Learning Guide

Understanding anatomy and physiology

27457 Describe the anatomy and physiology of systems and associated organs of the human body

Name:

Workplace:
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>What is anatomy and physiology</td>
<td>2</td>
</tr>
<tr>
<td>Cardiovascular system</td>
<td>3</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>7</td>
</tr>
<tr>
<td>Musculo-skeletal system</td>
<td>10</td>
</tr>
<tr>
<td>The muscular system</td>
<td>11</td>
</tr>
<tr>
<td>The skeletal system</td>
<td>12</td>
</tr>
<tr>
<td>Endocrine system</td>
<td>16</td>
</tr>
<tr>
<td>Nervous system</td>
<td>19</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>21</td>
</tr>
<tr>
<td>Peripheral nervous system</td>
<td>22</td>
</tr>
<tr>
<td>Gastro-intestinal system</td>
<td>25</td>
</tr>
</tbody>
</table>
Introduction

This learning guide introduces you to the major systems and the associated organs in the human body and how they function.

How to use your learning guide

This guide supports your learning and prepares you for the unit standard assessment. The activities and scenarios should be used as a general guide for learning.

This guide relates to the following unit standard:

- 27457 Describe the anatomy and physiology of systems and associated organs of the human body (level 3, 6 credits).

This guide is yours to keep. Make it your own by writing notes that help you remember things, or where you need to find more information.

Follow the tips in the notes column.

You may use highlight pens to show important information and ideas, and think about how this information applies to your work.

You might find it helpful to talk to colleagues or your supervisor.

Finish this learning guide before you start on the assessment.

What you will learn

This topic will help you to:

- Describe the anatomy and physiology of the systems and associated organs of the human body.
What is anatomy and physiology

In the human body, anatomy and physiology are inseparable.

**Anatomy** is the study, classification and description of the shape, structure, positions (location) and interrelation of the systems and associated organs of the human body.

**Physiology** is the study of the mechanical, physical, and biochemical functions of the systems and associated organs of the human body.

The human body is organised on several levels, from the simplest to the most complex.

- **Cells** are the basic unit of life.
- **Tissues** are clusters of cells that perform a similar function.
- **Organs** are a group of tissues that perform a specific function.
- **Organ systems** are groups of organs that perform a specific purpose.

These systems work together in an integrated way to help us function and to promote the wellbeing of the entire body. The ability to balance these systems and maintain stability is called homeostasis.

**There are 11 systems in the human body.**

1. Cardiovascular (circulatory)
2. Respiratory
3. Skeletal
4. Muscular
5. Endocrine
6. Nervous
7. Gastro-intestinal
8. Immune
9. Integumentary (skin)
10. Reproductive
11. Excretory (urinary)

This learning guide focuses on the first seven of these systems.

More info
Refer to The aging process learning guide (US 23387) for information on how anatomy and physiology are influenced by ageing.

More info
For the unit standard assessment you need to be able to describe any six of the systems of the human body.
Cardiovascular system

This system transports:
- fuel (oxygen and nutrients) to the body.
- waste to the liver and kidneys.
- cells to fight diseases.
- hormones throughout the body.

Parts of the cardiovascular system.
- heart
- arteries
- veins
- capillaries
- blood

The cardiovascular system is sometimes called the circulatory system.
Cardiovascular system

The cardiovascular system includes:

- the pulmonary circulation – a ‘loop’ that goes through the lungs to oxygenate the blood.
- the systemic circulation – a ‘loop’ that goes through the rest of the body to provide the oxygenated blood.
- the coronary circulation – the heart receives blood under the highest possible pressure to meet the demands of active cardiac muscle tissue.

The pulmonary circulation transports oxygen-depleted blood away from the heart to the lungs and returns oxygenated blood back to the heart.

The systemic circulation transports oxygenated blood away from the heart to the rest of the body and returns oxygen-depleted blood back to the heart.

Both the pulmonary and systemic loops begin and end at the heart and blood travels through both loops in sequence. Blood that has gone through the pulmonary circuit will go through the systemic circuit before returning to the pulmonary circuit.

Heart

The heart is a fist-sized organ that lays a little left of the central chest area beneath the sternum. The heart has four chambers and a system of valves that control blood flow. Oxygen depleted blood from the body enters the right atrium via the venous system (veins) and is pumped from the right ventricle to the lungs. Enriched with oxygen, the blood enters the left atrium and is pumped from the left ventricle to the body via the arterial system (arteries).
In a single heartbeat, the ventricles pump blood to both the lungs and the rest of the body. Almost all the muscle cells in the heart (99%) are contractile cells that respond to the electrical impulse generated by specialist cells in the heart by contracting.

**Arteries and veins**

Arteries transport oxygen enriched blood away from the heart to the body. Veins are blood vessels that transport oxygen depleted blood from the rest of the body to the heart.

Both arteries and veins become smaller as they get further away from the heart. At the point between an artery ending and vein beginning, are capillaries.

**Capillaries**

Capillaries are small, thin-walled blood vessels that permit the exchange of nutrients, dissolved gases and waste products between the blood and the surrounding tissues.
About blood

Blood transports fuel to the body, waste to the liver and kidneys, cells to fight diseases, and hormones throughout the body. The average volume of blood ejected from the heart in a single beat is approximately 70 mls. The average number of beats per minute is 70. The average volume of blood in an adult human body is approximately five litres. This means that it takes about one minute for blood to do a complete circuit of the body.

Write

Complete the questions below.

1 What is the name of the system shown below?

2 Label the body structures and associated organs of the system.

3 Explain in your own words the physiology of the system (how it works).
Respiratory system

The respiratory system has **five** basic functions:

- to provide an area for gas exchange between circulating blood and the air. Oxygen is taken in and waste carbon dioxide is released.
- to move air to and from the area for gas exchange.
- to protect the surfaces of the respiratory tract that comes into contact with the air, from dehydration, temperature changes and infection.
- to help generate voice.
- to enable the sense of smell.
The **respiratory system** is divided into upper and lower sections.

The **upper respiratory system or airway** includes the nose and pharynx (the area shared by both the digestive and respiratory systems). This is where air first enters the body and the process of warming, filtering and humidification begins.

The **lower respiratory system** includes the larynx (voice box), trachea (windpipe), bronchi, bronchioles and alveoli of the **lungs**.

The **larynx** connects the pharynx to the trachea. It is involved in breathing, sound production and protecting the trachea from aspiration. If the larynx is stimulated by the touch of food or liquid, the coughing reflex is triggered.

The **trachea** is the primary windpipe. It divides into the left and right bronchi that take the air into the lungs.

The bronchi branch into the smaller bronchioles and end with the grape-like bunches of alveoli which is where the gas exchange takes place in the lungs.

---

In **external** respiration, gas exchanges are being made between the blood and the exterior (outside) of the body.

In **internal** respiration, gas exchanges are occurring between the blood and cells inside the body.

The **diaphragm** is a big, dome-shaped muscle that separates the abdomen from the chest cavity. The diaphragm is responsible for 75% of the chest wall movement required in breathing.
Write

Complete the questions below.

1 What is the name of the system shown below?

2 Label the body structures and associated organs of the system.

3 Explain in your own words the physiology of the system (how it works).
Musculo-skeletal system

The musculo-skeletal system is made up of two systems:
- the muscular system
- the skeletal system

The musculo-skeletal system is a framework of muscles, tendons and ligaments. These work together with the bones and joints to help the body move and maintain its form.

**Muscles**

- Pectoralis
- Biceps
- Rectus abdominis
- Quadriceps *(Four muscles)*
- Tibialis

**Bones**

- Mandible
- Clavicle
- Humerus
- Ribs
- Sternum
- Ulna
- Radius
- Pelvis
- Femur
- Patella
- Tibia
- Fibula
The muscular system

Muscles are made of an elastic type of tissue and there are thousands of small fibres that make up each muscle.

There are three types of muscle in the human body.

Smooth muscles are also called involuntary muscles. These muscles are found in the stomach, digestive system, bladder, uterus and eyes. Smooth muscle controls the movement of food through the digestive tract and the emptying of the bowels and bladder.

Cardiac muscles, also called the myocardium, form the walls of the heart. The muscles contract to pump blood to the rest of the body and then relax to allow the chambers to fill with blood again. Cardiac muscles are also involuntary and their movement depends on an electrical impulse being delivered from specialised cells called pacemakers.

Skeletal muscles are voluntary muscles and are attached to bones by tendons.

There are approximately 700 skeletal muscles and all of them are connected directly or indirectly with the skeletal system to allow the body to move. Some of the biggest and most powerful skeletal muscles are in the back, near the spine. These muscles keep the body upright.

Muscles have different functions, including:

- producing body movements.
- stabilising body position.
- producing heat.
- moving and storing substances.

<table>
<thead>
<tr>
<th>Functions of the muscles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producing body movements.</td>
<td>Body movements rely on the integrated functioning of skeletal muscles, bones and joints.</td>
</tr>
<tr>
<td>Stabilising body position.</td>
<td>Skeletal muscle contractions stabilise joints and maintain body positions such as standing or sitting.</td>
</tr>
<tr>
<td>Producing heat.</td>
<td>Heat is a by-product of muscular activity. Much of the heat released by the muscles is used to maintain normal body temperature.</td>
</tr>
</tbody>
</table>
Moving and storing substances.

Smooth muscle allows hollow organs to temporarily store food in the stomach or urine in the bladder because smooth muscles have the ability to open and close the outlets for these organs.

Smooth muscle contraction:
- moves food and other substances through the gastrointestinal tract.
- pushes gametes (eggs and sperm) through the reproductive system.
- propels urine through the urinary system.

Cardiac muscle contractions pump blood through the blood vessels of the body.

Skeletal muscle contractions aid the return of blood in the veins to the heart.

The skeletal system

The skeletal system is the internal framework of the body. It is made up of 206 bones.

<table>
<thead>
<tr>
<th>Functions of the skeleton</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support</td>
<td>The skeleton provides a structural framework for the body by supporting soft tissues and providing points of attachment for the tendons of most skeletal muscles.</td>
</tr>
<tr>
<td>Protection</td>
<td>The skeleton also has a protective function for internal organs, for example, the bones of the skull protect the brain and the rib cage and sternum protect the heart and lungs.</td>
</tr>
<tr>
<td>Assistance in movement</td>
<td>Skeletal muscles are attached to bones by tendons and control the movement of the bones to move the body and its parts.</td>
</tr>
<tr>
<td>Blood cell production</td>
<td>The bones and bone tissue that make up the skeletal system produce red blood cells, white blood cells and platelets.</td>
</tr>
<tr>
<td>Storage and mineral balance (homeostasis)</td>
<td>Bone tissue stores and releases minerals such as calcium and phosphorus. Bone releases minerals into the blood to maintain mineral balances.</td>
</tr>
</tbody>
</table>
**Bones**

- Bones provide support and shape for our bodies.
- The skull protects the brain and forms the shape of our face.
- The spinal cord, which acts as the pathway for messages between the brain and the body, is protected by the spinal column which also helps to hold the body in an upright position.
- The ribs form a cage that protects the heart, lungs, liver, and spleen; the pelvis helps protect the bladder, intestines, and in women, the reproductive organs.
- The long bones in our legs and arms are very strong and are designed to support weight.
- Bones are made up of living cells, which constantly grow and reshape themselves throughout our life. As we age, this process slows down.
- Calcium helps make bones strong which allows them to support our weight.
- Bones store calcium. Bones also release calcium into the bloodstream when it's needed by other parts of the body.
- Bones are attached to other bones by long, fibrous straps called ligaments.
Joints

Joints are where two bones meet. The most common and most movable type of joints in the body are synovial joints. These joints contain synovial fluid which has a ‘yolk-like’ consistency and functions to reduce friction between the articular cartilage when the joint is moving.

Joints move in different ways. Some joints open and close like a hinge (such as knees and elbows). Others allow more complicated movement such as the ball and socket joints found in the shoulders or hips. These allow backward, forward, sideways, and rotating movement. Saddle joints allow movement back and forth and up and down but do not allow for rotation like a ball and socket joint. The fingers and toes contain saddle joints. Pivot joints allow for rotation, for example, turning the lower arm or turning the head.

Cartilage, tendons and ligaments

Cartilage is a flexible, rubbery substance in the joints, which supports bones and protects them where they rub against each other.

Cartilage coats the ends of bones. Along with synovial fluid it prevents the bones grinding on each other. By stopping the bones grinding together, cartilage and synovial fluid together reduce the wear and tear on joints. It enables bones to pivot and move smoothly.

Tendons attach the muscles to the bones. They allow the muscles to pull on the bones. When a muscle contracts to move a joint, it is the tendon which pulls on the bone. When you wiggle your fingers, you can see the tendons on the back of your hand move as they do their work.

Ligaments hold the joints together and are stretchy (like elastic).
Complete the questions below.

1 What is the name of the system shown below?

2 Label the body structures and associated organs of the system.

3 Explain in your own words the physiology of the system (how it works).
Endocrine system

The endocrine system is made up of glands that produce, store and secrete hormones that are released into the bloodstream to be transported to the appropriate organs, tissues or cells.

These hormones and their effects on body systems help maintain and control:

- energy levels.
- growth and development.
- homeostasis (internal balance of body systems).
- responses to stress and injury.
- reproduction.

There are five major glands in the endocrine system.

- Hypothalamus/Pituitary.
- Thyroid.
- Adrenal.
- Pancreas.
- Reproductive.
The **pituitary** gland is called the ‘master gland’ but is, in fact, controlled by the **hypothalamus**. Working together, these glands control many other functions of the endocrine system. Some of the hormones secreted are:

- follicle stimulating hormone which stimulates the production of follicles in a woman’s ovaries.
- leutinising hormone that triggers ovulation.
- antidiuretic hormone that helps to prevent excess water loss by reducing the amount excreted by the kidneys.
- endorphins that reduce the sensitivity of pain receptors.

The **thyroid** gland secretes thyroid hormones that regulate metabolism (body temperature and weight), blood pressure, heart rate and the rate at which food is converted into energy.

The thyroid uses iodine – a mineral found in some foods and in iodised salt – to make its hormones, the two most important of which are thyroxine and triiodothyronine.

The **adrenal** glands are positioned above the kidneys. One of the hormones produced is adrenaline, which is released in response to stress factors such as anger or injury. Adrenaline increases the heart rate and speeds up the rate of breathing, to allow extra oxygen to be circulated through the body.

The **pancreas** secretes two main hormones, insulin and glucagon, that regulate blood sugar levels. **Insulin** reduces the level of sugar (glucose) by stimulating cells in the liver, muscle and fat tissue to take glucose from the blood and store it as glycogen. **Glucagon** raises the level by releasing sugar that has been stored.

**Reproductive** glands produce and secrete hormones such as testosterone in males and oestrogen in females. **Testosterone** controls things like male body shape, facial hair, depth of voice and sexual drive. **Oestrogen** controls the female body shape and development of breasts.
Next to each named organ, write one thing that a hormone released from this organ can influence.

- Pituitary gland
- Thyroid
- Adrenal glands
- Pancreas
Nervous system

The nervous system comprises the brain, the spinal cord and a network of nerves that go through all the organs and muscles, and out to the skin. It is the most complex organ system and it is vital to both life and the appreciation of life. The nervous system shares many characteristics with the endocrine system and they act together to help regulate the body. Endocrine responses develop more slowly but last much longer than nervous system responses.

Neurons

Neurons are the functional units (cells) of the nervous system. The nervous system is composed of billions of neurons, which carry impulses. The impulses are responsible for the majority of functions our body performs.

Neurons occur in a variety of sizes and they can vary largely in length, ranging from a fraction of a millimetre to over a metre long. They contain a cell body, a nucleus, dendrites, an axon surrounded by a myelin sheath, and axon terminals.

Neurons are highly specialised cells that carry impulses throughout our bodies. The impulses cause a change in target cells, for example the contraction of muscles and/or the secretion from glands.

The nervous system is responsible for a wide variety of functions including:

- relaying messages.
- triggering the muscles.
- responding to the senses.
- thinking.
- memory.
- carrying out automatic reflexes.
- giving us the capacity to analyse information and make judgments.
Although the structures and functions of the whole nervous system are very closely integrated and usually work seamlessly, the nervous system can be divided into central and peripheral portions to help understand its functions.
Central nervous system

The central nervous system (CNS) is made up of the brain and the spinal cord.

The brain

The brain lies within the skull and controls most functions of the body. The spinal cord is a continuation of the brain and lies within the vertebral column.

Between the soft brain tissue and the bones of the skull, there are three different membranes called the meninges. As well as covering the brain, the three layers of meninges also form a continuous covering over the spinal cord within the vertebral column. Thus, both the brain and spinal cord (the central nervous system) are completely contained within the three layers of meninges.

The three layers of meninges and the outer bony covering of the skull and vertebral column help to protect the central nervous system from mechanical forces such as a blow to the head.
The spinal cord

The spinal cord is divided into two main parts:

- grey matter – this contains cell bodies and dendrites or neurons.
- white matter – this surrounds the grey matter and contains myelinated axons of neurons.

The spinal cord extends from the brain down through the spinal canal (inside the vertebral column, which protects it). The spinal cord is surrounded by extensions of the same three layers of meninges that cover the brain (pia mater, arachnoid mater and dura mater). The subarachnoid space around the spinal cord is continuous with the subarachnoid space around the brain and it also contains cerebrospinal fluid (CSF).

The spinal cord is a vital link between the brain and the body, transmitting neural signals.

The spinal cord consists of millions of nerve fibres which transmit electrical information between the limbs, trunk and organs of the body, and the brain. The nerves which carry information from the brain to muscles are called motor neurones. The nerves which carry information from the body back to the brain are called sensory neurones. Sensory neurones carry information about skin temperature, touch, pain and joint position.

Peripheral nervous system

The brain and spinal cord are referred to as the central nervous system (CNS), and the nerves connecting the spinal cord to the body are referred to as the peripheral nervous system (PNS).

The peripheral nervous system delivers sensory information to the CNS (afferent division) and carries motor commands to peripheral tissues and systems (efferent division). These commands are carried by nerves.

The peripheral nervous system can be further divided into the somatic nervous system (SNS) and the autonomic nervous system (ANS).

Somatic nervous system

The somatic nervous system controls skeletal muscle contractions. Some are voluntary, for example, moving your arm to pick something up. Some are subconscious, for example, moving your hand away from a hot surface usually before you even feel any pain. This type of automatic response is called a reflex.
**Autonomic nervous system**

The autonomic nervous system divides further into the sympathetic and parasympathetic nervous systems. These systems work in harmony to control smooth muscle, cardiac muscle and glands. The ANS operates automatically and includes the functioning of the digestive system, heart and breathing.

This diagram shows what happens when a reflex action takes place when you step on a pin.

1. The sharp pin touches pain receptors in your foot.
2. Nerve endings send information to special cells in the spinal cord bypassing the brain.
3. The spinal cord processes this information and sends impulses down the muscle that moves the leg; while the brain also sends impulses informing the leg of the action.
4. Your leg moves quickly.
Complete the questions below.

1 What is the name of the system shown below?

2 Label the body structures and associated organs of the system.

3 Explain in your own words the physiology of the system (how it works).
The gastro-intestinal system processes the food we eat, turning it into the fuel that keeps all the body’s cells functioning. It also provides the nutrition needed for cell growth and repair.

The gastro-intestinal system consists of a muscular tube – the digestive tract or gastrointestinal (GI) tract and associated organs. It includes all the body structures involved in preparing food for absorption into the body and the excretion of waste products.

The digestive process can be seen as a series of steps that begin with the ingestion of food and/or drink.

The mouth, in combination with the teeth, tongue and salivary glands begins the mechanical processing of ingested material. Saliva both moistens the food and contains enzymes that break down carbohydrates.

The food then enters the pharynx and oesophagus. Pharyngeal muscles help move the food down the oesophagus and into the stomach.
The **stomach** stores and processes food. The mechanical breakdown of food is aided by muscular contractions. Chemical breakdown happens through the addition of digestive juices (acid and enzymes). Food may stay in the stomach for 3–4 hours. The thick, partially digested food that passes from the stomach into the small intestine is called **chyme**.

The **small intestine** plays a key role in the digestion and absorption of nutrients. The vast majority (90%) of nutrient absorption happens in this section of the digestive tract which measures an average six metres in length.

The duodenum is the part of the small intestine closest to the stomach and this is where chyme is mixed with digestive secretions from the pancreas, liver and gallbladder.

The **liver** is the largest glandular organ of the body, and is divided into four lobes of unequal size and shape. The liver lies on the right side of the abdominal cavity beneath the diaphragm. Blood is carried to the liver via two large vessels called the hepatic artery and the portal vein.

The liver has many functions which include:

- producing substances that break down fats.
- converting glucose to glycogen.
- amino acids.
- filtering harmful substances from the blood (such as alcohol).
- storing vitamins and minerals.

The **large intestine** (or large bowel) is made up of the colon, caecum and rectum. It has an average length of 1.5 metres and it completes most of the remaining 10% of nutrient absorption. It is also responsible for the compaction of waste materials into faeces that are expelled by defecation via the anus (the external sphincter muscle of the digestive system).
Complete the questions below.

1 What is the name of the system shown below?

2 Label the body structures and associated organs of the system.

3 Explain in your own words the physiology of the system (how it works).