. This moves in the direction of the surface to supply cells on higher levels. Movement This is sped up by rapid normality and wound regeneration (Kalangi, 2014).

b. Stratum Spinosum
   It is made up of many layers of cubes and polygons that resemble cells; the nucleus is in the centre. The cytoplasm contains files connected by fibre on desmosomes (bridge cells), throughout cell-bound meeting regions, as well as fibre, making the entire layer of cells feel somewhat prickly. This to withstand external friction and pressure, thus it must be substantial and present in areas where many bodies converge or exert pressure, such as the heel and base of the foot soles (Syaifuddin, 2014).
c. Stratum Granulosum
   Layer in a pregnant gecko, this comprises of 2-4 layers of cells. Many granules contain the so-called basophilic granule keratohyalin, which may be seen under an electron microscope to be an amorphous particle without a membrane that is encircled by ribosomes. Granules with microfilaments adhered on the surface. This prevents the body from absorbing foreign substances, pathogens, and chemical compounds (Kalangi, 2014).
d. Stratum Lucidum
   An extremely small number of flat, transparent layers of cells. Limiting membrane cells were obscured, making the layer as a whole appear transparent. This was found on a bodily part with thick skin (Syaifuddin, 2014).
e. Stratum Corneum
   Featuring many layers cell horns (keratinization), flattening, drying, and the absence of a core. Keratin fiber-filled cytoplasm, more cells that protrude from the body, and more scale-like cells were present before one cell peeled away from the body and was replaced by another. Because it contains

water and that water evaporates, layer horn is almost non-existent. Its low elasticity is highly effective at keeping water from more layers from evaporating (Syaifuddin, 2014).

2. **Dermis**

Network subcutaneous connective tissue that binds and supports the epidermis the epidermal projections and the papillae dermis are interwoven (Leni, 2017). The stratum reticular and stratum papillae are the two layers that make up the dermis. Because it combines with the subcutis (hypodermis), it is challenging to distinguish the dermis. The component network binder gives it a thickness of between 0.5 and 3 mm, several times more than the epidermis. According to Syaifuddin (2014), the dermis' derivative (derived) layer is made up of hairs, gland mucus, gland oil, and gland-soaking perspiration.

a. Papillary stratum

There are dermal papillae here, which are organised more loosely and range in number from 50 to 250/mm2. the most and more so in places like the soles where there is the most pressure. Vessels that provide capillaries on the underlying epithelium with nutrients are part of the large papillae. Papillae on Meissner's body contain body end nerve sensory. Collagen fibres are placed in a meeting just below the epidermis (Syaifuddin, 2014).

b. Stratum reticularis

This is rougher and thicker in the collagen files, and numerous tiny elastin fibres form dense, asymmetric braiding. The cavities between the braided hair are filled with network fat, perspiration and sebaceous glands, and hair follicles as the portion is more inward. Certain locations, such as follicular hair, the scrotum, the prepuce, and the nipple boobs, also have fibre muscle. The dermis of the skin, face, and neck is infiltrated by muscular fibres that form a network connection. Expressions on the face play this role. In other words, network tie lots of loose contain cell fat merge with the hypodermis and superficial fascia below the layer reticular (Syaifuddin, 2014).

3. **Hypodermic**

The hypodermis is a subcutaneous layer that lies beneath the dermis reticularis. Collagen fibres that are finely oriented, especially parallel to the skin's surface, and some of which converge with dermal fibres help him create a looser network tie. Layer this potential movement skin on top of the structure underlying on some locations, like the backs of the hands. In some regions, the dermis's incoming fibres are denser and the skin is more rigidly elastic. The epidermis' cells are larger than the dermis' cells. The quantity is influenced by type, sex, and environmental factors, including nutrition. Specific regions are where subcutaneous fat tends to collect. The network of subcutaneous petals that surrounds the eye or penis contains a small amount of fat, but the ass, thighs, and abdomen all had 3 cm or more of it. Add fat. Panniculus adiposus is the name of this (Kalangi, 2014). In the hypodermic layer beneath the dermis, matted vessels, arteries, veins, and webbing running nerves run parallel to the epidermis. This varies in thickness. Additionally, attach the skin loosely to the network below (Syaifuddin, 2014).

4. **Hair**

With the exception of the feet, soles of the hands, dorsal surfaces of the distal phalanges, about bone rectal, and urogenital regions, elastic keratin threads that took the shape of hair spread across the body from the epidermis. Each hair has a free stem and skin-indented roots. The epithelial portion of the epidermis—the hair root—comes from the dermis (the tissue tie) and is encased in follicle-shaped hair tubes. The lower follicle swells at the end to produce bulbus hair, some sebaceous glands, and a smooth sheaf muscle (erector pili). As a result, hair grows vertically (Syaifuddin, 2014). According to Kalangi (2014) and Syaifuddin (2014), the following structure hair

a. Follicle hair

Dermal fibrous component is surrounded by follicle hair. The so-called sarong root hair outside is located between the elements of the epithelium follicle and the non-cellular vitrea, which is very thick foundation membrane from the epithelium follicle's outer layer. Sheath root hair is visible externally on portion bulbus pili. According to the epidermis's stratum basal, this is the only thick cell. approach the skin's surface, have multiple layers of cells, and have strata that resemble the thin epidermis of the skin. Sarong root hair, which consists of three elements and grows in concentrated layers after the follicle, includes: (1) Henle layer, one layer cell attached wedge tightly on innermost cells from sarong root hair outer; (2) Huxley tier, consisting of two- or three-line cells flattened; (3) cuticle sarong root hair in, consisting of cells flattened on an analogous scale, arranged similarly to a rooftile with edge-free lead to down. All of the follicle's cells are in active mitosis at the beginning of development, but after the follicle differentiates perfectly, only the cells in the lower bulbus, or the cell matrix, are fixedly in active mitosis; these cells will be filling out the medulla, cortex, and cuticle, among other parts of the hair.

b. Medulla

Part of the middle loose hair is made up of two to three layers of cells that are spaced apart by an airy chamber. The hair is golden, fine, short, rome, and part of the head. I have medulla, so no. Cells in the medulla, particularly soft keratin, frequently contain colour and keratin.

c. Cortex Hair

The largest hair, called cortex hair, has a number of layers made up of concentric keratinized cells. Melanin gives hair its colour because it is typically positioned inside and between cells.

d. Cuticle

The outermost is the cuticle hair. The thinnest cells, comparable scales, and an open distal end can all be found in root and stem hair. Composing cells' cuticle hair is really flat, mutually tucked in, and matches with cells' cuticle sarong root hair in, making it challenging to tell them apart.

Hair growth according to Ministry of Health (2014):

1. 0.35 mm every day for 2–6 years during phase anagen (growth).
2. Phase telogen (rest): lasts no longer than 4 months, and during this time, the hair loses 50–100 sheets every day. Trauma, stress, and other factors are those that contribute to hair loss.
3. Catagen (transition) phase. The thickening network was first tied around follicle hair to begin the changeover period. The experience horn developed, and the underside of the middle root hair widened and narrowed, respectively. As a result, the created mace (club) lasts for two to three weeks. At any given time, 85% of men's hair is in the anagen phase, and the remaining 15% is in the telogen phase.

5. Nail

The plates that surround the dorsal surface of the phalanges on the fingers, hands, and toes are known as nails. The dermis and epidermis are related by the structures. The line of the flat arch is filled with nail development, which in the area closest to the surface is slightly inclined towards the surface (Syaifuddin, 2014). According to Siska et al. (2020), one of the nails is:

a. Root of the nail.

b. The portion of the nail that extends past the arrangement of soft end fingers and into the front finger (nail-free), the body of the nail (nail plate).

c. Skin on top, a small nail root protrudes from the nail wall.

d. The groove on the side of the nail body is known as the nail groove.
e. Eponychium: The covering of the stratum corneum enlarged the nail wall so that occasionally, white (lanula) nail bodies could be seen.
f. Below the free nail tip is a stratum corneum, or hyponychium. Covering a portion of the terminal finger.
g. Nail: portion to direction, part proximal. Part of a direction-free nail tip that is at the nail root.

6. Gland on Skin

b. Gland Sweat

In accordance with the 2014 book by Syaifuddin, there are two varieties of gland sweat:

1. Eccrine gland sweat

   Spread all over the body with the exception of the forehead, palms, hands, soles of the feet, and foreskin penis.
2. Sweat glands and apocrine

   Large sweat glands. Additionally discovered on the rectum, skin around the tool gender, nipple skin, and armpits.

c. Gland Sebaceous

Located next to root hair and boiling down in the root lumen hair (follicle hair), sebum, and secretions consisting of triglycerides, squalene, wax esters, cholesterol, and sour fat free. This gland is also known as a holocrine because it has no lumen and its secretions come from decomposing cells. Androgen hormones and other factors can have an impact on secretion (Siska et al., 2020).

7. Function Skin

According to Siska et al. (2020) and Syaifuddin (2014), the skin serves a variety of purposes, including:

a. Thermoregulation as a Function

Use this technique to make your forehead sweat and your face frown. The glands sweat when the body temperature rises. Lots of people perspire, and when the body's temperature dropped, blood capillaries and vessels constrict. Mechanism sympathetic nerves (acetylcholine) orchestrate this.

b. Protection of Function

The skin protects the body against physical (such as friction, pull, and chemical distractions) and thermal (such as radiation, UV light, and infection from external [bacteria, fungus]) disturbances that can cause irritation. Protecting against physis disruptions by storing fat beneath the skin. Skin is shielded from the sun's rays by melanocytes. Protection and chemical stimulation are possible thanks to the stratum corneum's resistance to water and chemical substances. A layer of acidity covers the skin to guard against chemical interaction between substances and the skin. Skin becomes acidic from soap, and a pH of 5–5.6 guards against infection. When a cell skin dies, it frequently releases itself.

c. Absorption of Function

Healthy skin does not readily absorb water and evaporates liquids more quickly. As well as dissolving in fat. The skin's ability to be permeable to oxygen, carbon dioxide, and water vapour enables it to participate in breathing. Skin's capacity for absorption has an impact on its thickness, hydration, moisture, and metabolism. The process of absorption passes across cell spaces, enters epidermal cells, and travels through glands.

d. Excretion of Function

The body's gland skin generates chemicals such NaCl, urea, acids veins, and ammonia that are not beneficial (substance residual metabolism). Useful sebum layer for skin defence because the sebum layer includes oil to shield the skin and hold onto extra water to prevent drying. Acidity in the skin is caused by sweat and production gland fat.

e. Perception of Function

Skin has sensory nerve endings in the dermis and subcutis that stimulate the dermis and subcutis to respond to heat. The dermis is where the sensation of cold arises. The pressure felt by the fibrous epidermis nerve is more sensory than the difference felt by the papillary dermis of Markel Renvier, which is located in the dermis. There are many sexy individuals in the neighbourhood. Forming a Function Pigment Melanocytes give skin its colour. In order to improve tyrosination, metabolism cells, Cu ions, and oxygen, enzyme melanosomes created tool golgi. Melanosomes, pigments that are distributed across the epidermis by hand dendrites, are impacted by solar rays while melanophages are located below them. Coloured skin can also be affected by thick or thin skin in addition to pigmentation.

f. Keratinization with Purpose
Basal cells will advance and undergo a change in shape to become spinosum cells. The cell granulosum becomes flatter and more granular as you go closer to it. The cell nucleus then vanishes, and keratinocytes develop into amorphous horn-like cell structures. Throughout your entire life, this process continues. Through the process of synthesis and production, keratinocytes develop into layers of living horn in around 14 to 21 days. Through a physiological mechanism, keratin shields the skin against infection.

g. Vitamin D: Its Role and How it is Made
Dihydroxy cholesterol is converted into vitamin D with the aid of sunlight. The method still needs systemic vitamin D treatment since the body still needs vitamin D.

Summary

Animals use their integument, an organ system, to tell one another apart, stay safe, and discover their environment. The skin, hair, feathers, scales, nails, glands, perspiration, and product (sweat or mucus) are all found in this system, which is the biggest organ in the body. The epidermis of the skin is made up of three layers: stratum dermis, subcutis/hypodermian, and epidermis. The stratum basal, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum are the five layers that make up the epidermis.

The papillary layer, reticularis stratum, hair, and nails make up the dermis layer. Follicle hair, medulla hair, cortex hair, and cuticle hair make up the hair. The root hair, nail body, nail walls, grooves, epipodium, hyponychium, portion of the nail proximal section, and part of the nail distal section make up the nail part.

Sweating is another by-product of the function of the integument, which is the skin. Skin temperature rises when there is an anomaly or psychological disturbance producing a change in skin tone.

The top layer of the skin, the epidermis, is made up of flat layers of horn and epithelium. It is made up of network epithelium, the sole source of nutrients and oxygen. The sole source of nutrients and oxygen is the dermal layer's capillaries. A number of keratinocyte-containing cell layers give the epithelium its flat layering. Mitosis occurs in the basal layer cells, gradually advancing them to the surface epithelium. As they move, the cells proliferate, enlarge, and gather cytoplasmic inner keratin filaments. The epithelium develops on a level, with possible distribution in a piece that is histologically upright and parallel to the skin's surface. This process is known as cytomorphosis.

The network of subcutaneous connective tissue that makes up the dermis binds and supports the epidermis. The dermis is made up of two layers called the Stratum Reticular and Stratum Papillae. Hairs, gland mucus, gland oil, and sweat-soaking perspiration make up the dermis' derivative (derived) layer. There are 50 to 250 papillae per millimeter2 in the papillae layer, which is loosely structured. Network fat, sweat glands, sebaceous glands, and hair follicles are all present in the reticularis layer, which is rougher and thicker in collagen-containing files. Muscular fibres that join in a network permeate the dermis of the skin, face, and neck.

The dermis reticularis, which is made up of collagen fibres that are precisely aligned parallel to the skin's surface, is a subcutaneous layer above the hypodermis. The size of the epidermis' cells, which are bigger than those of the dermis, is controlled by characteristics such as type, sex, and environmental factors including diet. The ass, thighs, and belly all have 3 cm or more of fat, compared to the network of subcutaneous petals that surrounds the eye or penis.

The intricate structure of hair is made up of keratin strands that emerge from the epidermis and extend throughout the body. Each hair contains a free stem, roots that are incised into the skin, and an epithelial root hair that is enclosed in follicle-shaped hair tubes. In order to create bulbus hair, sebaceous glands, and a smooth sheaf muscle, the lower follicle expands at the end. With a medulla made up of two to three layers of cells separated by an airy chamber, hair develops vertically. The cortex hair, the biggest hair, is made up of concentric layers of keratinized cells that give hair its colour. The outermost cuticle hair has the thinnest cells, scales that are identical, and an open distal end. According to the Ministry of Health (2014), hair grows in two phases: anagen (growth) and telogen (rest). During anagen and telogen, hair sheds 50–100 sheets every day. With 85% of men's hair in the anagen phase and the other 15% in the telogen phase, the thickening network is initially wrapped around follicle hair to start the transition stage.

The plates that cover the dorsal surface of the phalanges on the fingers, hands, and toes are known as nails. The nail plate is the nail's root, and the dermis and epidermis are associated by their structural similarities. Eccrine gland sweat, apocrine sweat glands, and sebaceous gland sweat are the two forms of gland sweat. The skin performs a number of tasks, including regulating body temperature, protection, absorption, and excretion. It can breathe because it is permeable to oxygen, carbon dioxide, and water vapor. The process of absorption has an impact on the metabolism, hydration, and thickness of the skin.

The dermis and subcutis of the skin contain sensory nerve endings that cause them to react to heat. Melanosomes, an enzyme that enhances tyrosination, metabolism cells, copper ions, and oxygen, produce melanocytes, the pigments that give skin its colour. Sunlight has an impact on melanosomes, which lie underneath melanophages. Thick or thin skin may also have an impact on those with coloured skin.

Basal cells are converted into spinosum cells by the process of keratinization, which gives rise to amorphous horn-like cell formations. The keratin layers that shield the skin from infection are created throughout life by this process. Sunlight converts vitamin D into vitamin D, but the body requires systemic therapy to meet its requirements.

Review Questions

1. The part of the skin that is under the epithelium and is in the form of rather dense connective tissue:
   A. Dermis
   B. Epidermis
   C. Hair Shafted
   D. Hypodermis
   E. Endodermis
   Answer: A

2. Tissue that has a lot of fat tissue:
   A. Dermis
   B. Epidermis
   C. Hair shaft
   D. Hypodermis
   E. Endodermis
   Answer: D

3. A layer that is rather thick, the cells are spina (spina) which is also called the epidermis layer:
   A. Stratum Germinatium Epidermis
   B. Stratum Granulosum Epidermis
   C. Stratum Spinosum Epidermis
   D. Stratum Corneum Epidermis
   E. Stratum Lucidum Epidermis
   Answer: C

4. Consists of layers of stratum corneum formed?
A. 10 layers
B. 20 layers
C. 30 layers
D. 40 layers
E. 50 layers
Answer: C

5. The epidermis consists of two types of skin, namely: thick skin and thin skin. What includes thick skin?
A. Thigh skin
B. Neck skin
C. Scalp
D. Ear skin
E. The soles of the feet and hands
Answer: B

6. Where is the clear layer of the epidermis located?
A. Epidermal stratum lucidum
B. Epidermal stratum corneum
C. Epidermal stratum spinosum
D. Stratum germinatium epidermis
E. Epidermal stratum granulosum
Answer: A

7. Where was Vater Pacini found?
A. Dermis
B. Epidermis
C. Hypodermic
D. All wrong
E. Stratum papillary dermis.
Answer: C

8. Susi was sewing clothes, then her finger was pricked by a needle, but there was no bleeding, the needle only stuck to the skin:
A. Dermis
B. Epidermis
C. Reticular
D. Hypodermic
E. Meissner's body
Answer: B

9. What is one of the functions of the skin as a touch, the part of the skin that can feel the touch?
A. Apocrine
B. Papillary
C. Pacinid bodies
D. M. Arector pilie
E. Meissner's body
Answer: E

10. The layers of the part of the nail that affect its growth:
A. Nail Plates
B. Nail Bed
C. Bone
D. Lunula
E. Nails
Answer: D

11. Included in the accessory structure of the integumentary system is….
A. Skin
B. Eye
C. Nail
D. Mouth
E. Nose
Answer: C

12. Order the division of the skin layers from the outermost to the deepest!
A. Hypodermis-epidermis
B. Skin-epidermis-dermise
C. Dermis-epidermis-dermis
D. Epidermis-dermis-hypodermis
E. sweat glands sebaceous glands nails
Answer: D

13. How thick is human skin in general?
A. 0.1-1mm
B. 0.2-2mm
C. 0.3-3mm
D. 0.4-3mm
E. 0.5-3mm
Answer: E

14. This layer is under the epithelium and is a dense connective tissue. What is this layer called?
A. Kutane
B. Dermis
C. Subcutaneous
D. Epidermis
E. Hypodermis
Answer: B

15. Connective tissue that has a lot of fat tissue:
A. Kutane
B. Dermis
C. Subcutaneous
D. Epidermis
E. Hypodermis
Answer: B

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CHAPTER 15
SENSORY SYSTEM

Learning Objectives:

Understanding the structure and function of the sensory system

Introduction

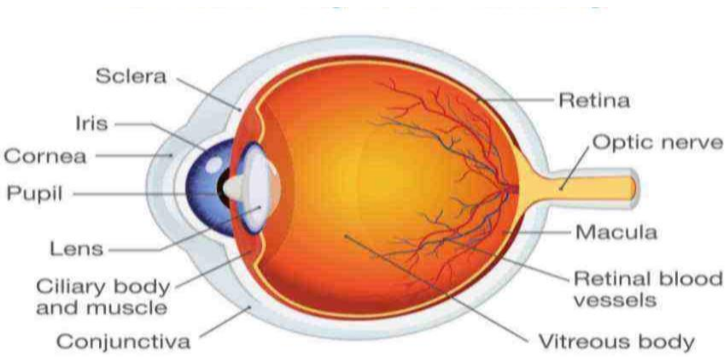
One of the bodily systems that cooperate to perform a number of bodily functions is the sensory system. Five systems make up this system: touch, taste, smell, and sight. To be able to decide better the classification and coding of diseases and medical actions related to the sensing system, a health recorder and information officer needs to be familiar with the notion of each prior sensing system.

The body's organs that are responsible for knowing the external environment make up the sensory system. The five senses that humans possess are the senses of sight (eyes), hearing (ears), smell (nose), taste (mouth), and touch (skin). These senses are collectively known as the "five senses" or "human senses". His senses operate as a bridge, a point of contact between his spiritual self-awareness and the physical world.

Anatomy of Sensory System

1. Eyes

The eye has numerous components. Together, the parts of the eye's anatomy enable it to serve as the organ responsible for sight. Please be aware that approximately 75% of the information we get takes the form of visual data. The first step in the vision process is the reflection of light off of an object or our surroundings. The retina, which is located at the rear of the eye, is the ultimate point of reception for this light after it is absorbed by the cornea, which is located at the front of the eye. The front, centre, and back make up the three sections of the eye's anatomy. Each part consists of a number of organs, each having a distinct purpose. The outermost part of the eye that we can directly see is the anatomy of the front of the eye. There are various components that make up the front of the eye, including the cornea, iris, pupil, sclera, and conjunctiva.



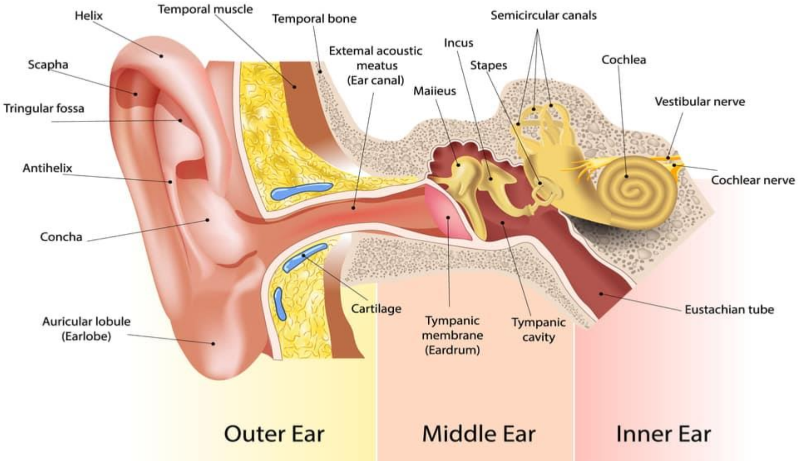
2. Cornea

   The cornea, a translucent membrane in the form of a dome that covers the front of the eye, is the eye's outermost layer. The cornea plays a crucial function in vision. The cornea of the eye's includes several distinct components, each of which supports the others. The cornea lacks blood vessels, in contrast to other body tissues. Tears and aqueous humour, an eye fluid that is transparent and sticky, perform the role of the blood vessels in the cornea. The cornea's primary job is to focus and refractively bend light entering the eye. also serves the purpose of shielding the eye from potentially harmful foreign substances like infections, dirt, and UV radiation. The cornea is made up of five components: the endothelium layer, Descemet’s membrane, Bowman's layer, stroma, and epithelial tissue.

3. Iris
   Between the cornea and the lens is where the coloured portion of the eye is found. The anterior and posterior chambers of the iris are filled with aqueous fluid. Circular and radial fibres make up the iris. The coiled fibres cause the pupil to constrict and enlarge. The parasympathetic nerves stimulate pupillary constriction, whereas the sympathetic nerves stimulate pupillary dilation.
4. Pupils
   The circular, black portion of the eye's centre is known as the pupil. The pupil's job is to control how much light enters the eye. The pupil will enlarge to catch lighter when the eye is in a dark environment in order to perform its function. In contrast, when the eyes are in a bright environment, the pupils will constrict. Both pupils typically contract when the eyes are focused on looking at a close object in addition to being influenced by light.
5. Sclera
   Has a tough membrane that contributes to the eyeball's shape. It is the conjunctiva-covered white outer layer of the eye.
6. Conjunctiva
   Mucous layer that covers the palpebral and sclera's inner surfaces. contains glands that secrete mucus that help to keep the eyeball and cornea wet. The bulbar conjunctiva, which covers the sclera, the palpebral conjunctiva, which covers the inner lid, and the fornix conjunctiva, which is situated in the middle of the two, make up the conjunctiva.
7. Ears
   One of the five senses that humans possess is the ear. The ear's role extends beyond hearing sound to maintaining body equilibrium, which prevents falls when performing various actions. The ear is a hearing organ that both records and transforms sound into mechanical energy, which is then transmitted to the brain for realisation and comprehension.

The three components of the ear are as follows:

a. The auricle and ear canal in the outer ear
b. The eardrum (tympanic membrane), auditory bones, tympanic cavity, and eustachian tube are all parts of the middle ear.
c. The cochlea, vestibular system, and auditory nerve are all parts of the inner ear.



a. Outer Ear
   1) Earlobes (Auricles)
      Consists of skin and cartilage and has a unique form. Its purpose is to gather, channel, and capture sound for the ear canal.
   2) Ear Canal (External Acoustic Meatus)
      Consists of cerumen glands, oil glands, and cartilage. To remove filth and keep little insects out, cerumen and fine hair work together. Its purpose is to direct sound to the ear and serve as a barrier against variations in temperature and humidity that can affect the tympanic membrane's elasticity.
   3) Middle Ear
      a) Eardrum (tympanic membrane)
         Round and concave on the outside, it is made of elastic fibrous tissue. Four quadrants, including the

top front, top back, bottom front, and bottom back, make up the eardrum. Sound vibrations are received via the tympanic membrane, transferred to the ossicles, and then transformed back into sound.

b) Hearing Bones

The malleus, incus, and stapes make up this structure. These three bones' job is to carry vibrations to the inner ear.

c) Tympanic Cavity

the space near the mastoid bone, where a middle ear infection could develop into mastoiditis.

d) Eustachian Tube

The tube is roughly 4 cm long. serves to maintain the equilibrium of air pressure in the middle ear and outside air pressure by connecting the tympanic cavity with the nasopharynx. Eustachian tube closure is the usual. The tubes open to equalise pressure if you swallow or yawn while in a high-pressure environment.

b. Inner Ear

a) Labyrinth

The labyrinth is made up of a membranous labyrinth and a bone labyrinth. The membranous labyrinth is lined by the periosteum in the temporal bone cavity known as the bony labyrinth. Peri-lymph fluid keeps the two labyrinths apart, while endo-lymph fluid is present in the membrane labyrinth. The vestibule, which has oblong and round windows on the lateral wall, the cochlea, and the semi-circular canals make up the bone labyrinth.

b) Cochlea

Likewise known as a snail home. includes fluid and delicate "hair" cells. When activated by sound waves, this structure, which resembles fine hair, vibrates.

c) Vestibular System

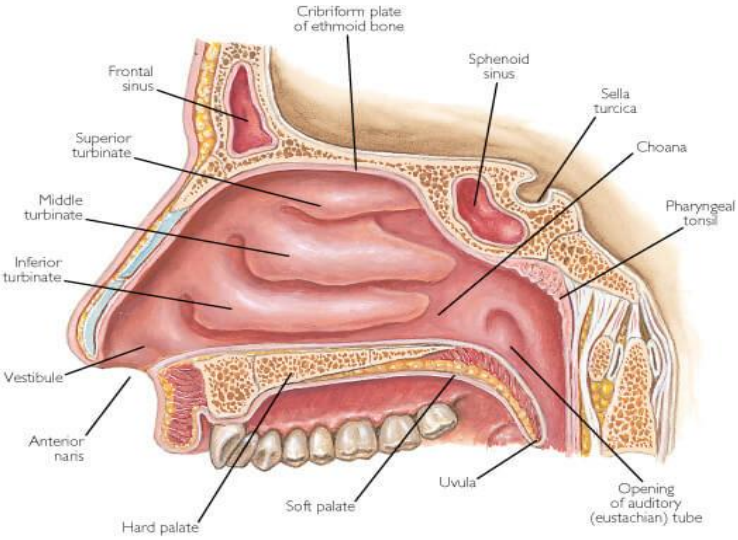
Contains cells that regulate equilibrium.

d) Cochlear and Vestibular Nerves (Vestibulocochlear/Acoustic)

This nerve connects the cochlea to the brain.

8. Nose

Humans have a sense of smell that is controlled by the nose. Humans are able to distinguish between different smells, such as sweet or foul, because to this organ. The anatomy of the nose is made up of a number of components that work together to form an ideal functional mechanism. The nose's ability to serve as an organ of smell may be compromised if one of these components is damaged. The sinuses, centre wall, side walls, fine hairs, and nostrils are only a few of the nasal anatomy.



a. Nostrils

Only two tiny openings going to the nasal cavity are evident based on the nose's outward appearance. When breathing, these two apertures serve as the air's entry and exit sites.

b. Skinny hairs

The nasal cavity will develop fine hairs. Filtering the debris that enters the nasal cavity is what these hairs do. In some cases, debris and mucus can accumulate between the hairs and need to be cleaned out.

c. Cilia

The purpose of cilia, which are tiny networks that behave like brooms, is to collect debris and push it away from the deeper respiratory system. Cigarette smoke is one toxic substance that cilia are particularly sensitive to. If these compounds are continually exposed, the cilia's ability to operate will be compromised. Damage to the cilia increases the likelihood of respiratory conditions including bronchitis.

d. Middle wall

The septum is the middle or separating wall that separates the two nostrils. These walls are constructed from soft bone or cartilage. Bone fills the upper dividing wall, which is located next to the eye. whereas cartilage fills the middle and bottom. The middle and lower noses seem flexible when squeezed because of this.

e. Lateral walls

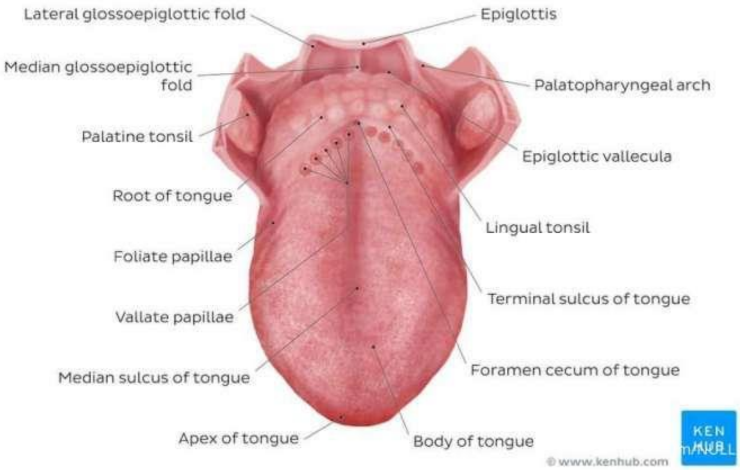
Additionally, the nose features lateral or side walls. The turbinate or concha, which are composed of bone tissue and blood arteries, make up this wall. The air we breathe is warmed, made humid, and filtered in large part by these buildings.

f. Sinuses

The skull's air channels connect the tiny cavities that make up the sinuses. Mucus is created by the sinuses and serves as a filter and cleaner for bacteria or other airborne particles.

9. Tongue

One of the more delicate human body parts is the tongue, which also serves as a taster, a tool for discerning flavours, and an organ for turning food in our mouths as we chew. The oral cavity contains the tongue, which also serves as a natural mouth and teeth cleanser. The muscles that allow the tongue to move are those that are striated. The tongue has mucous membranes in addition to striated muscles. The feliform papillae, fungitormis papillae, and circumvallate papillae are minute protrusions that make up the receptors on the tongue's surface. The receptors, known as gemma sustantoera, are formed like taste cups.



10. Skin

One of the largest organs in the human body, the skin almost completely covers the body's surface. The skin serves a variety of purposes, including safeguarding interior organs, bones, and muscles. The skin also helps to produce vitamin D, maintain fluid and electrolyte balance, protect the body from bacteria, viruses, and toxins, and control body temperature. As long as a person is alive, their skin will continue to change and develop. The epidermis, dermis, and hypodermis are the three layers of the skin.

a. Epidermis

In the epidermal layer, there are:

1. Melamine pigment-forming cells and layers of keratinocyte cells, which are actively involved in skin cell regeneration
2. Melamine serves to both colour the skin and protect it against sunburn, particularly from UV rays.

b. Dermis

Blood arteries, hair follicles, sebaceous glands, sweat glands (glandula sudorifera), nerve fibres, and the subcutaneous fat layer are all found in the dermis layer.

- Numerous collagen and elastin fibres can be seen in the dermis.
- Skin elasticity is significantly influenced by collagen and elastin.
- The dermis's components serve the following purposes:

1) Blood Vessels

   Transferring the nutrients and oxygen that the dermal and epidermal tissues require to function. It is a crucial component of the body's mechanism for controlling temperature.

2) Sweat Cells

   Its purpose is to create perspiration, which the body uses to expel chemicals or waste products from metabolism through the pores. Some of the body's heat is transferred through the sweat.

3) Hair Follicles

   The place where the hair can grow and change colour is at its base. The pigment melanin, meantime, determines the colour of hair. As long as it receives nutrition from the blood vessels surrounding the hair follicles, hair can continue to grow.

4) Oil Glands

   In order to prevent the skin and hair from drying out, it produces oil.

5) Hypodermic

   Many fat cells are found in the hypodermis layer. The body uses fat as a food reserve, as well as a means of defence against harmful environmental factors including solar pressure and collisions, as well as a means of maintaining appropriate body temperature.

Summary

The eye is the organ that gives us sight, and around 75% of the information we take in is visual. The cornea, which is situated at the front of the eye, transmits light to the retina, which is situated at the back of the eye. Three different organs, each serving a specific function, make up the front, middle, and rear of the eye.

A transparent membrane covering the front of the eye, the cornea is essential to vision. The endothelium layer, Descemet's membrane, Bowman's layer, stroma, and epithelial tissue are its five constituents. Between the cornea and the lens lies the colourful part of the eye, the iris, which is also filled with aqueous fluid. The pupil, which is responsible for regulating how much light enters the eye, constricts while the attention is on a near object.

The sclera, the white part of the eye, has a thick membrane that helps to form the eyeball. The inner surfaces of the palpebral and sclera are covered by a mucous coating called the conjunctiva. The conjunctiva is made up of the fornix conjunctiva, palpebral conjunctiva, and bulbar conjunctiva.

One of the five senses that people have is their ear, which records and converts sound into mechanical energy before sending it to the brain for perception and understanding. The outer ear is made up of the auricle and ear canal, the middle ear is made up of the auditory bones, the tympanic cavity, and the eustachian tube, and the inner ear is made up of the cochlea, the vestibular system, and the auditory nerve. A synapse located in the ear is also in charge of maintaining a balance between the air pressure in the middle ear and the air pressure outside. The vestibular system forms the link between the synapse and the brain.

The nose is an essential part of the human body because it regulates our sense of smell and enables us to discriminate between various odours. It is made up of the nasal cavity, the sinuses, the centre wall, the side walls, the fine hairs, and the nostrils. The septum, the main wall separating the two nostrils, two small apertures for air entrance and departure, fine hairs filtering debris, cilia collecting debris, and other components make up the

nasal cavity. The lateral walls of the nasal cavity also warm, humidify, and filter air.

A taster, flavour judge, and mouth and teeth cleaner, the tongue is a sensitive organ of the human body. It has mucous membranes and striated muscles. The tongue possesses taste-cup-shaped sensors known as gemma sustantoera.

One of the largest organs in the human body, the skin covers the surface of the body and has a number of functions, including protecting internal organs, bones, and muscles, producing vitamin D, preserving fluid and electrolyte balance, shielding the body from bacteria, viruses, and toxins, and regulating body temperature. The epidermis, dermis, and hypodermis are the three layers of the skin. Melanin pigments, keratinocyte cells, and melanin pigment-forming cells are all found in the epidermis. The sweat glands, hair follicles, oil glands, and hypodermis are also found in the dermis and are in charge of keeping the skin elastic and regulating temperature.

Review Questions

1. What cells are responsible for seeing in the dark?
   a. Conus Cell
   b. Stem Cells
   c. Cone Cell
   d. Granulose Cell
   e. Fibroblast Cell
   Answer: C
2. Is that part of the retinal layer through which nerve bundles pass and is not sensitive to light?
   a. Sclera
   b. Choroid
   c. Blind spot
   d. Yellow spot
   e. Fovea
   Answer: C

3. The eye can capture images of objects because of these objects.
   a. Reflected light
   b. Real
   c. Big in shape
   d. Coloured
   e. Solid
   Answer: A

4. The way to observe the pupil reflex is to observe....
   a. Change in pupil colour
   b. Change in pupil diameter
   c. Change in the diameter of the eye lens
   d. Change in the colour of the iris of the eye
   e. Changes in activity of blinking by eye
   Answer: B

5. If a foreign object enters the eye, the reflex that arises is...
   a. Pupillary reflex
   b. Lens reflex
   c. Light reflex
   d. Blink reflex
   e. Eyeball reflex
   Answer: D

6. The part of the eye that is most sensitive to light is the...
   a. Cornea
   b. Retina
   c. Fovea
   d. Pupils
   e. Iris
   Answer: B

7. Presbyopia disorders in the eye can be helped with lenses....
   a. Sunken
   b. Cylindrical
   c. Double
   d. Single
   e. Convex

   Answer: C

8. What is the role of the optic nerve?
   a. Forming objects
   b. Shade
   c. Forming incoming light
   d. Processing shadows to the nervous system
   e. Connect left and right eyes

   Answer: D

9. Try listening to the sound of tapping on the wall, then listen to the sound of tapping on the wall by placing your ear directly against the wall. Which is clearer, why is that?

   Answer Instructions: Propagation through solid objects will be easier and faster when compared to air, because solid objects have molecules that are close together, making it easier for vibrations to propagate.

10. Try smelling several types of odours such as perfume, how many types of perfume can you inhale, why is that.

    Answer: The nose cannot smell many odours at once because there is an arousal threshold and it takes time to adapt. If too many scents enter the nose, the receptors will receive all of them at the same time and so we cannot determine what this scent is.

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CHAPTER 16
REPRODUCTIVE SYSTEM

Learning Objectives:

Understanding the structure and function of the reproductive system

Introduction:

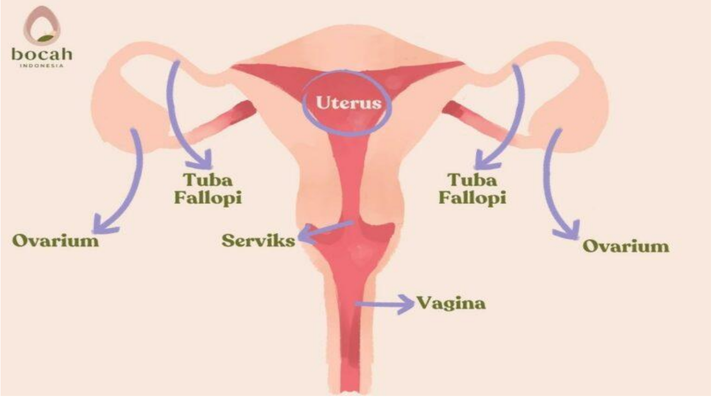
Reproduction is the capacity to create offspring with the goal of preventing the extinction of offspring. Both the female and the male reproductive systems make up the human reproductive system.

1. **Female Reproductive System**

   Both internal and exterior organs make up the female reproductive system.

   a. Internal Body

   The uterus, ovaries, and fallopian tubes make up this organ.



a) Uterine

Between the rectum in the rear and the bladder in the front of the pelvis, the uterus is a thick, muscular, pear-shaped organ. Pregnancy, delivery, and the menstrual cycle all take place in the uterus. The uterine cervix and uterine corpus make up the uterine wall.

b) Ovary

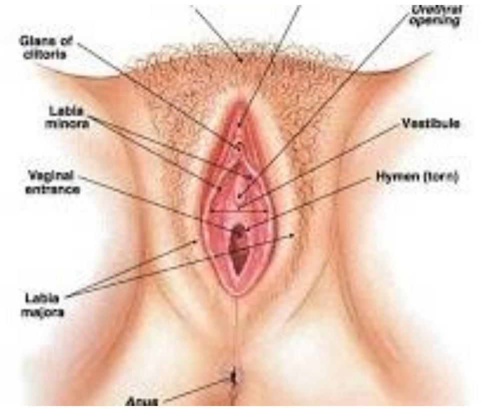
The ovary is a walnut-shaped gland that is situated below the uterine tube, to the right and left of the uterus, and is attached to the back via the uterine latum lementum. The ovaries perform the roles of producing eggs as well as oestrogen and progesterone by-products. The ovarian cortex and ovarian medula make up the ovary.

c) Fallopian tubes

The uterine tube is a muscular tubular organ that is between 3 and 8 mm in diameter and 12 cm in length. The purpose of the uterine tube is to transport the egg from the ovary to the uterus and to act as a site for fertilisation. The pars interstitialis, pars istmika tubae, pars ampularis tubae, and pars infudibulo tubae make up the uterine tube.

b. External Organs

The mons veneris, labia majora, labia minora, clitoris, and vestibule make up this structure.



a) Mons Veneris
The pubic symphysis contains a fat pad called the mons veneris.

b) Labia Mayora
The labia majora are two substantial folds of skin, fat, smooth muscle, blood vessels, and nerve fibres that make up the sides of the vulva.

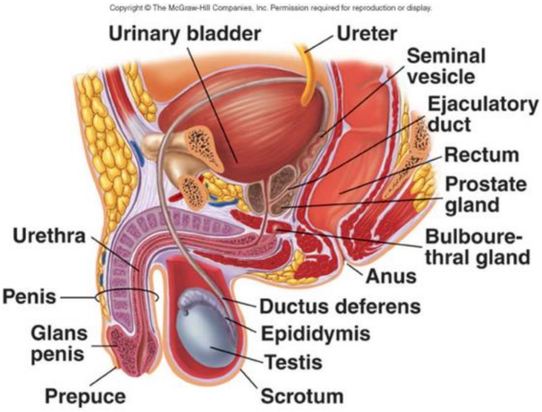
c) Labia Minora
Between the top of the labia majora and the labia minora are two very thin layers of skin.

d) Clitoris
The clitoris is a little piece of erectile tissue that resembles a man's penis.

e) Vestibule
The labia on either side of the vestibule define its boundaries, and the vestibule is connected to the vagina. On each side, the main vestibular gland is situated behind the labia majora. Between the hymen and the labia minora, this gland's ducts exit, releasing the lender into the body.

2. Male Reproductive System

Male reproductive organs can be found both inside and outside the body.



a. Internal Organs

The seminal duct, ejaculatory duct, prostate, and cowper make up this structure.

a) Seminal Ductus

The seminal ductus is a 5-cm-long, tiny, asymmetrical pouch that is situated between the rectum and the base of the urinary vesica. Seminal fluid is created when sperm and a thick, yellowish fluid secreted by the seminal ductus are combined.

b) Ejaculatory Ductus

The ejaculatory ductus, which joins the vasa deferentia and urethra, is about 2.5 cm long and is created when the vas deferens and seminal ductus come together.

c) Prostate

The prostate is a cone-shaped organ with dimensions of 4 cm in length, 3 cm in width, and 2 cm in thickness. It weighs about 8 grammes. Inside the fibrous capsule, the prostate is made up of glandular tissue and involuntary muscle fibres.

d) Cowper (Glandula Bulbourethralis)

The cowper is a little gland in the lower portion of the prostate that is yellow in colour and about the size of a pepper. This gland's ducts, which are about 3 cm long, discharge into the urethra before reaching the penis.

b. External Organs

The penis, scrotum, testicles, epididymis, and vas deferens make up this organ.

a) Penis

The penis is made up of the roots, shaft, and glans. The three cavities that make up the penis are two cavernous corpus spongy tissue cavities and one corpus spongiosum sponge tissue cavity. The sponge tissues of the corpora cavernosa and corpus spongiosum are located at the top and bottom, respectively.

b) Scrotum

The penis is stretched in the scrotum, a structure that is covered by skin. One testis, one epididymis, and the vas deferens begin in the fibrous tissue that makes up the scrotum.

c) Testicle

The testicles are oval-shaped, white, and between 10 and 14 grammes in weight. They measure around 4 cm long, 2.5 cm wide, and 3 cm thick. The spermatozoa in the testes serve as the source of testosterone.

d) Epididymis

The epididymis joins the testicle to the 6 cm long, smooth, and twisting vas deferens.

e) Vas Deferens

A canal called the vas deferens can be tied or cut during a vasectomy. Spermatozoa are transported by the vans deferens from the epididymis to the tubular, 45 cm long urethra pars protastica.

Summary

There are internal and external organs in the female reproductive system. The uterus, ovaries, and fallopian tubes are parts of the internal body that are responsible for pregnancy, delivery, and the menstrual cycle. The ovary, a walnut-shaped gland located below the uterine tube, is responsible for creating eggs as well as the by-products of oestrogen and progesterone. The ovary sends the egg to the uterus via the fallopian tubes, which also serve as the site of fertilization.

The mons veneris, labia majora, labia minora, clitoris, and vestibule are examples of external organs. The labia majora and labia minora are thin skin layers, but the pubic symphysis has a fat pad termed the mons veneris. A little portion of erectile tissue called the clitoris resembles a man's penis.

The prostate, ejaculatory duct, seminal duct, and cowper make up the male reproductive system. Sperm and a thick, yellowish fluid join in the seminal duct, a tiny pouch, to form seminal fluid. The vasa deferentia and urethra are joined by the ejaculatory duct, and the prostate is a cone-shaped organ containing glandular tissue and involuntary muscle fibres. A yellow gland called the cowper is located in the lowest part of the prostate.

The penis, scrotum, testicles, epididymis, and vas deferens are examples of external organs. The source of testosterone is the white, oval-shaped testicles. The spermatozoa are transported from the epididymis to the urethra pars protastica via the vas deferens, which links the testicle to the epididymis.

Review Questions

1. During oogenesis, each oogonium will form:
   a. 1 haploid functional ovum
   b. 2 haploid functional ova
   c. 3 haploid functional ova
   d. 4 haploid functional ova
   e. 5 haploid functional ova

   Answer: A

2. During the menstrual cycle, the follicle that has released the ovum turns into the corpus luteum, which produces the hormone progesterone. What is the effect of these hormones if the ovum is not fertilized by sperm?
   a. The endometrium sheds, stimulating the development of new follicles
   b. Activate the mucus secretion of endometrial glands
   c. Stimulate the growth of follicles, so they grow quickly
   d. Increases the production of LH and FSH by the pituitary gland
   e. Maintains the endometrium so that it is ready for implantation

   Answer: A

3. Why won't the ovaries form new Graaf follicles during pregnancy?
   a. FSH prevents the formation of progesterone
   b. Progesterone prevents the formation of FSH
   c. FSH prevents the formation of estrogen
   d. Estrogen prevents the formation of FSH
   e. Estrogen prevents the formation of progesterone

   Answer: B

4. What is the role of the oviduct in the human fertilization process?
   a. Place of attachment of the embryo
   b. Where eggs are produced
   c. As a provider of nutrition for egg cells
   d. The place where the ovum and sperm meet
   e. Produces the hormone estrogen

   Answer: D

5. Where is the location of the fertilized embryo in the fertilization process?
   a. Testicles
   b. Uterus
   c. Oviduct
   d. Urethra
   e. Labia major

   Answer: C

6. If not fertilized, the egg will become...
   a. Zygote
   b. Morula
   c. Embryo
   d. Fall
   e. Regenerate

   Answer: D

7. The cessation of a woman's ability to produce eggs is called:
   a. Ovulation
   b. Menstruation
   c. Fertilization
   d. Menopause
   e. Oogami

   Answer: D

8. The part that is always wet by the mucus produced by the Bartholin's glands:
   a. Vagina
   b. Ovary
   c. Uterus
   d. Clitoris
   e. Pubic

   Answer: D

9. Besides producing ova, what do the ovaries produce?
   a. Estrogen and testosterone hormones
   b. Estrogen and insulin hormones
   c. Estrogen and progesterone hormones
   d. The hormone progesterone and the hormone prolactin
   e. The hormone testosterone and the hormone insulin

   Answer: C

10. Reproductive organs that also function as additional/accessory organs for women are:
    a. Vagina
    b. Pubic
    c. clitoris
    d. Labia
    e. Breast

    Answer: D

11. The medical specialty dealing with men's health, in particular to problems related to the male reproductive system and urinary system
    a. Andrology
    b. Biology
    c. Gynaecology
    d. Sociology
    e. Psychology
    Answer: A

12. The outer structure of the male genitalia that functions to transport sperm is called:
    a. Scrotum
    b. Penis
    c. Vas deferens
    d. Urethra
    e. Prostate gland
    Answer: C

13. Seminiferous tubules:
    a. Glands that produce alkaline mucus
    b. Fusion between egg and sperm
    c. Place of maturation and temporary storage of sperm
    d. Glands that secrete prostaglandins
    e. The part of the testes which is the site of production of sperm and the hormone testosterone
    Answer: E

14. Production results from the male genitalia consisting of sperm together with the fluid secreted by the glands:
    a. Cement
    b. Copulation
    c. Fertilization
    d. Epididymis
    e. Seminal vesicles
    Answer: E

15. The correct process of spermatogenesis:
    a. Spermatogonia – primary spermatocytes – secondary spermatocytes – spermatozoa – spermatids
    b. Spermatids – primary spermatocytes – secondary spermatocytes – spermatogonia – spermatozoa
    c. Spermatozoa – spermatogonia – spermatids – primary spermatocytes – secondary spermatids
    d. Spermatogonia - primary spermatocytes - secondary spermatocytes - spermatid-spermatozoa
    e. Primary spermatocytes – secondary spermatocytes – spermatogonia – spermatozoa – spermatids

    Answer: D

16. If the corpus spongiosum, the body that surrounds the urethra, is filled with blood, the penis becomes larger, stiffer and more erect.
    a. Masturbation
    b. Masturbation
    c. Contraction
    d. Ejaculation
    e. Erection

    Answer: E

17. Below is one of the components contained in sperm which can function as a sugar digester in the body which is very useful as a prevention of diabetes:
    a. Creatine
    b. Calcium
    c. Lipids
    d. Fructose
    e. Sorbitol

    Answer: D

18. In spermatogenesis, will be formed:
    a. 5 spermatids
    b. 4 spermatids
    c. 3 spermatids
    d. 2 spermatids
    e. 1 spermatid
    Answer: B

19. Maturation of sperm formed in the testes occurs in:
    a. Epididymis
    b. Vas deferens
    c. Urethra
    d. Vas afferent
    e. Prostate gland
    Answer: A

20. Contraception by using a condom during sexual intercourse prevents the occurrence of:
    a. Ovulation
    b. Ejaculation
    c. Fertilization
    d. Copulation
    e. Insemination
    Answer: A

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GLOSARY

Imaginary	:	An imaginary field or line to facilitate in describe
Flexion	:	anatomy
Extension	:	Bending, folding joints or bending movements
Adduction	:	The movement of realigning the joint
Abduction	:	Movement towards the body
Rotation	:	Movement away from the body
Circumduction	:	Rotating movement of the joint
		Circular movements or combined movements of
Elevation	:	flexion, extension, abduction and adduction
Depression	:	Represents a lifting motion
Inversion	:	Lowering motion
Eversion	:	The motion of tilting the soles of the feet into
Supination	:	the body
Pronation	:	The movement of tilting the soles of the feet
Endorotation	:	outward
		The movement of raising the hand
Exortation	:	Turn over
Sagittal Axis	:	Inward movement around the long axis of the
		long bone jointed (rotation)
Transverse	:	Outward rotation movement.
Axis		The line that intersects the sagittal plane with
	:	the plane
Longitudinal		transverse motion.
Axis	:	The line that intersects the frontal plane of
		motion with the plane of motion transverse.
Origin	:	The line that intersects the median and frontal
		planes and running from top to bottom
Inertia		Tendons attached to bones that do not change
		position when the muscle contracts
		Tendons attached to bones that move when
		muscles contract.

The development and publishing of this book have been supported by WHO Indonesia and Directorate General of Health Workforce, Ministry of Health Indonesia

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Telp/Fax : (0274) 4533427
Anggota IKAPI (076/DIY/2012)
cs@deepublish.co.id
Penerbit Deepublish
@penerbitbuku_deepublish
www.penerbitdeepublish.com

Kategori : Biomedical
ISBN 978-623-02-7313-1
9 786230 273131