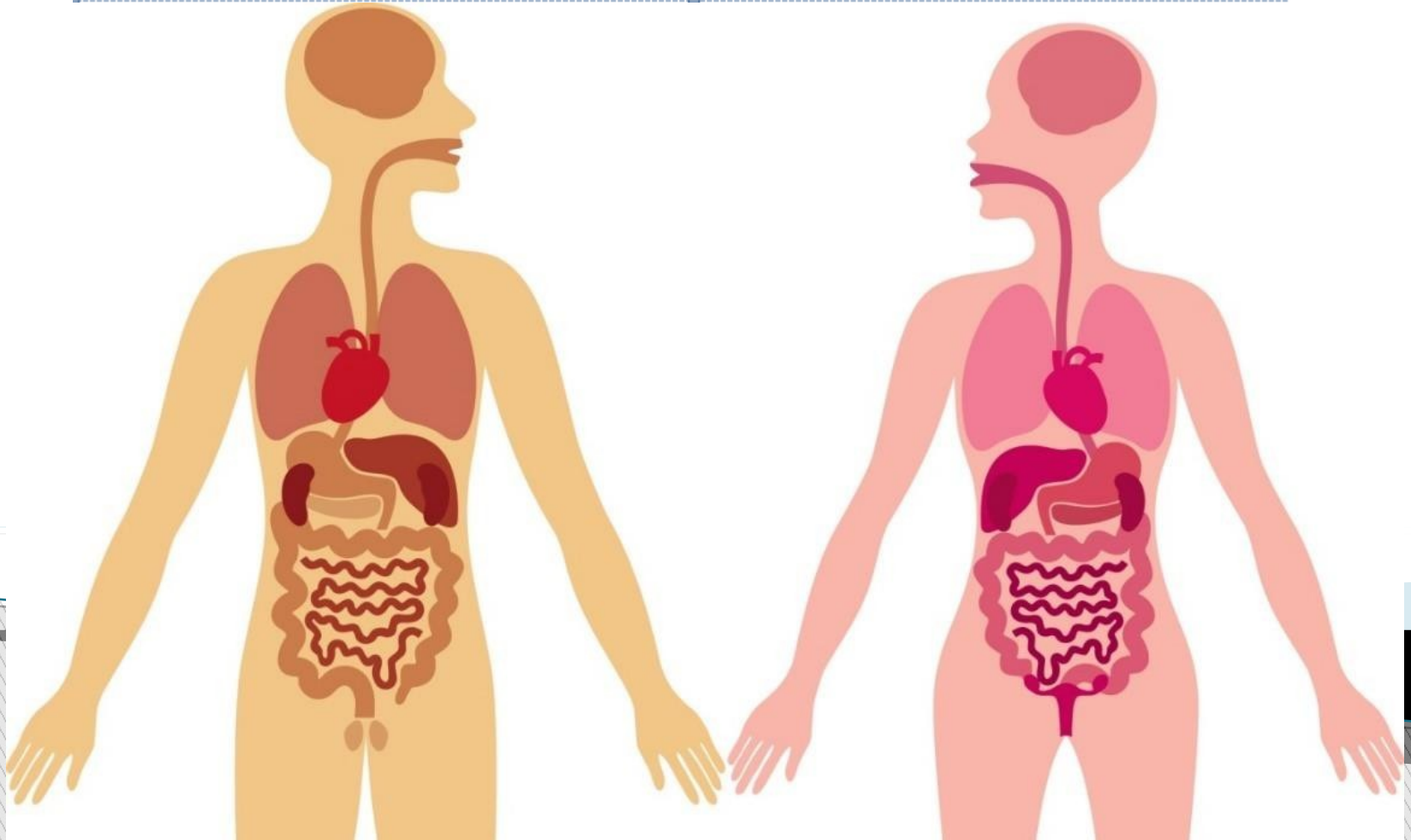


**Biology**  
**Lesson Note**  
**Unit 4 & 5**  
**Nervous system &**  
**Sense Organ**  
**For Grade 12**



# Unit 5

## Human body system



## **5.Human body system**

### **5.1The Nervous System**

#### **Definition of the nervous system**

- o Define the nervous system
- o Define reflex action
- o Describe the structure and function of neurons
- o Identify types of the nervous system

## 5.2Types of the nervous system

- ❖ Human beings not only control our own bodies, our co-ordination system
- ❖ also control complicated machines.
- ❖ All living organisms need some level of awareness of their surroundings so that they can avoid danger, find food and, in some cases, find a mate.
- ❖ Whatever the level of awareness, it requires co-ordination and control within an organism to respond to changes in the surroundings.
- ❖ In large and complex organisms like a human being, it is also very important that the different systems within our body are coordinated and work together.
- ❖ We need to pick up all sorts of changes in the environment, and respond to them

- ❖ In human beings the nervous system is a highly complex system that provides rapid, coordinated responses to the situations we meet in our lives.
- ❖ It allows us to react to our surroundings and co-ordinate our behavior. Human nervous system has two main parts.
- ❖ These are the central nervous system (CNS), which is made up of **brain** and **spinal cord**, and the **peripheral nervous system** which consists of the nerves that

## ***The Central Nervous System***

The Central Nervous System (CNS) consists of two main parts: – the **brain** and the **spinal cord**

### **5.2.1The Brain**

- ❖ Human brain is a delicate mass of the nervous tissue with the consistency of thick yoghurt.
- ❖ It is enclosed in membranes and protected by the bones of a skull in a space known as the **cranium**.
- ❖ The nerves that come out of the brain are

- ❖ Human brain is a very complex structure that carries out an amazing variety of functions. The different areas of the brain (Figure 5.2) carry out very different functions, from the basic reflexes that keep us breathing to the complex ideas needed to create a story or write and play music.
- ❖ The bulk of the brain is made up of **grey matter and white matter**.
- ❖ The **grey matter** (cell bodies and short relay neurons) in the brain **is** the darker outer portion whereas the **white matter** (mostly axons) is the lighter, inner section underneath the grey

- ❖ As an **embryo** develops in the womb, the brain starts off as a tube in the head with three main areas.
  - ❖ The **fore brain** develops into the olfactory lobes, which deal with smell, and the cerebral hemispheres that are involved in all the higher levels of thought. Some areas of the cerebrum (cerebral hemispheres) are involved in the co-ordination and interpretation of
- 

- ❖ As an embryo develops in the womb, the brain starts off as a tube in the head with three main areas. The **fore brain** develops into the olfactory lobes, which deal with smell, and the cerebral hemispheres that are involved in all the higher levels of thought.
- ❖ Some areas of the cerebrum (cerebral hemispheres) are involved in the co-ordination and interpretation of  
    affecter input from the sense organs.  
Other areas are involved in sending out  
effector impulses to control the actions of the  
body in response to the affecter information.

# THE MAJOR DIVISIONS OF THE BRAIN

## FOREBRAIN

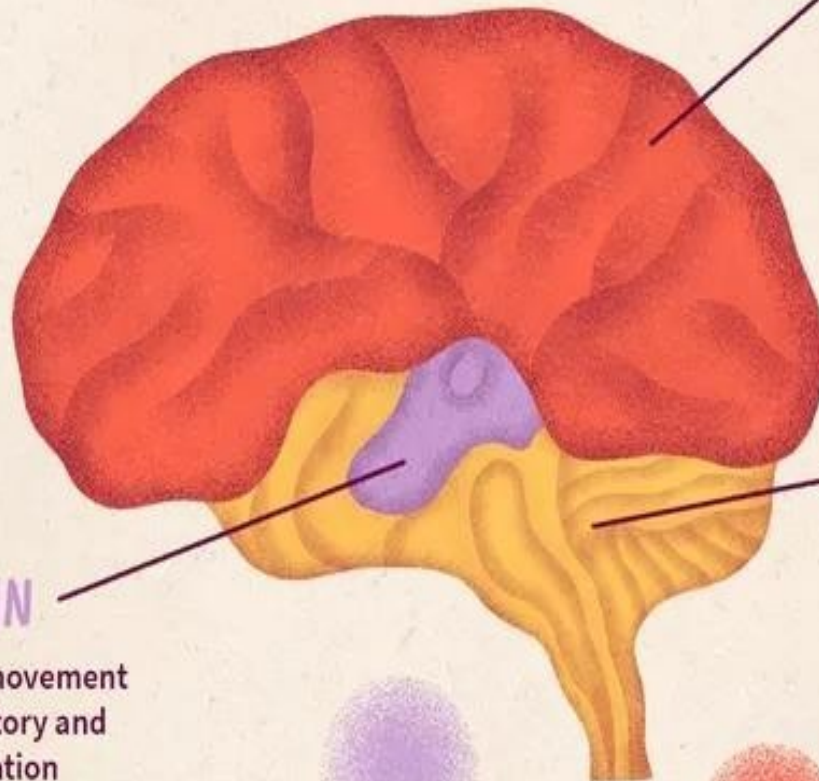
Processes sensory information, helps with reasoning and problem-solving, and regulates autonomic, endocrine, and motor functions

## HINDBRAIN

Helps to regulate autonomic functions, relay sensory information, coordinate movement, and maintain balance and equilibrium

## MIDBRAIN

Helps to regulate movement and process auditory and visual information



- ❖ **Figure 5.2** The three main areas of the human brain; the fore, mid and hind brain.
- ❖ The **mid brain** develops into the areas of the brain that deals with vision (the optic lobes) while the **hind brain** forms the areas of the brain that deals with balance and orientation (the cerebellum) and the most fundamental

- ❖ **Fore brain** *the large frontal area of the human brain*
- ❖ **Grey matter** *areas in the brain and spinal cord that consist of unmyelinated nerve cells*
- ❖ **White matter** *areas of the brain and spinal cord composed mainly of long-range myelinated axons*  
**Affector (afferent)** *neuron that sends impulses from organs to the spinal cord and brain*  
**Effector (efferent)** *neuron that sends impulses from the brain and spinal cord to organs*

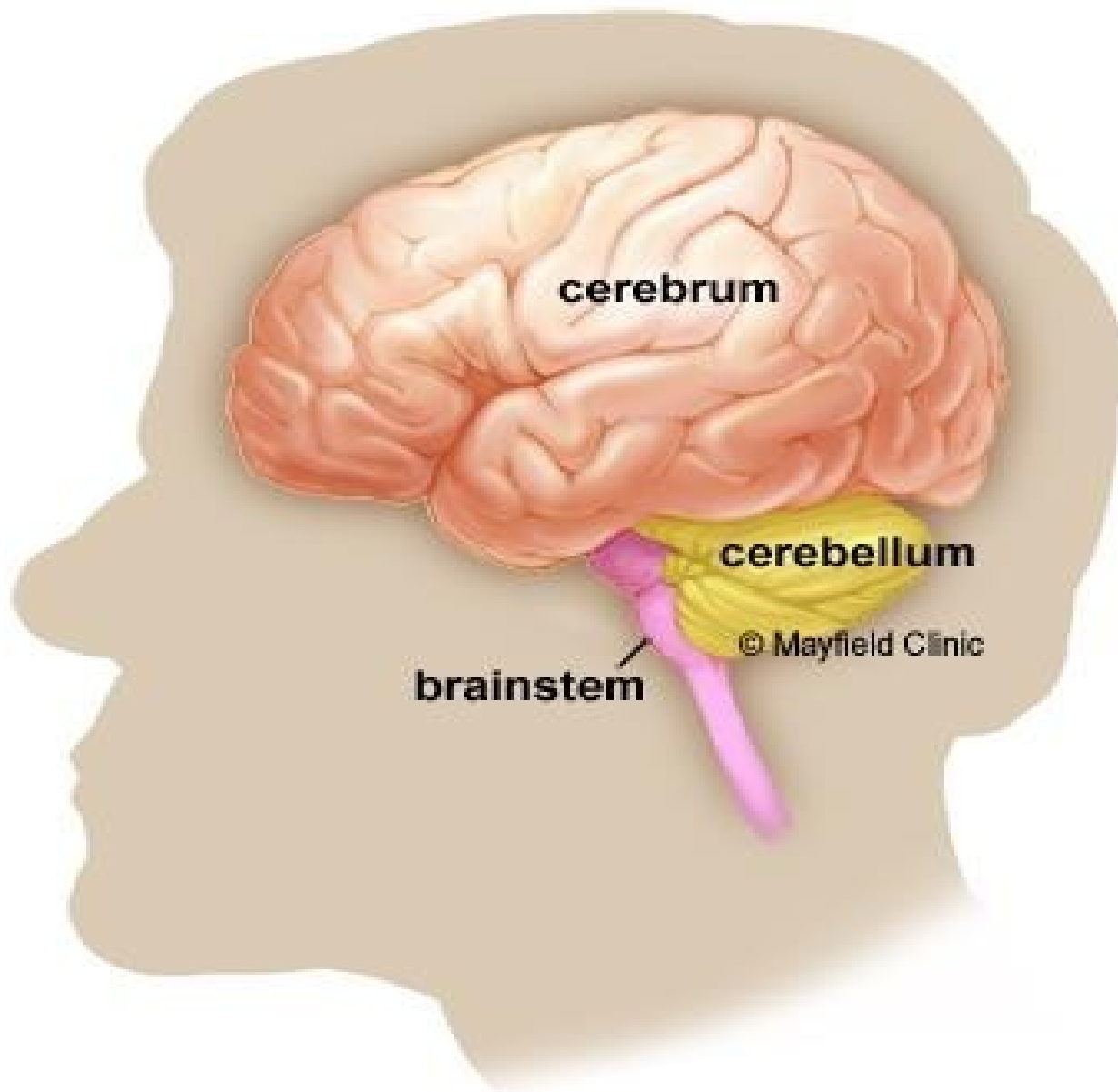


**Figure 5.3** Main parts of the human brain

- ❖ The brain is an amazing three-pound organ that controls all functions of the body, interprets information from the outside world, and embodies the essence of the mind and soul.
- ❖ Intelligence, creativity, emotion, and memory are a few of the many things governed by the brain. Protected within the skull, the brain is composed of the **cerebrum**, **cerebellum**, and **brainstem (Medulla)** (Figure

❑ **Cerebrum:** is the largest part of the brain and is composed of **right** and **left** hemispheres. It performs higher functions like interpreting touch, vision and hearing, as well as speech, reasoning, emotions, learning, and fine control of movement.

❑ **Cerebellum:** is located under the cerebrum. Its function is to coordinate muscle

- ❖ **Brainstem (Medula):** acts as a relay center connecting the cerebrum and cerebellum to the spinal cord.
- ❖ It performs many automatic functions such as **breathing, heart rate, body temperature, wake and sleep cycles, digestion, sneezing, coughing, vomiting, and swallowing.**
- ❖
- ❖ The brain receives information through our five senses: **sight, smell, touch, taste, and hearing** which many often do at one time.
- ❖ It assembles the messages in a way that has meaning for us, and can store that information in our memory.
- ❖ The brain controls our thoughts, memory and speech, movement of the arms and legs and the functioning of the internal organs.

## 5.2.2 The spinal cord

- ❖ The **spinal cord** has a much simpler structure than the brain.
- ❖ It is a tubular structure composed of the nervous tissue that extends from the brainstem and continues distally before tapering at the lower thoracic/upper lumbar region as the **conus medullaris** (the terminal end of the spinal cord).
- ❖ The spinal cord runs out from the brain down the body.
- ❖ The spinal cord is encased and protected by the vertebrae making up the spine.

- ❖ The majority of nerves come out of the spinal cord are known as the **spinal nerves**.
- ❖ They stretch to the arms, legs, trunk and to the rest of the body (Figure 5.4).
- ❖ In the spinal cord **the grey matter** is located in the middle whereas the **white matter** is found on the outside (Figure 5.5).
- ❖ At regular intervals along the spinal cord there are entrance points for **afferent** nerves that bring information into the CNS and exit points for **efferent** nerves carrying

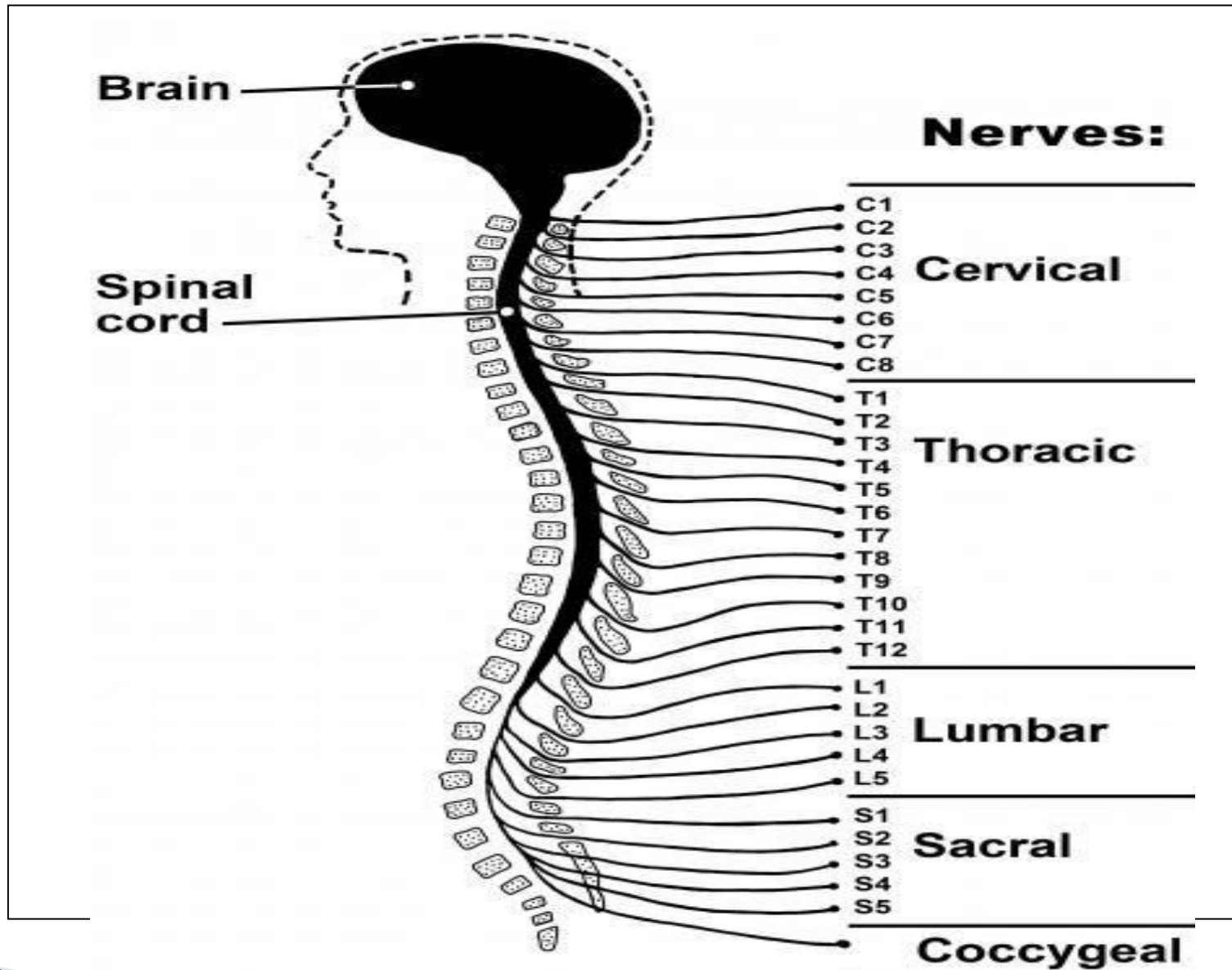


**Figure 5.4** The spinal cord and spinal nerves

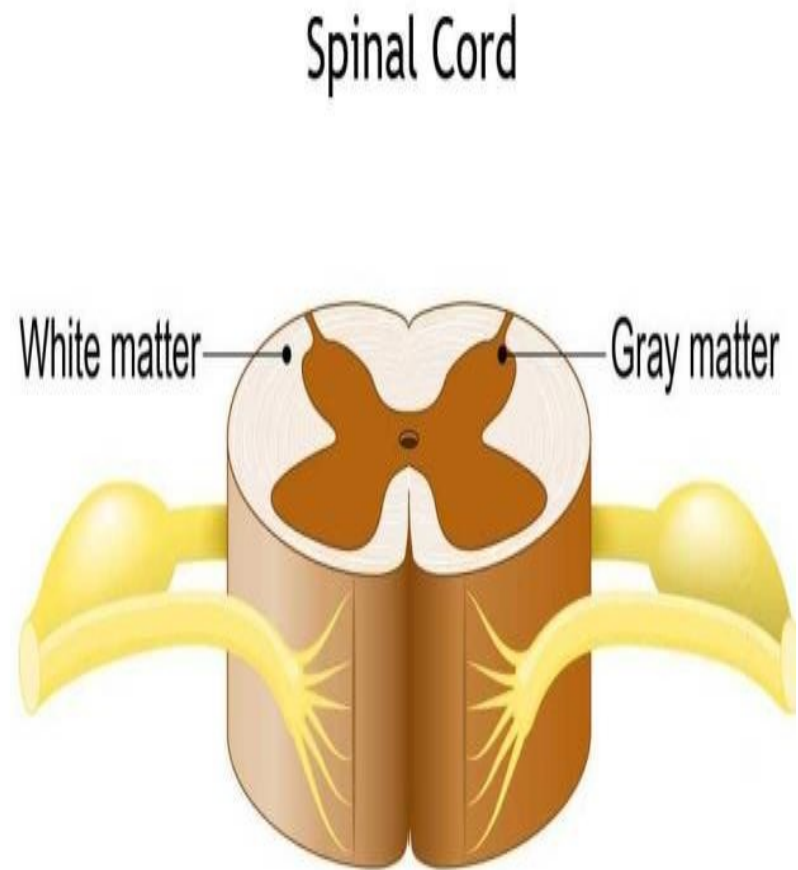
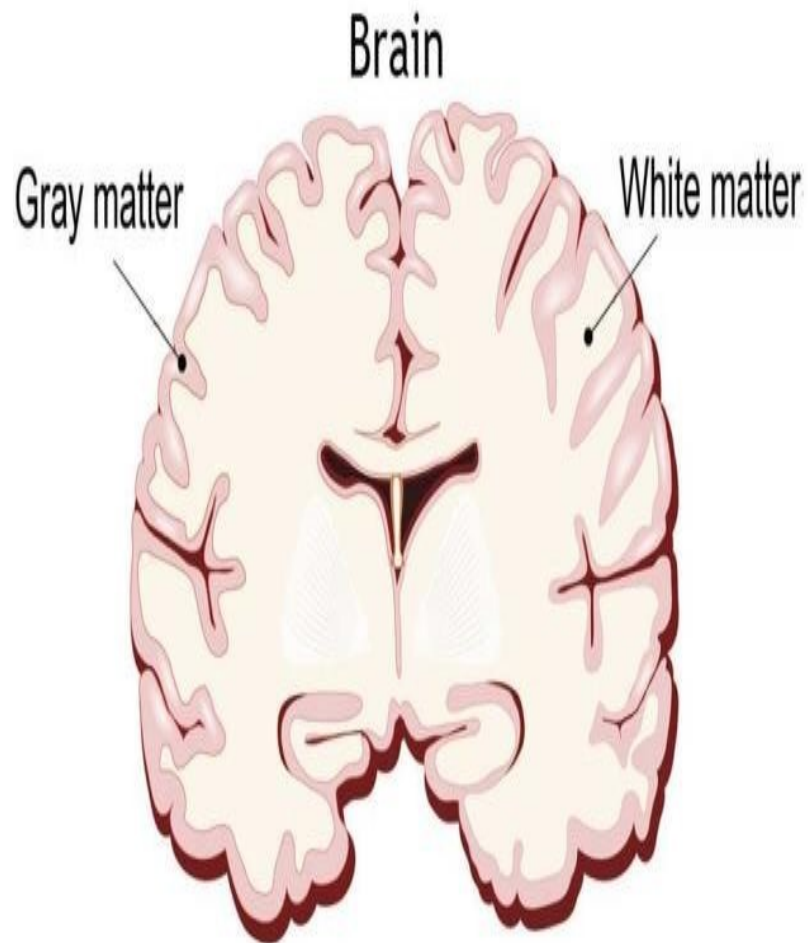
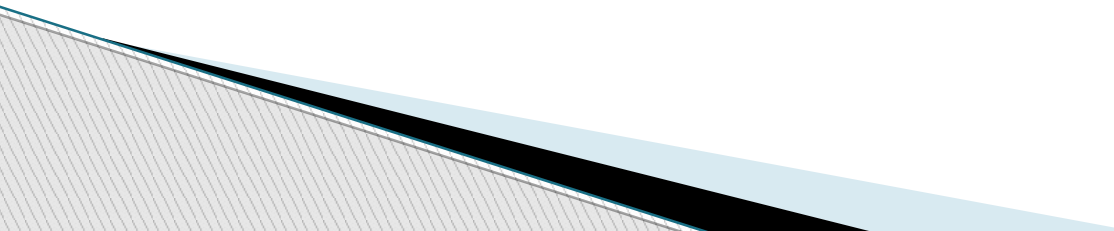


**Figure 5.5** The cross-section of the CNS showing the position of grey and white matters.

- ❖ **Dura mater** – This is the thick outermost covering (meninges) of the brain and spinal cord.
  - ❖ It is the layers of connective tissue that make up the meninges of the brain (dura, arachnoid, and pia).
  - ❖ It is the outermost layer of the three meninges that surround and protect the brain and spinal cord
- 

- ❖ **Pia mater** – This is the innermost covering of the spinal cord.
- ❖ Intimately adhered to its surface, the pia mater stabilizes the spinal cord through lateral extensions of the pia called the denticulate ligaments, extending between the ventral and dorsal roots unto the dura mater.
- ❖ **The arachnoid mater** is interposed between Dura mater and Pia mater.
- ❖ It is delicate layer which is not attached to the inside of the dura but against it and surrounding the brain and spinal cord.

- ❖ **Cerebrospinal fluid** (CFS)- is the fluid that flows in and around the hollow spaces of the brain and spinal cord, and between two of the meninges (the thin layers of tissue that cover and protect the brain and spinal cord).
- ❖ **Cerebrospinal fluid** is made by tissue called the **choroid plexus** in the ventricles (hollow spaces) in the **brain**..

## **5.3The Peripheral Nervous System**

- ❖ The Peripheral Nervous System (PNS) is the division of the nervous system that contain all the nerves that lie outside of the central nervous system.
- ❖ The primary role of the PNS is to connect the CNS to the organs, limbs, and skin (Figure 5.6).
- ❖ These nerves extend from the central nervous system to the outermost areas of the body

- ❑ The Peripheral Nervous System allows the brain and the spinal cord to receive and send information to other areas of the body which allows you to react to stimuli in your environment.
- ❑ The peripheral nervous system itself is divided into two parts: the somatic nervous system and the autonomic nervous system.
- ❑ Each of these components plays a critical role in how the

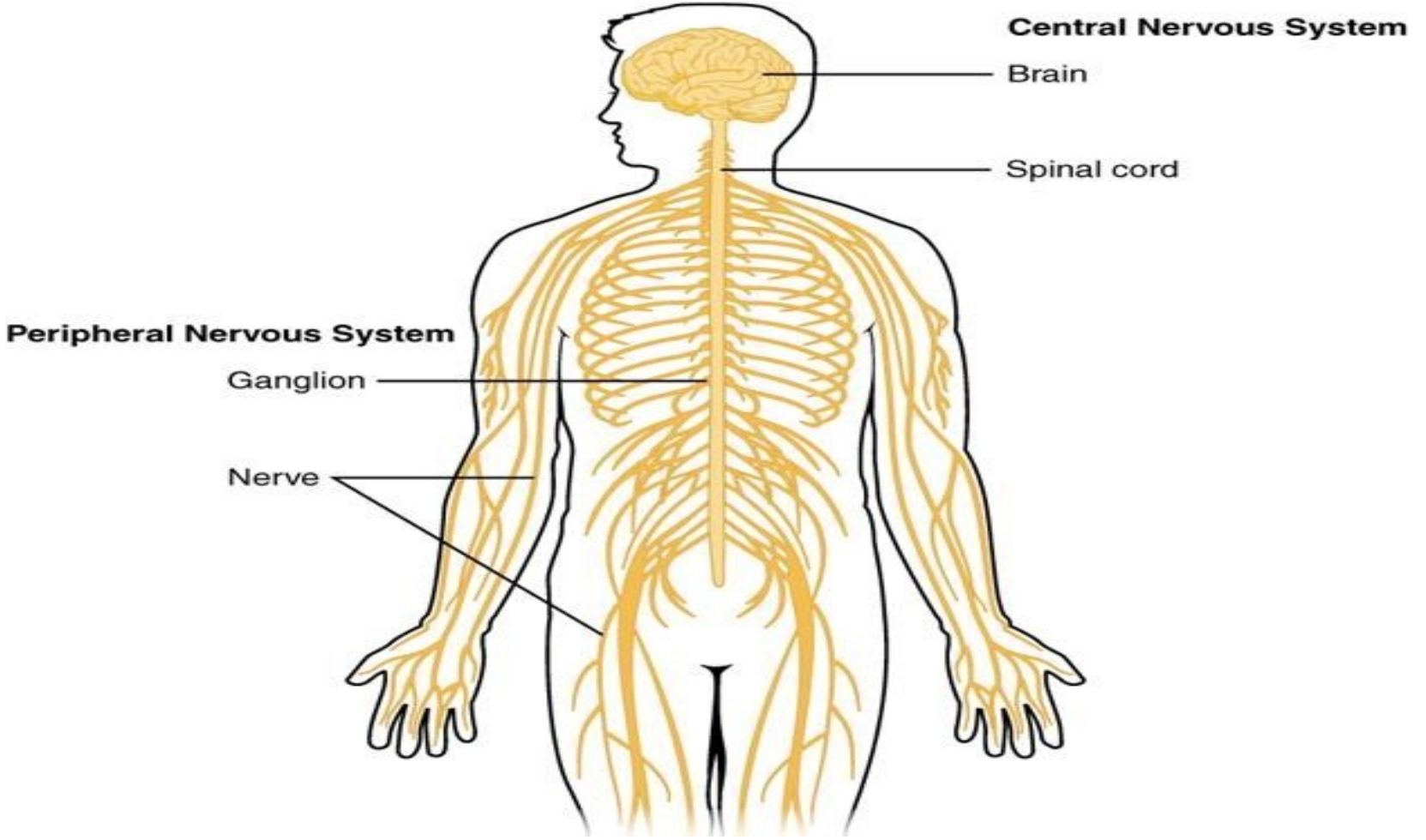


**Figure 5.6** The human central and peripheral nervous systems.

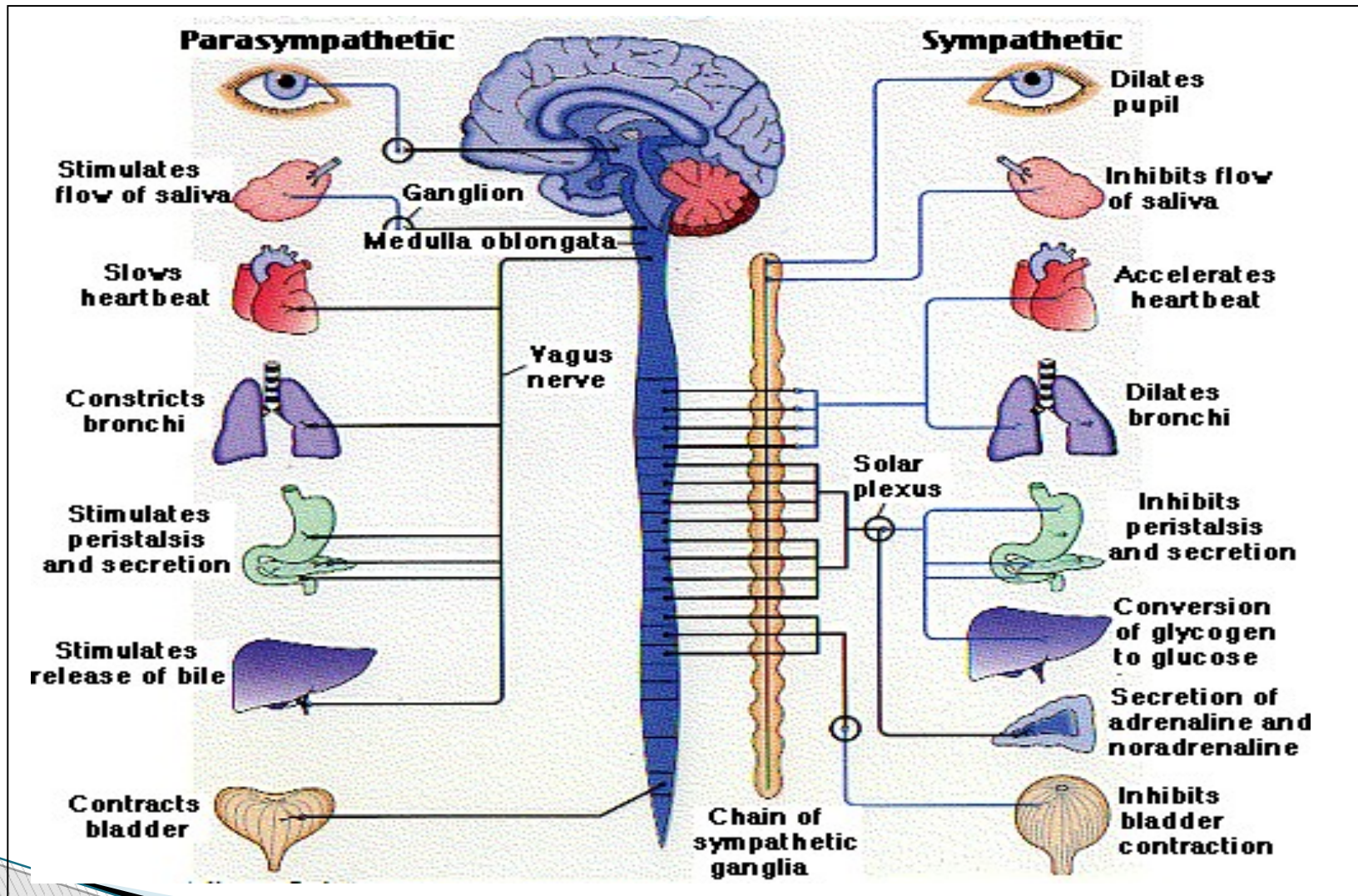
## 5.2.1 The Somatic Nervous System

- ❑ The somatic system is the part of the PNS that is responsible for carrying out sensory and motor information to and from the central nervous system.
- ❑ The somatic nervous system derives its name from the Greek word *soma*, which means "body."
- ❑ The somatic system is responsible for transmitting sensory information as well as for voluntary movement.

# **The Autonomic Nervous System**

- ❖ The autonomic system is part of your PNS that is responsible for regulating involuntary body functions, such as blood flow, heartbeat, digestion, and breathing.
- ❖ In other words, it is the autonomic system that controls aspects of the body that are usually not under voluntary control.
- ❖ This system allows these functions to take place without the need to consciously think about what is

- ❖ **Sympathetic system:** By regulating the 'flight-or-fight' response, the sympathetic system prepares the body to expend energy to respond to environmental threats.
- ❖ When action is needed, the sympathetic system triggers a response by accelerating heart rate and increasing breathing rate, boosting the blood flow to muscles, activating sweat secretion, and dilating the pupils.
- ❖ **Parasympathetic system:** This helps maintain the normal body functions and conserve physical resources. Once a threat is recognized, this system will slow the heart rate, slow breathing, reduce blood flow to muscles, and constrict the pupils.
- ❖ This allows us to return our bodies to a normal



- ❑ **Parasympathetic system:** This helps maintain the normal body functions and conserve physical resources.
- ❑ Once a threat is recognized, this system will slow the heart rate, slow breathing, reduce blood flow to muscles, and constrict the pupils.
- ❑ This allows us to return our bodies to a normal resting state. **Figure 5.7 The Autonomic Nervous System**

## 5.2.3 Neurons and their functions

- ❑ The basic **unit** of **communication** in the nervous system is the nerve cell (**neuron**). Each nerve cell consists of the **cell body**, which includes the nucleus, a **major branching fiber (axon)** and numerous **smaller branching fibers (dendrites)**.
- ❑ **Neurons** vary in size, shape, and structure depending on their role and location. However, nearly all neurons have three essential parts: a cell body, an axon, and dendrites.

# Cell body

- ❑ Also known as a soma, the cell body is the neuron's core.
- ❑ The cell body carries genetic information, maintains the neuron's structure, and provides energy to drive activities.
- ❑ Like other cell bodies, a neuron's soma contains a nucleus and specialized organelles.
- ❑ It's enclosed by a membrane which both protects and allows it to

# Axon

- ❖ An axon is a long, tail-like structure which joins the cell body at a specialized junction called the axon hillock.
- ❖ Many axons are insulated with a fatty substance called myelin. **Myelinated sheath** provides a layer of insulating material so the nerve impulse travels as fast as possible. Neurons generally have one main

- ❖ **Node of Ranvier** is periodic gap in the myelin sheath on the axon of certain neurons that serves to facilitate the rapid conduction of nerve impulses.
- ❖ These **interruptions** in the myelin covering were first discovered in 1878 by French histologist and pathologist Louis-Antoine Ranvier, who described the nodes as constrictions.

# Dendrites

- ❖ **Dendrites** are fibrous roots that branch out from the cell body. Like antennae, dendrites receive and process signals from the axons of other neurons.
- ❖ **Neurons** can have more than one set of dendrites, known as dendritic trees.
- ❖ The number of dendritic tree neurons have generally depends on their role.
- ❖ **For instance**, Purkinje cells are a special type of neuron found in the cerebellum.
- ❖ These cells have highly developed dendritic trees which allow them to receive thousands of signals.

Node of Ranvier is periodic gap in the insulating myelin sheath on the axon of certain neurons that serves to facilitate the rapid conduction of nerve impulses. These interruptions in the myelin covering were first discovered in 1878 by French histologist and pathologist Louis-Antoine Ranvier, who described the nodes as constrictions

**Dendrites:** tree-like branches from nerve cell bodies that receive signals from other nerve cells at synapses

**Axon:** long process from nerve cell that carries the nerve impulse

**Cellbody:** the neuron's core

**Myelin sheath:** fatty insulating sheath that grows around many nerves.

**Node of Ranvier:** periodic gap in the insulating sheath (myelin) on the axon of certain neurons that serves to facilitate the rapid conduction of nerve impulses

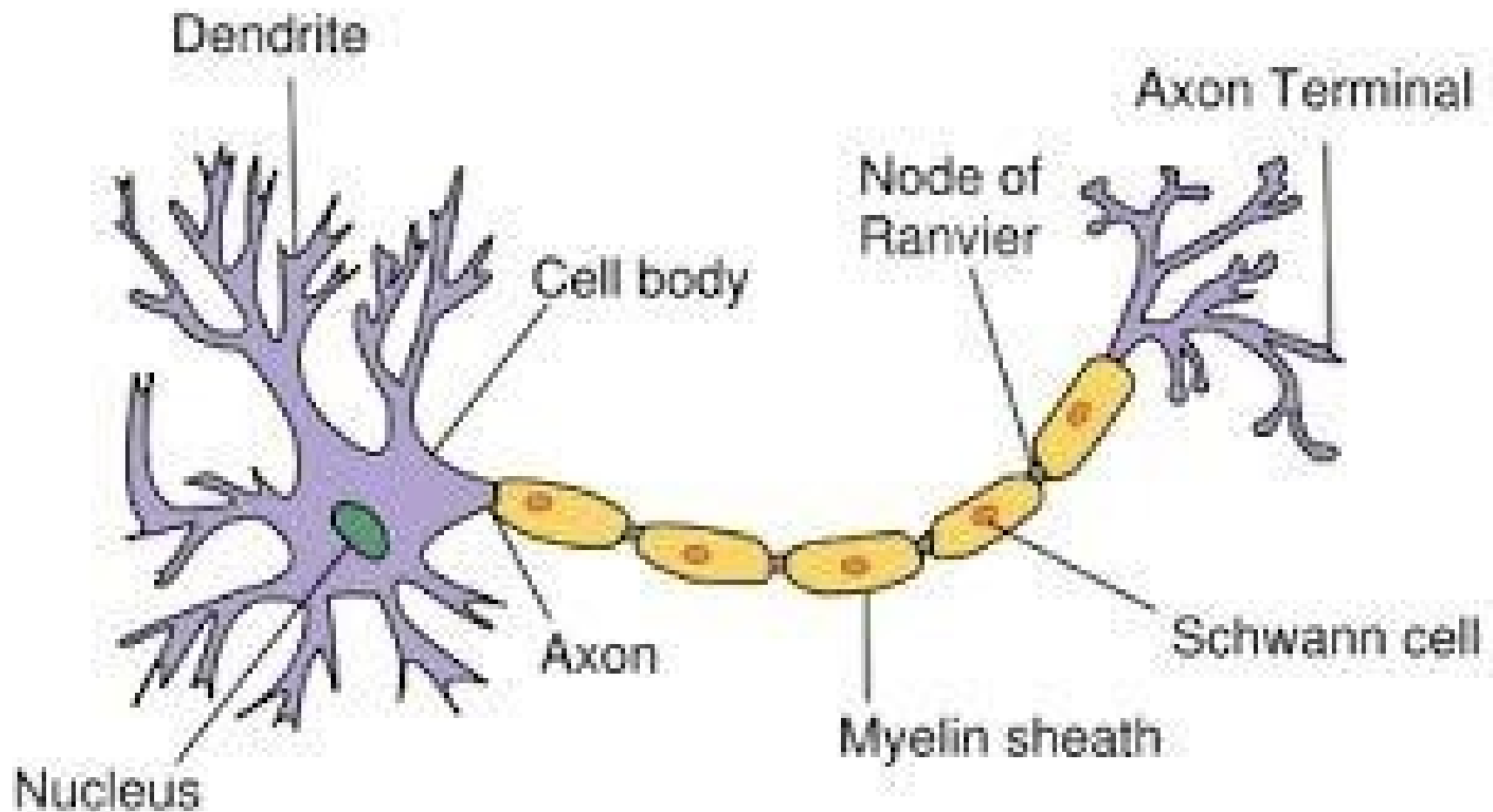


**Figure 5.8** Structure of a neuron

## 5.2.4 Types of neurons

- ❖ Neurons vary in structure, function, and genetic makeup. Given the sheer number of neurons, there are thousands of different types, which are as many as thousands of species of living organisms on earth.
- ❖ In terms of function, scientists classify neurons into three broad types: **sensory, motor, and interneurons.**

# ❖ **1. Sensory (effector) (afferent) neurons**

- ❖ Sensory neurons help you to taste, smell, hear, see, and feel things around you. Sensory neurons are triggered by the physical and chemical inputs from your environment. Sound, touch, heat, and light are physical inputs.
- ❖ **Smell** and **taste** are chemical inputs. For example, stepping on hot sand activates sensory neurons in the soles of your feet.
- ❖ Those **neurons** send a message to the brain, which makes you aware of the heat.
- ❖ **Sensory** neurons that carry messages from **sensory receptors** to the central nervous

## 2. Motor (effector) (efferent) neurons

- ❖ Motor neurons play a role in movements that include voluntary and involuntary movements.
- ❖ These neurons allow the brain and the spinal cord to communicate with muscles, organs, and glands all over the body. Motor neurons have a **long axon and short dendrites** and transmit messages from the **central**

- There are two types of motor neurons: lower and upper. Lower motor neurons carry signals from the spinal cord to the smooth muscles and the skeletal muscles.
- Upper motor neurons carry signals between the brain and the spinal cord

## **5.2.5 Interneurons**



Interneurons are neural intermediaries found in the brain and the spinal cord. They are the most common type of neuron.



They pass signals from sensory neurons and other interneurons to motor neurons and other interneurons.



Often, they form complex circuits

- ❖ The nervous system takes in information through our senses.
- ❖ Once a stimulus is picked up by a sensory receptor, the information is passed along special nerve cells, **afferent** or **afferent (sensory)** neurons, to the central nervous system (CNS). In the CNS **interneurons (associated neurons)** pass signals from sensory neurons to motor neurons and other interneurons.
- ❖ Once the information has been processed in the CNS, instructions are sent out to the body along more neurons called **efferent** or **efferent (motor)** neurons.
- ❖ These stimulate the effector organ, usually muscles or a gland (**effectors**) as follows:
- ❖ sense organ → afferent neuron → central nervous

- ❑ **Affector (afferent)** *neuron that sends impulses from organs to the spinal cord and brain* **Effector (efferent)** *neuron that sends impulses from the brain and spinal cord to organs* **Interneurons** form connections between afferent and efferent neurons

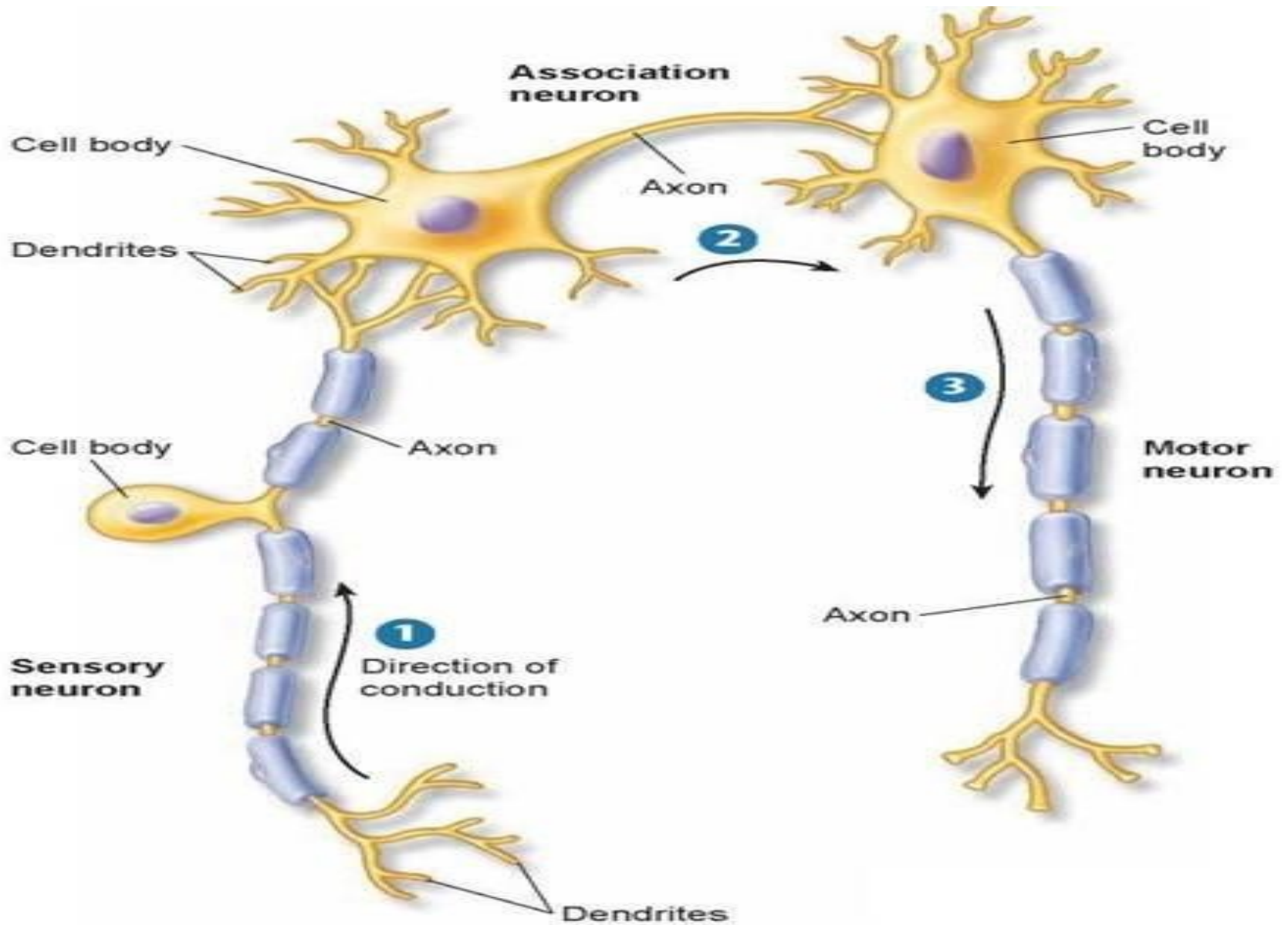


**Figure 5.9** Types of a neuron

## Nerves

- ❖ **Nerves** are bundles of neurons. Some nerves that carry only effector neurons are known as effector nerves.
- ❖ Some nerves that carry only affector neurons are known as affector nerves, whilst others that carry a mixture of effector and affector neurons and are called mixed nerves.

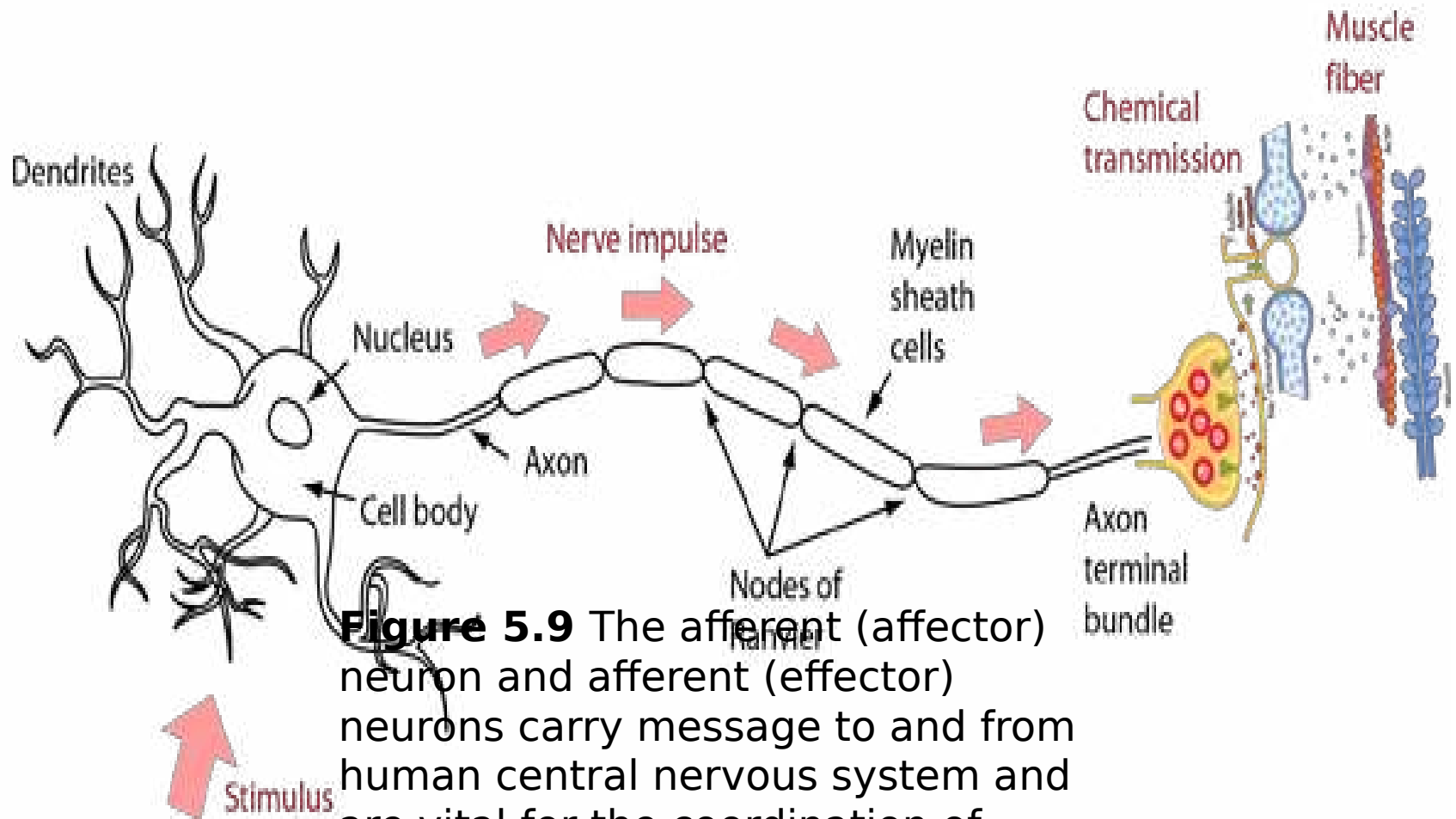
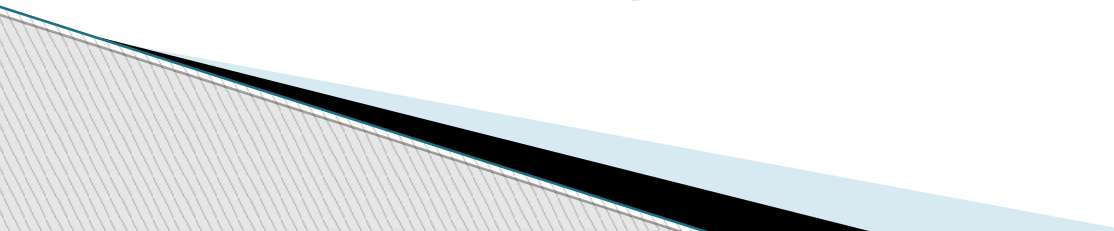


**Figure 5.9** The afferent (affector) neuron and afferent (effector) neurons carry message to and from human central nervous system and are vital for the coordination of human body

## Neural Junctions (Synapses)

❑ **Figure 5.9** The afferent (afferent) neuron and afferent (effector) neurons carry message to and from human central nervous system and are vital for the coordination of human body

❑ **Neural Junctions (Synapses)**



❖ Whenever one neuron ends and another begins there is a gap known as a **synapse**.

❖ The electrical impulses that travel along the neurons have to cross these synapses, but an

- ❖ cannot leap the gap. Therefore, when an impulse arrives at the end of a neuron, chemicals are released.
- ❖ These chemical transmitters (**neurotransmitters**) cross the synapse and are picked up by special receptor cells in the end of the next neuron.
- ❖ In turn this starts up an electrical impulse, which then travels along the next neuron.
- ❖ This is how impulses pass from one

- ❖ cannot leap the gap. Therefore, when an impulse arrives at the end of a neuron, chemicals are released.
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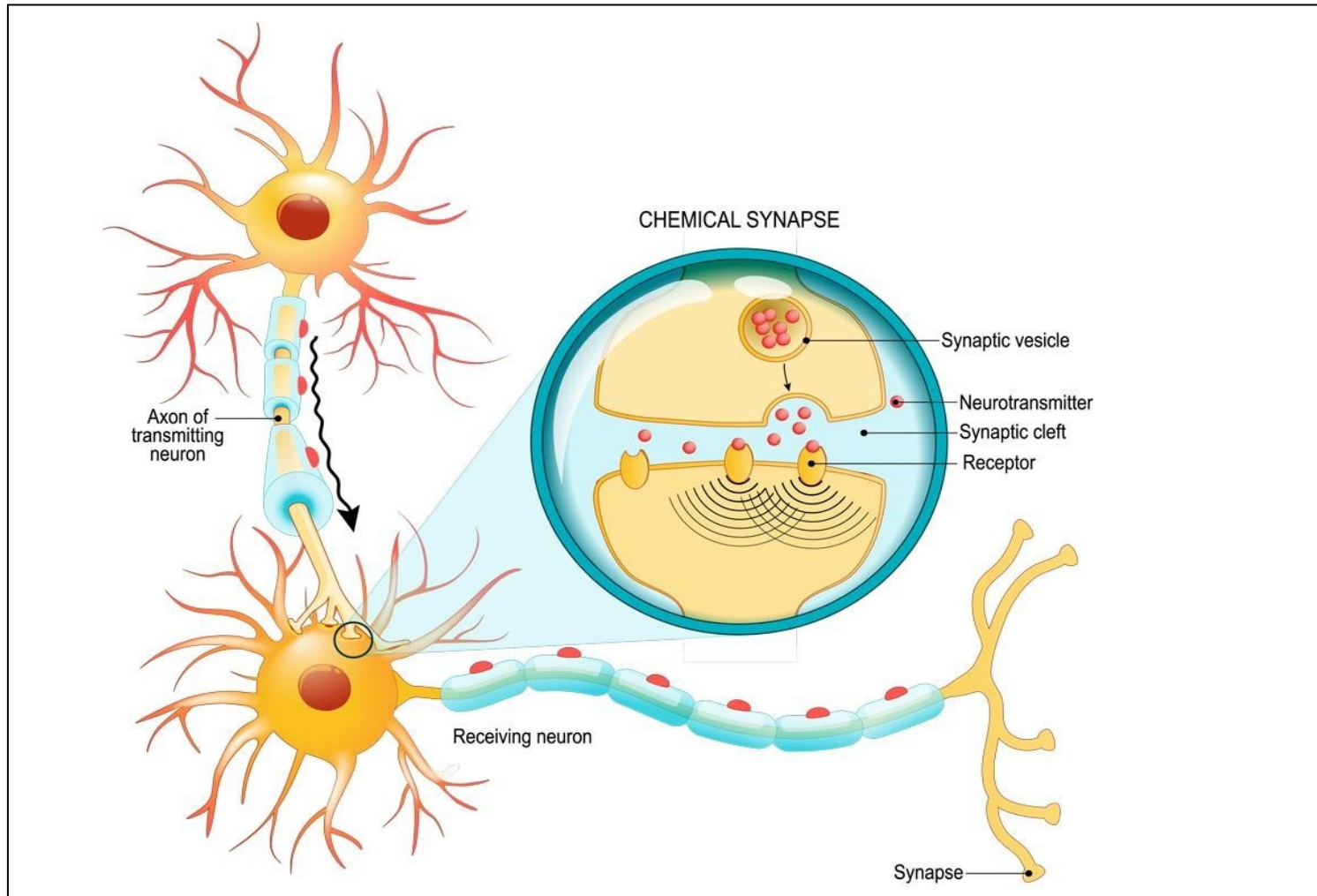


**Figure 5.10** Neurons communicate with each other by imparting neurotransmitters via contact points, the so-called neuronal synapses

## 5.2.6 Nerve impulse and transmission

- ❖ The nervous system relies on nerve impulses travelling along the neurons.
- ❖ Each nerve impulse is a minute electrical event that works as a result of charge differences across the membrane of the axon.
- ❖ The wave of positive charge inside the axon when the neuron is stimulated is known as the **action potential**.
- ❖ When a neuron is stimulated, the potential across the cell membrane changes.
- ❖ This is because when a neurotransmitter binds to its receptor, it can open channels

- ❖ When a sodium **channel** is open,  $\text{Na}^+$  ions will flow through the membrane into the cell for two reasons:
- ❖ The resting potential keeps the inside of the cell negatively charged, so positive ions are attracted in.
- ❖ There is an attracting concentration gradient for sodium, because there are many more  $\text{Na}^+$  ions outside the cell than inside it.
- ❖ The resulting influx of positive ions makes the inside of the cell less negative, reducing the resting potential. This is called **depolarizing** the cell.
- ❖ If the cell is **depolarized** from its resting potential of around minus 70 millivolts to its **threshold potential** of about minus 55 millivolts, an abrupt change occurs.
- ❖ This is called an **action potential**

- ❖ The potential across the cell membrane radically flips from the normal state, to a transient state.
- ❖ Consequently, the inside is negative relative to the outside the inside becomes positive relative to the outside.
- ❖ The normal direction of polarization is rapidly restored once the stimulation stops.
- ❖ In fact, the neuron becomes **hyperpolarized** for a few

- ❖ even more **negatively** charged than usual.
- ❖ During this time – the **refractory period** – the hyperpolarized neuron is less readily able to respond to further input.
- ❖ So a single, relatively small, stimulation pulse can produce a radical change in the neuron's electrical state.

- ❖ **Action potential** *a short- term change in the electrical potential on the surface of a cell when it is stimulated*
- ❖ **Synapse** *the junction between two neurons (axon-to-dendrite) or between a neuron and a muscle*
- ❖ **Neuromuscular junctions** *the junction between an axon terminal of a motor neuron and a muscle fibre* **cranium** *the part of the skull that encloses the brain*
- ❖ **Threshold potential** *the voltage at which depolarization of a cell leads to generation of an action potential.*
- ❖ **Hyperpolarization** *increasing neuronal membrane potential to more than its usual resting potential (making it harder to induce the cell to produce an action potential)*

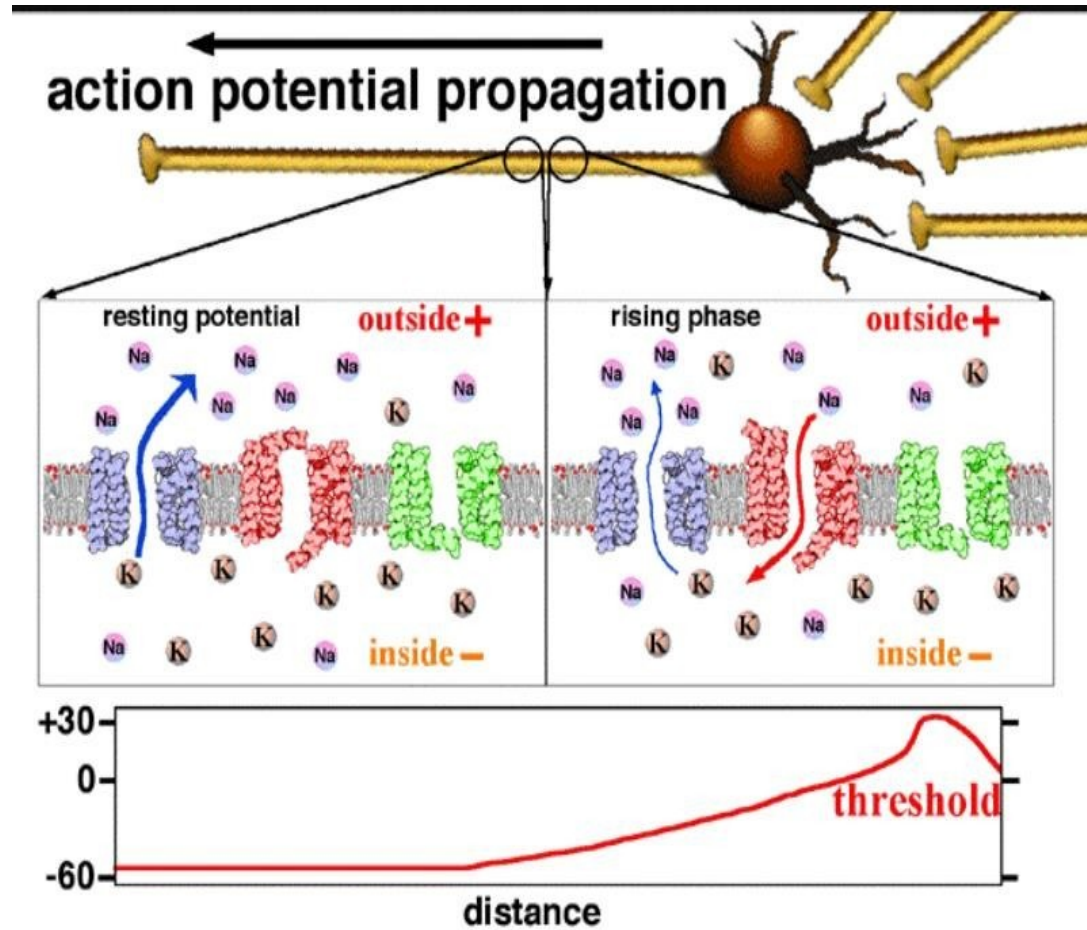


**Figure 5.11** The action potential is the basis of all the electrical signals in the nervous system of the body.

# Neurotransmitters

- ❖ Neurotransmitters are often referred to as **the body's chemical messengers**. They are the molecules used by the nervous system to transmit messages between neurons, or from neurons to muscles.
- ❖ Acetylcholine (ACh) is **an abundant neurotransmitter in the human body**. It is found in both the central nervous system

- ❑ An **excitatory transmitter** promotes the generation of an action potential in the receiving neuron, whereas an **inhibitory transmitter** prevents it.
- ❑ Whether a neurotransmitter is excitatory or inhibitory depends on the receptor it binds to. **Neuromodulators** are a bit different, as they are not restricted to the synaptic cleft between two neurons, and so can affect large numbers of neurons at once.
- ❑ **Neuromodulators** therefore regulate populations of neurons, while also operating over a slower time course than excitatory and inhibitory transmitters.

## 5.1.3 reflexes

### Reflex action

- ❖ A **reflex action** is a sudden, automatic and uncontrolled response of parts of the body or the whole body to the external stimuli.
- ❖ They are usually involved in helping us to avoid danger or damage. We also have lots of reflexes that help us take care of our basic bodily functions by leaving the brain free for thinking
- ❖ about other things. Breathing is a good example. You don't consciously
- ❖ instruct the diaphragm to flatten, and the
- ❖ intercostal muscles to contract, because breathing is a reflex action

# The pupillary light reflex

- ❑ The **pupil** of an eye dilates or constricts depending on the light levels.
- ❑ This is another example of a protective reflex action.
- ❑ It protects the **retina** from damage from too much light, and enables a person to see in low light conditions.
- ❑ You blink the eyes if something comes towards your face to protect the eyes from physical damage

The key point about a reflex action is that the messages do not reach a conscious area of your brain before instructions are sent out to take action. Many reflexes involve the spinal cord, whereas others involve the brain. They involve three types of neuron: afferent neurons, relay



neurons and effector neurons.  
Relay neurons (interneurons with short axons) connect the affector and effector neurons directly in the CNS, without input from other areas. The receptors, neurons and effectors involved are referred to as a **reflex arc**. The brain and spinal cord act together as coordinators that process the information coming from sensory receptors and neurons and instruct effector neurons and effectors to react.

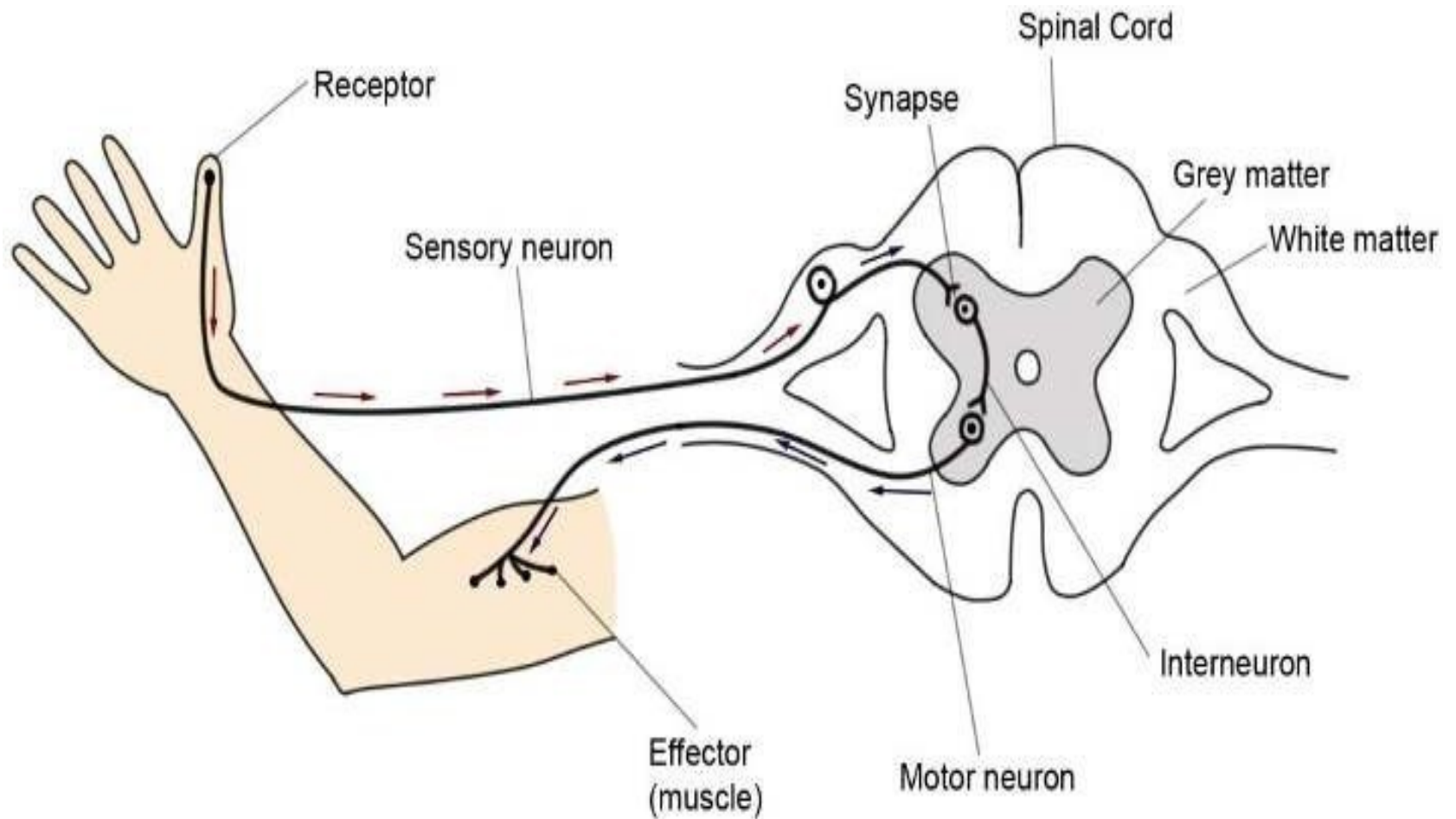


**Figure 5.13** The reflex action

- ❑ As shown in the Figure 5.13:
- ❑ Impulses from a sensory receptor in the skin pass along an **afferent** neuron to the central nervous system – the spinal cord.
- ❑ The neuron enters the spinal cord through the **dorsal root**.
- ❑ When an impulse from the **afferent** neuron arrives in the synapse with a short relay neuron a transmitter is released, which causes an impulse to be sent along the relay neuron.
- ❑ When the impulse reaches the synapse between the relay neuron and an effector neuron returning to the arm again another **transmitter chemical** is released.

- ❖ This starts impulses travelling along the effector neuron to the organ (effector), which brings about change. The effector
- ❖ neuron leaves the spinal cord by the **ventral root**.
- ❖ In this example the impulses arrive in the muscles of the upper arm, causing them to contract and move your hand

# 5.4Drug abuse

- ❑ At the end of this section, the learner will be able to:
- ❑ Illustrate the effects of drug abuse on nervous systems with local and international examples.
- ❑ Drugs are substances that change a person's mental or physical state.
- ❑ They can affect the way the brain works, how you feel and behave, your understanding and your senses.
- ❑ This makes people, especially young

- ❑ In every society there are certain drugs which are used for medicine and there are others which are used for pleasure.
- ❑ Usually some of these substances are socially acceptable and others are illegal. In Ethiopia caffeine, nicotine, **khat** and alcohol are not prohibited legally.
- ❑ The status of a drug may be related to its effect on people, or it may be simply down to the history of its use.
- ❑ Most of the drugs being used for medicine affect our bodies. The drugs people use for pleasure tend to have a distinct effect on their minds.
- ❑ Drug (or substance) use is when some one is used to the extent that affects the brain

- ❖ Legal drugs are used for the mild pleasure they bring, to be sociable and as a habit. **Drug (or substance) abuse** is when a person uses a substance to the point of excess and/or dependence.
- ❖ When drugs are taken in excess they cause a serious health risk and even death. Drug dependence is when a person use a drug again and again and become **addicted**.
- ❖ Addiction is marked by a change in behavior caused by the biochemical changes in the brain after continued substance abuse.

- ❖ **Substance use disorder (SUD)** or drug addiction is a disease that negatively affects a person's brain and behavior.
- ❖ A person can become obsessed with any legal or illegal drugs. Some people can get addicted to certain medications.
- ❖ This addiction gradually starts developing when the individual continues to consume the drug despite the impairment it causes. Nicotine, marijuana and alcohol are commonly misused drugs in today's

- ❖ Drug abuse, of both legal and illegal substances, is becoming more of a public health problem in Ethiopia. School surveys have shown that alcohol, khat, tobacco, cannabis (marijuana) and solvents are the substances most widely used in Ethiopia.
- ❖ Alcohol, khat and tobacco are legal drugs in Ethiopia but cannabis is illegal.
- ❖ Solvents like gasoline are legal but are not meant for humans to inhale.
- ❖ Drugs such as lysergic acid

- ❑ **heroin** are illegal but rarely used in Ethiopia.
- ❑ **Khat**, alcohol and tobacco are linked to a wide range of health problems.
- ❑ The **health** issues linked to these **legal** drugs are mainly the result of their effect on the systems of the body.

### 5.4.1 Common substances (drugs) used in Ethiopia

- ❖ In Ethiopia, **alcohol and khat** are the most common substances of abuse, followed by cannabis and solvents.
- ❖ Hard drugs such as heroin and cocaine are rarely used

## 5.4.2 Smoking

- ❖ **Smoking** is not as common in Ethiopia as it is in many parts of the world.
- ❖ However, the documented evidence suggests that more and more young people are smoking across the world.
- ❖ The addictive drug in cigarette smoke is **nicotine**, which affects the brain and produces a sensation of calm, well-being and being able to cope with.
- ❖ However, it is very physically addictive. Unfortunately cigarette smoke also contains many very harmful chemicals, and these are linked to a number of very serious health problems.



**Figure 5.14 Cigarette is an  
addictive drug**

## 5.4.3 Alcohol

- ❖ Alcohol is one of the drugs most commonly used by people of all ages in Ethiopia.
- ❖ Interestingly, however, we still drink far less than many other countries.
- ❖ For many people alcohol is part of their social life. They like to share a drink with friends and don't think of themselves as drug users.
- ❖ In small amounts, alcohol makes people feel relaxed and cheerful. It makes users less inhibited.

- ❑ **Shy** people may feel more confident when they've had an alcoholic drink, alcohol has a powerful effect on human body.
- ❑ It is very **addictive** and it is also very poisonous.
- ❑ Although some **religions** ban the use of alcohol many people all over the world drink in defiance of the ban.
- ❑ Perhaps this is because



**Figure 5-15** Alcohol is addictive and poisonous

## 5.4.4 Khat

- ❑ ***Catha edulis*** (Khat) is a plant grown commonly in the horn of Africa.
- ❑ The leaves of khat are are chewed by people for it is stimulant. Its young buds and tender leaves are chewed to attain a state of euphoria and stimulation. Khat
- ❑ contains a drug that affects

- ❖ It can also be made into a tea. It is a mild stimulant that makes people feel happy and reduces their appetite.
- ❖ It is often used in social situations.
- ❖ In Ethiopia, **khat** use is growing fast among young people.
- ❖ It is not yet prohibited legally in the country. **Khat** contains a

- ❖ The drug **cathinone** from the khat leaves is absorbed into the bloodstream
- ❖ through the membranes lining of the mouth and the stomach. It acts quickly, within **30 minutes** of time, before it is broken down and removed by the liver.
- ❖ When **addicted** people cannot get the drug, feel depressed,



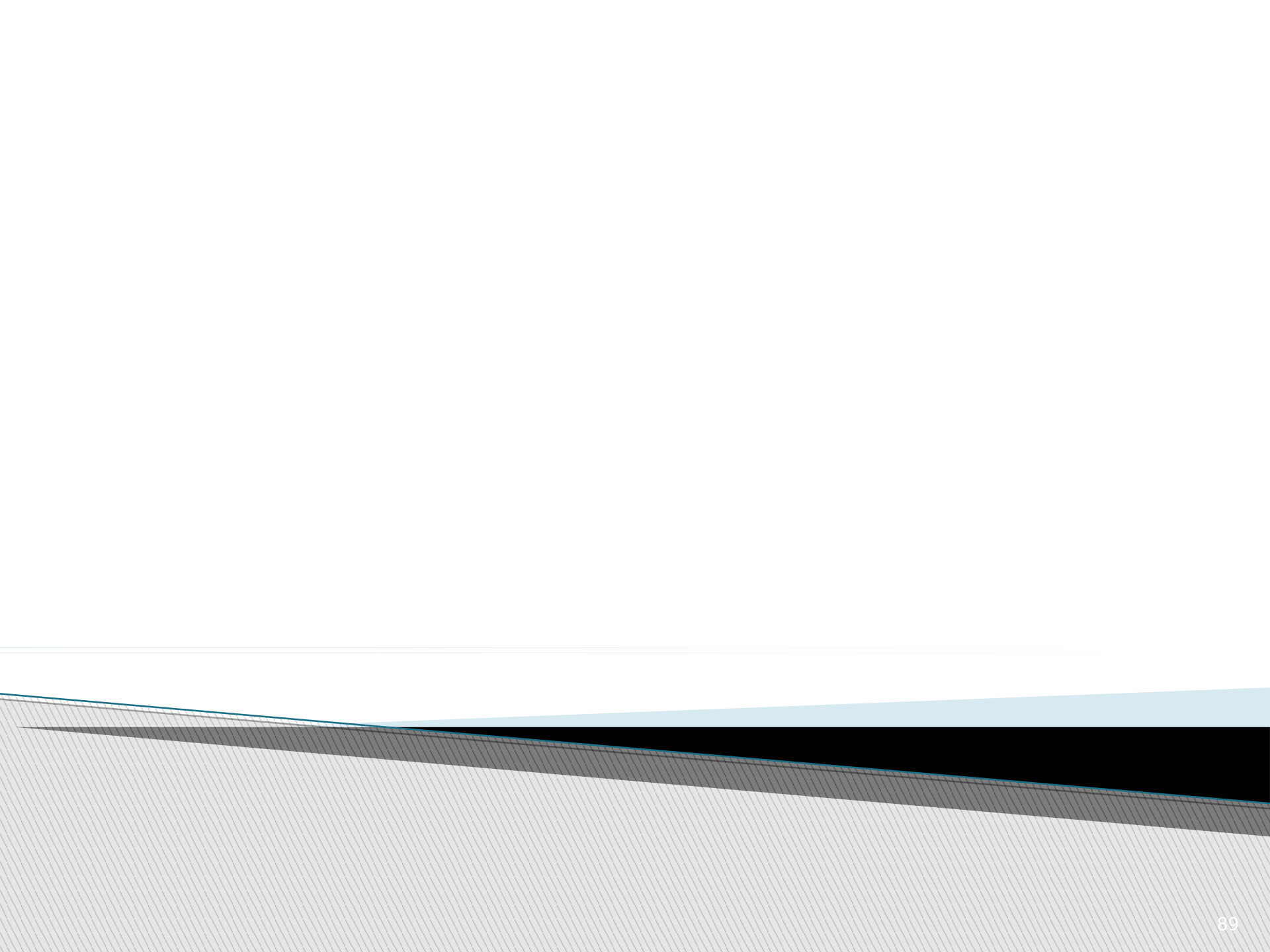
**Figure 5.16** A monoculture of Khat in Ethiopia

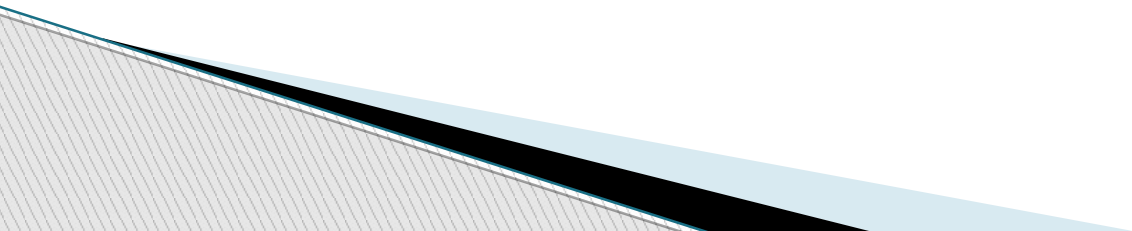
## Cannabis (marijuana)

- ❖ **Cannabis** is a plant that contains 400 known chemicals, 60 of which are the cannabinoids, unique to the plant.
- ❖ The most potent is delta-9-tetrahydrocannabinoid (**THC**). **THC** is known to affect the brain cells that are responsible for memory, emotion and motivation. Cannabis is usually smoked but it can also be eaten, when it has a much stronger effect because your liver converts it into a much more powerful drug.
- ❖ It can make you feel a great sense of **wellbeing** and **relaxation**, happy and euphoric and this is why people use it.

- ✓ It is a mild hallucinogenic drug. **Hallucinogens** are drugs that produce vivid waking dreams, where the user sees or hears things that are not really there, or has a distorted view of the world.
- ✓ However, many people find the effect of the drug a very unpleasant and disturbing experience. The effect of cannabis is very variable.
- ✓ It affects different people in different ways, and even the same person can react very differently depending on how it is used.

- ❖ **Cannabis** is illegal in Ethiopia.
- ❖ In spite of this, there is a long tradition of using it.
- ❖ It is currently used in a number of **social** contexts. There are many other **illegal** drugs, but they are not widely used in Ethiopia where in some places.
- ❖ they are becoming more common





# 5.5 Sense organs

**Objectives.** Discuss the structure and function of skin

- ☐ Draw taste sites on the tongue
- ☐ Indicate the different taste sites on a diagram of tongue correctly.
- ☐ Explain the structure and functions of nose
- ☐ Draw the structure of the human eye
- ☐ Label the structure of the human eye on a diagram correctly
- ☐ Explain the functions of the human eye
- ☐ Explain the way the eye sees things
- ☐ Identify common eye defects and their causes in humans
- ☐ Draw the structures of the human ear
- ☐ Indicate parts of human ear on a diagram
- ☐ Label the structures of the human ear
- ☐ Describe the functions of the human ear

# 5.5.1 Skin

- ❖ The skin is one of the largest organs in the human body in surface area and weight.
- ❖ It is a remarkably complex organ which carries out a number of important functions in human body.
- ❖ It gives you

# The skin:

- Contains a huge variety of sense organs (touch, temperature, pressure, pain).
- Forms a waterproof layer around the body tissues, which protects against the loss of water by evaporation and prevents
- gaining water by osmosis while swimming in the river or wash.
- It protects the body from the entry of bacteria and other pathogens.
- It protects the body from damage by UV light.
- It is an excretory organ (nitrogenous wastes are lost with the sweat).
- It is vital in controlling the body temperature.

# Basic components of the human skin

- ❑ The human **skin** is the largest organ of the body, with a total area of about 20 square feet.
- ❑ The **skin** protects us from microbes and elements, helps regulate body temperature, and permits the sensations of touch, heat, and cold.
- ❑ **Skin** has three main layers.
- ❑ These are **epidermis, dermis** and **hypodermis**.

- The **epidermis**, the outermost layer of skin, provides a waterproof barrier and creates our skin tone.
  - The **dermis**, beneath the epidermis, contains tough connective tissue, hair follicles, and sweat glands.
  - The deeper subcutaneous tissue (**hypodermis**) is made of fat and connective tissue.
- 

- The lower layer, the **hypodermis**, contains fatty tissue which is both an energy store that acts as an insulation layer, protecting against heat loss.
- The middle layer or **dermis** contains the blood vessels, the sweat glands, the sensory receptors and the hair follicles.
- This layer is closely involved in temperature control in homeostasis and in your sense of touch.
- The upper layer or **epidermis** is made up of dead cells

- **Keratinocytes**, **melanocytes** and **langerhans cells** are some of the important cells found in the epidermis.
- Keratinocytes- produce the protein known as **keratin**, the main component of the epidermis. Keratin makes up hair, nails, and the surface layer of the skin.
- **Keratin** is what forms the rigidity of your skin and helps with the barrier protection that your skin offers.
- **Melanocytes** produce skin pigment, which is known as **melanin**.
- **Langerhans cells**, which prevent things from getting into your skin.

- ❖ Epidermal layer of the skin stop water loss and also protect against the entry of pathogens.
- ❖ The **dermis** is a complex combination of blood vessels, hair follicles, and sebaceous (oil) glands.
- ❖ In the dermis, there are collagen and elastin proteins necessary for skin health because they offer support and elasticity (the skin's ability to go back to its original state after being stretched)

❖ **Collagen** is the most plentiful protein in the skin, making up 75-80% of the skin.

❖ Collagen and elastin are responsible for warding off wrinkles and fine lines.

❖ Over time, the environment and aging

- ❖ It is the dermis which is particularly involved in the homeostatic mechanisms of the skin.
- ❖ The thickness of the epidermis and dermis may vary.
- ❖ Due to variation in the thickness the skin can be categorized as **thick** and **thin**.

- ❖ thinness, with the thinnest skin covering the eyelids.
- ❖ Thick skin is present on the soles of the feet and palms of the hands.
- ❖ In addition to differing thicknesses, the skin also differs in what is available in the layers.
- ❖ For example, thick skin has no

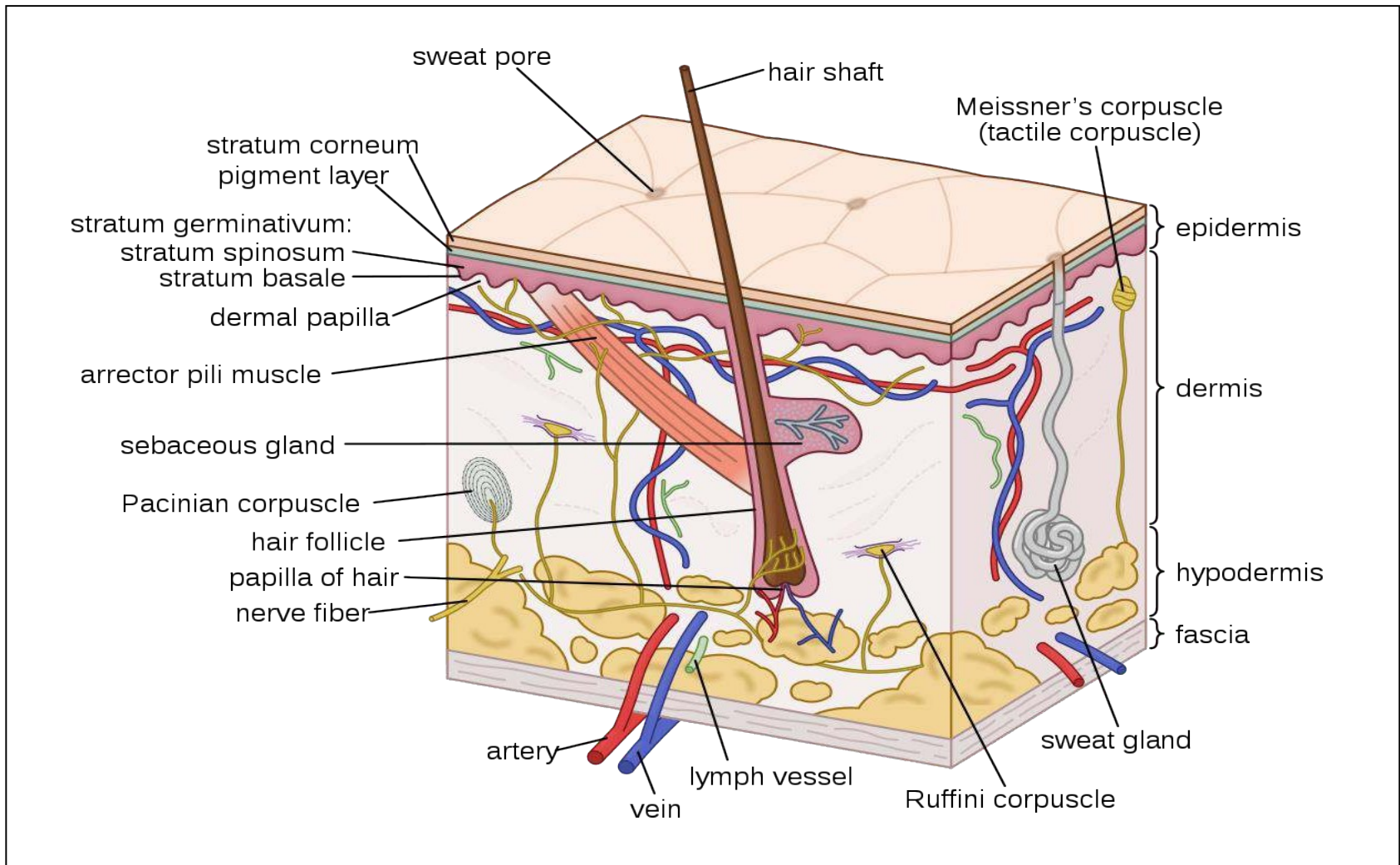


**Figure 5.17** Part of the human skin

## 5.5.2 The Tongue

- ❖ The tongue is a muscular organ in the mouth.
- ❖ The tongue is covered with moist, pink tissue called mucosa. Tiny bumps called **papillae** give the tongue its rough texture.
- ❖ Thousands of taste buds cover the surfaces of the papillae.
- ❖ Taste buds are collections of nerve-like cells that connect to nerves running into the brain

- ❖ The **tongue** is anchored to the mouth by webs of tough tissue and mucosa.
- ❖ The tether holding down the front of the tongue is called the **frenum**. In the back of the mouth, the tongue is anchored into the hyoid bone.
- ❖ The tongue is vital for chewing and swallowing food, as well as for speech.

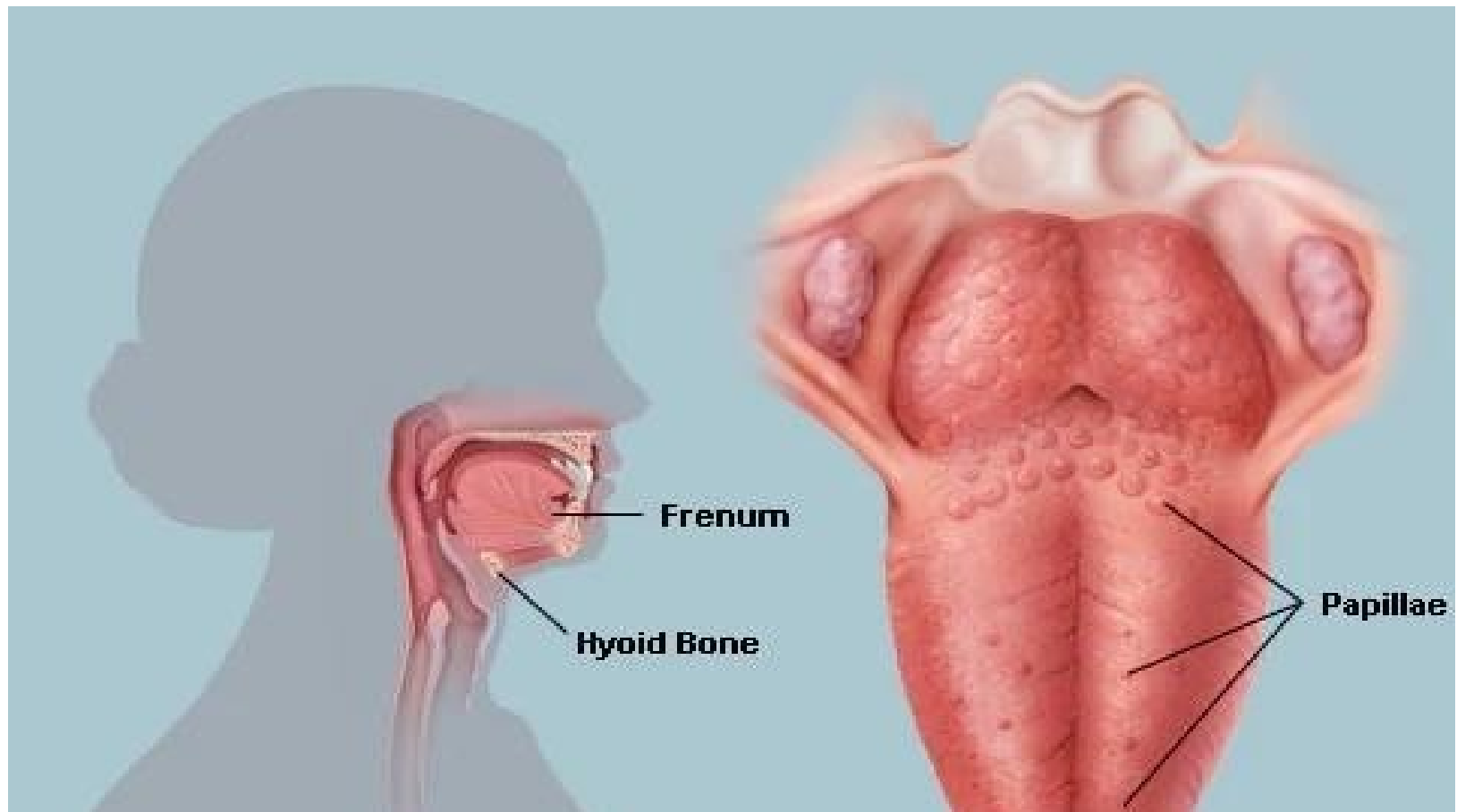


**Figure 5.18** The human tongue

- The **sensory receptors** of the tongue and those found in the nostrils are sensitive to solutions of certain chemical substances.
- The **sensory receptors** of taste are located on the upper surface of the tongue, and to a lesser extent on the surface of the throat.
- The **receptors** for smell are located in the **upper** parts of the **nasal passages**

- There are **five** basic taste sensations. The first four are sweet, sour, bitter and salt.
- We have known too much about these for many years. Scientists have also discovered a fifth taste called **umami** (a very **savoury flavour** found in foods such as meat, cheese, broth and mushroom)

- For many years it was thought that the receptors for the four known senses had their areas of greatest concentration on different parts of the tongue.
- It has now been clearly shown that in fact all of the five different taste organs are spread out all over the tongue, although some of them may seem to be in a greater

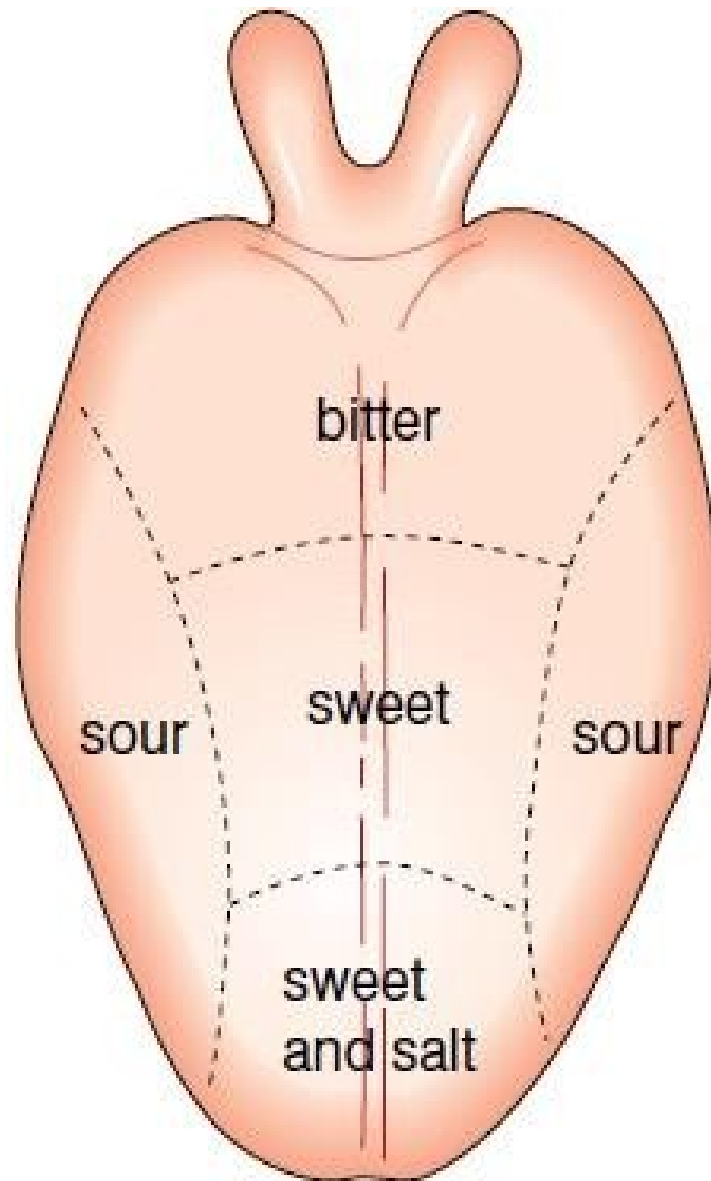


**Figure 5.19** The main taste areas of the tongue that has been taught for many years

## 5.5.3 The Nose

- ❖ The human nose is a sense organ of smell. Another word for smell is **olfaction**.
- ❖ The olfactory receptors in the nose help to identify food, mates, predators, and provides both sensual pleasure in the odor of flowers and perfume, as well as warnings of danger.
- ❖ For example, spoiled food, fire or chemical dangers. For both humans and animals, it is one of the important means by which the environment communicates with us.
- ❖ Another function of the nose is the
- ❖ conditioning of inhaled air, which the nose makes it more humid and warmer. Hairs inside the nose

# Anatomy and Physiology

- ❖ The **nasal** passages not only allow the passage of air for respiration through the nose but also warm and filter the air.
- ❖ The **nasal** concha or turbinate bone is a long, narrow and curled bone shelf that protrudes into the breathing passage of the nose.
- ❖ In humans, the **turbينات** divide the nasal airway into four groove like air passages, and are responsible for forcing inhaled air to flow in a steady regular pattern around the largest possible surface of cilia and climate controlling

# How do you smell?

- ❖ Specialized receptor cells of the olfactory epithelium detect and recognize smells.
- ❖ The air passes through the nasal cavity and through a thick layer of mucus to the olfactory bulb.
- ❖ The olfactory bulb is situated in the forebrain. The smells are recognized here because each smell molecule fits into a nerve cell like a puzzle piece.
- ❖ The cells then send signals to the brain via the olfactory nerve. The brain then interprets those molecules as the sweet

- ❖ For human being to be able to taste and smell, chemicals must go into solution in the form of liquid coating the membranes of receptor cells before they can be detected.
- ❖ The major functional difference between the two kinds of receptors is that smell receptors are more specialized for detecting vapors coming to the organism from distant sources.
- ❖ Taste receptors are specialized for

## 5.5/4 The eye structure, function, and defects

- ❖ The eye transmits visual stimuli to the brain for interpretation and thereby functions as **sensory organ** of vision.
- ❖ The eyeball is located in the eye orbit, a round, bony hollow formed by several different bones of the skull. In the orbit,
- ❖ the eye is surrounded by a cushion of fat.
- ❖ The bony orbit and fat cushion protect the eyeball.
- ❖ To perform a thorough assessment of the eye, it is crucial to understand the external structures of the eye, the internal structures of the eye, the visual fields and pathways, and

# External structures of the eye

- ❖ The parts of the eye that include the following are visible externally.
- ❖ The **eyebrows** protect the eyes by preventing perspiration from running down the forehead and into the eyes, causing irritation. They also help shade the eyes from direct sunlight.
- ❖ The **eyelids (upper and lower)** with their associated lashes are two movable structures composed of skin and two types of muscle: striated and smooth.
- ❖ Their purpose is to protect the eye from foreign bodies and limit the amount of light entering the eye. In addition, they serve to distribute tears that lubricate the surface of the eye (see Figure 5.21).
- ❖ The eyelids join at two points: the lateral (outer) canthus and medial (inner) canthus.
- ❖ The medial canthus contains the puncta, two small

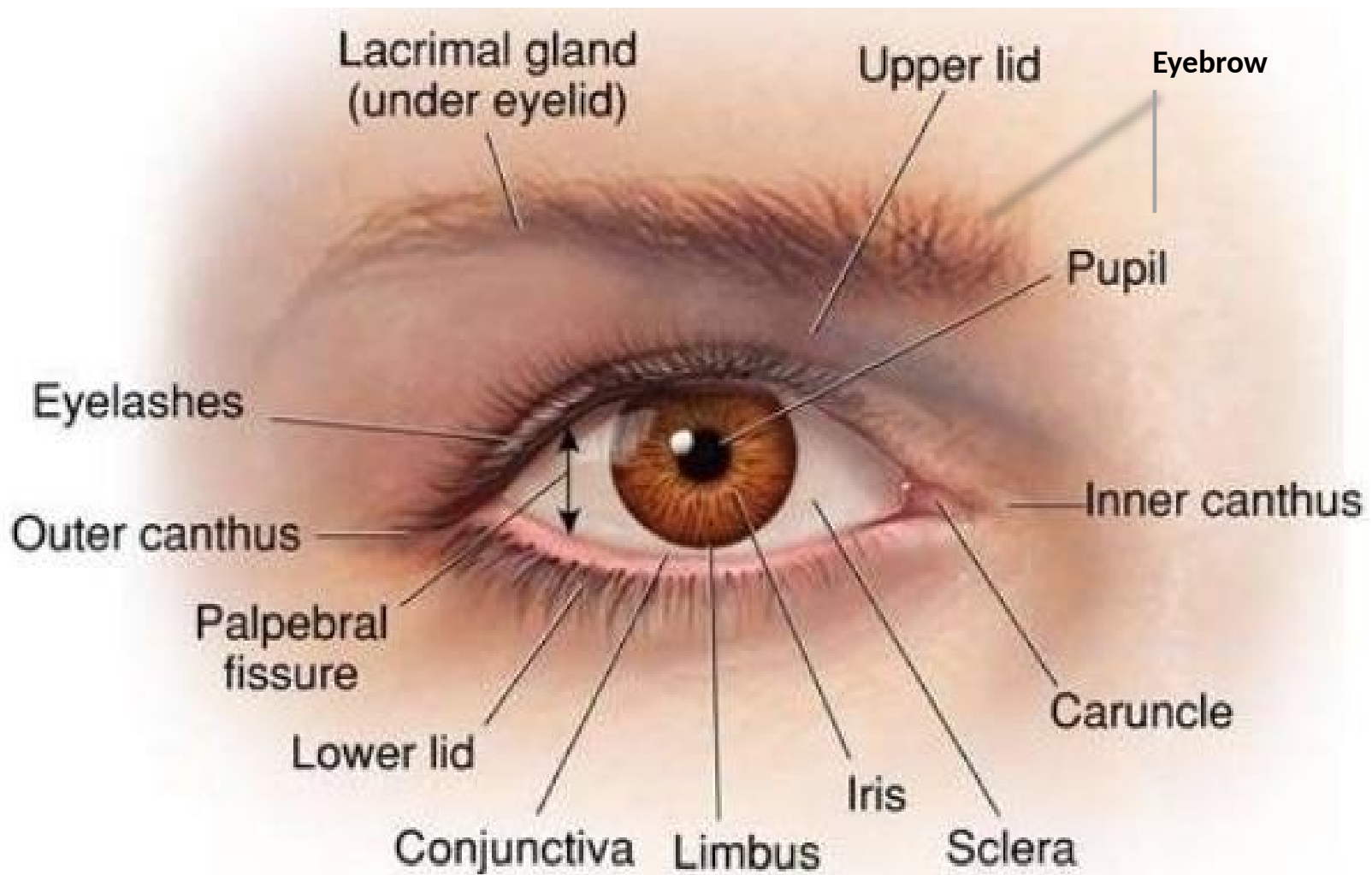
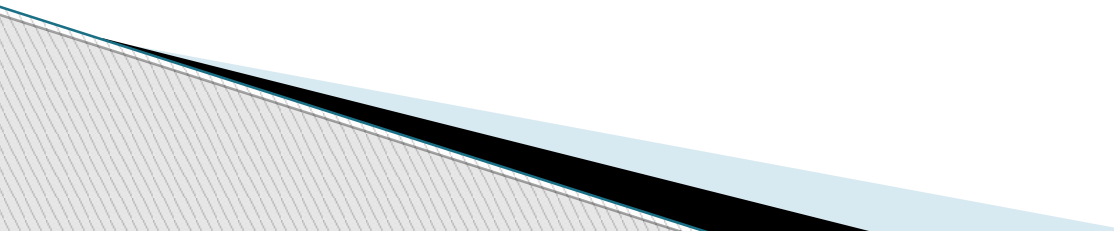


**Figure 5.21** External structures of the eye

- ❖ The white space between open eyelids is called the palpebral fissure. When closed, the eyelids should touch.
  - ❖ When open, the upper lid position should be between the upper margin of the iris and the upper margin of the pupil.
  - ❖ **Eyelashes** are projections of stiff hair curving outward along the margins of the eyelids that filter dust and dirt from air entering the eye
- 

- ❖ The **conjunctiva** is a thin, transparent, continuous membrane that is divided into two portions: a palpebral and a bulbar portion.
- ❖ The **palpebral conjunctiva** lines the inside of the eyelids, and the bulbar conjunctiva covers most of the anterior eye, merging with the cornea at the **limbus**.
- ❖ This transparent membrane allows for inspection of underlying tissue and serves to protect the eye from foreign

- ❖ The **lacrimal apparatus** consists of glands and ducts that serve to lubricate the eye (Figure 5.22).
- ❖ The **lacrimal gland**, that is located in the upper outer corner of the orbital cavity just above the eye, produces tears.
- ❖ The **extraocular muscles** are the six muscles attached to the outer surface of each eyeball (Figure 15.23).

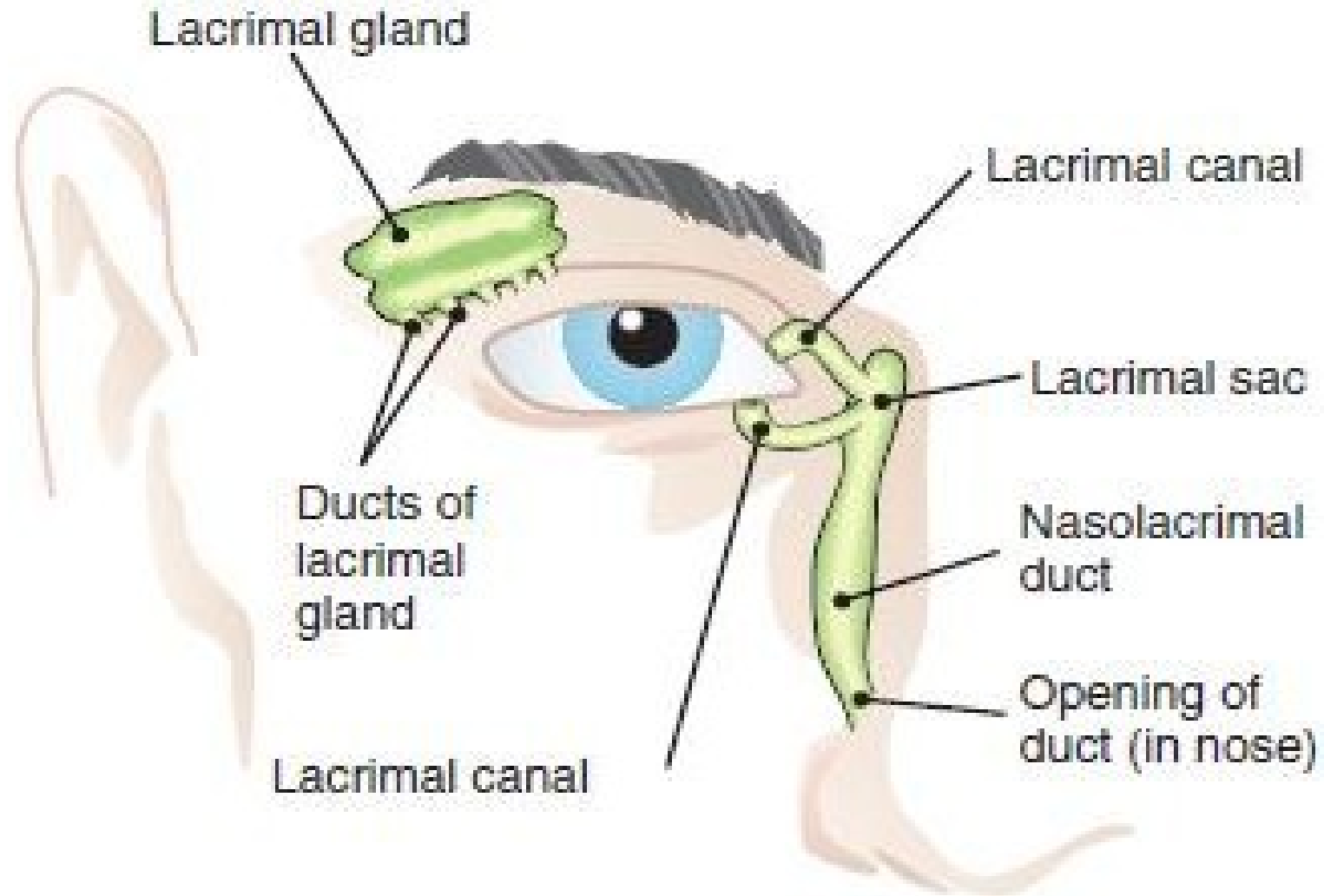


**Figure 5.22** Lacrimal apparatus in the human eye

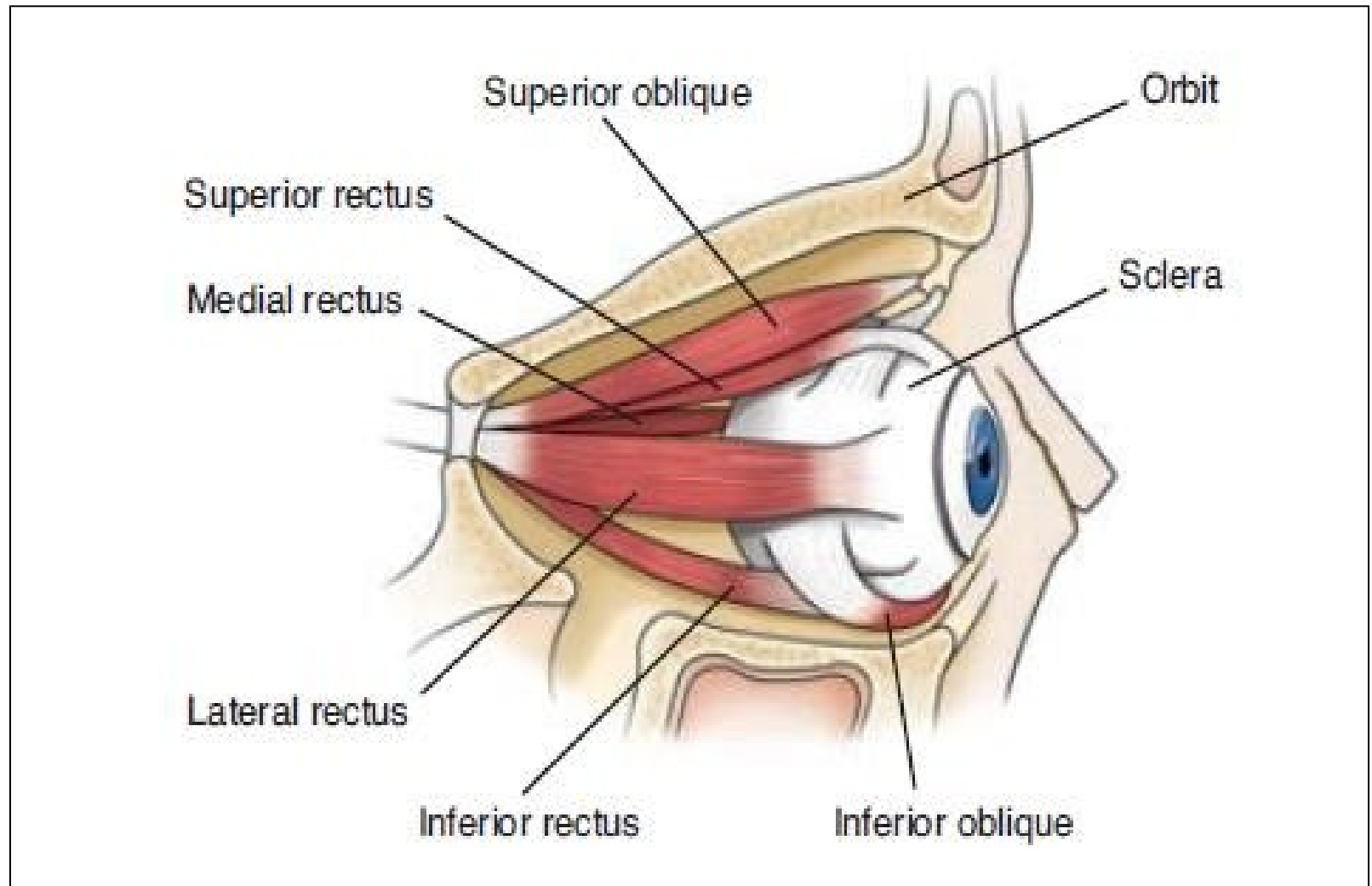


**Figure 5.23** Extraocular muscles of the human eye.

# Internal structure of the eye

## Internal structure of the eye

The eyeball is composed of three separate coats or layers (Figure 5.24). The external layer consists of the sclera and cornea.

- The sclera is a white visible portion. It is a dense, protective, white covering that physically supports the internal structures of the eye. It is continuous inferiorly with the transparent cornea (the “window of the eye”).

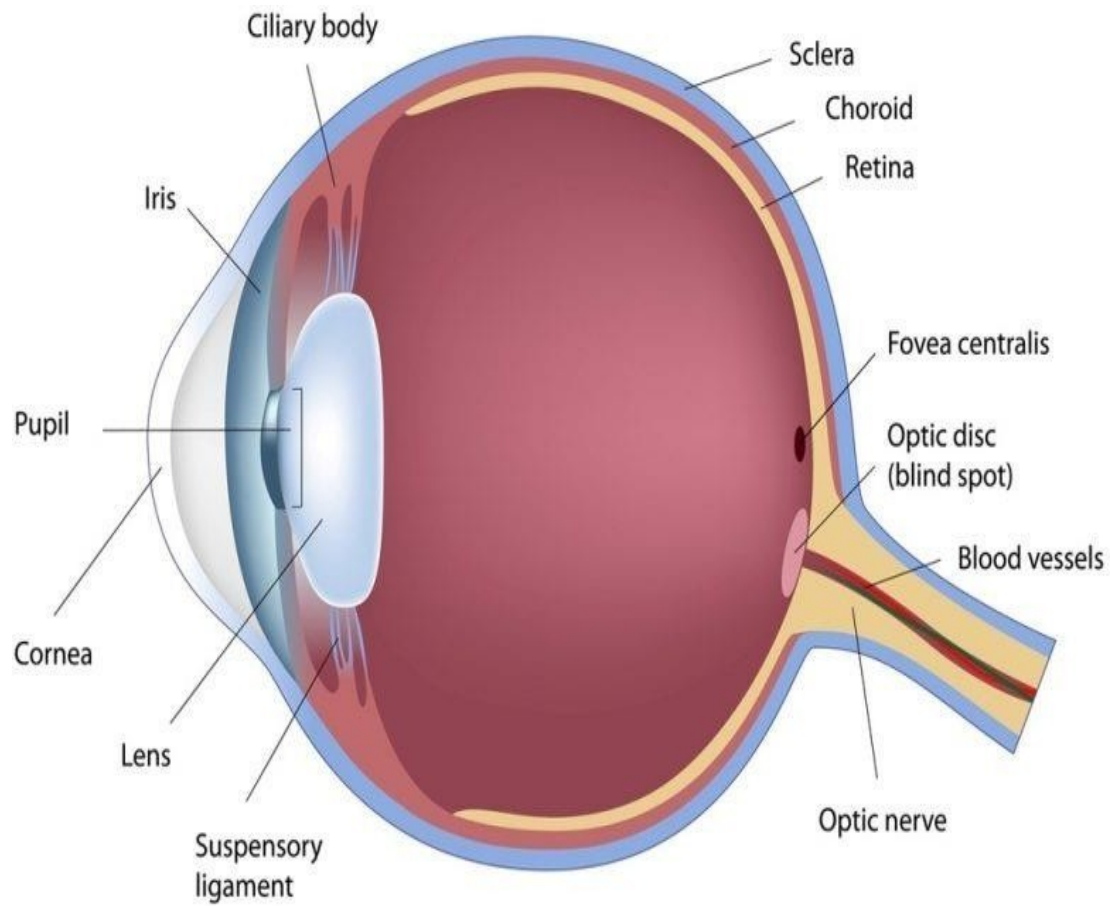


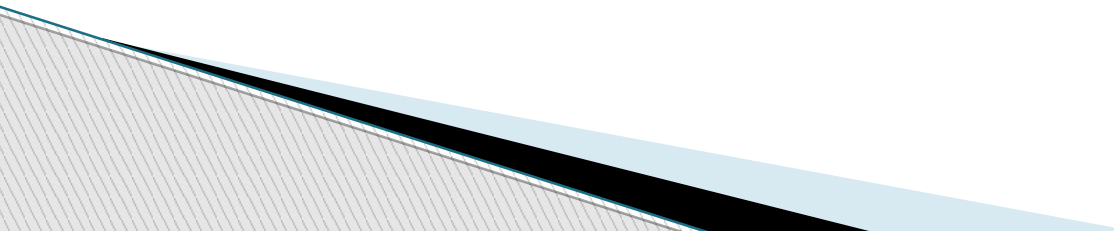
**Figure 5.24** Anatomy of the human eye

- ❖ The **cornea** is the transparent, anterior or front part of our eye, which covers the pupil and the iris.
- ❖ The main function is to refract the light along with the lens. The cornea permits the entrance of light, which passes through the lens to the retina.
- ❖ It is well supplied with nerve endings, making it responsive to pain and touch.
- ❖ **Iris:** It is the pigmented, colored portion of the eye, visible externally. The main

- ❖ function of the iris is to control the diameter of the pupil according to the light source.
- ❖ **Pupil:** It is the small aperture located in the centre of the Iris.
- ❖ It allows light to enter and focus on the retina.

- ❖ The **lens** is a biconvex, transparent, avascular, encapsulated structure located immediately posterior to the iris.
- ❖ **Suspensory ligaments** attached to the **ciliary muscles** support the position of the lens.
- ❖ The lens functions to refract (bend) light rays onto the retina.
- ❖ Adjustments must be made in refraction depending on the distance of the object being viewed

- ❖ The refractive ability of the lens can be changed by a change in the shape of the lens (which is controlled by the ciliary body).
  - ❖ The lens bulges to focus on close objects and flattens to focus on far objects.
  - ❖ The **choroid layer** contains the vascularity necessary to provide nourishment to the inner part of the eye and prevents light from reflecting internally.
  - ❖ Anteriorly, it is
- 

- ❖ continuous with the ciliary body and the iris.
  - ❖ Once the light has travelled through the cornea it has to pass through the **pupil** in the center of the **iris**.
  - ❖ The iris is the colored part of the eye .
  - ❖ The **iris** is made up of muscles that contract or relax to control the size of the pupil and to control the amount of light reaching the **retina**
- 

- ❑ The **circular** muscles run around the iris, whereas the radial muscles run across it like the spokes of a bicycle wheel.
- ❑ When the light is relatively dim, the radial muscles contract and the circular muscles relax and the pupil is pulled open wide (it **dilates**). When the pupil is dilated, lots of light can get into the eye that enable us to see even in relatively low light conditions.
- ❑ In **bright light**, however, the circular muscles of the iris contract and the radial muscles relax, which makes the pupil very small (it **constricts**).
- ❑ This reduces the amount of light that goes

- ❖ into the eye so that the delicate light-sensitive cells are not damaged by too much bright light (see Figure 5.25).
- ❖ The innermost layer, the **retina**, extends only to the ciliary body anteriorly.
- ❖ It receives visual stimuli and sends it to the brain.
- ❖ The retina consists of numerous

- ❖ including the cells commonly called **rods** and **cones**. These specialized nerve cells are often referred to as “**photoreceptors**” because they are
- ❖ responsive to light.
- ❖ The rods are highly sensitive to light, regulate black and white vision, and function in dim light.
- ❖ The cones function in bright light and
- ❖ are sensitive to color.
- ❖ The **optic disc** is a cream-colored, circular area located on the retina toward the medial or nasal side of the eye.
- ❖ It is where the optic nerve enters the

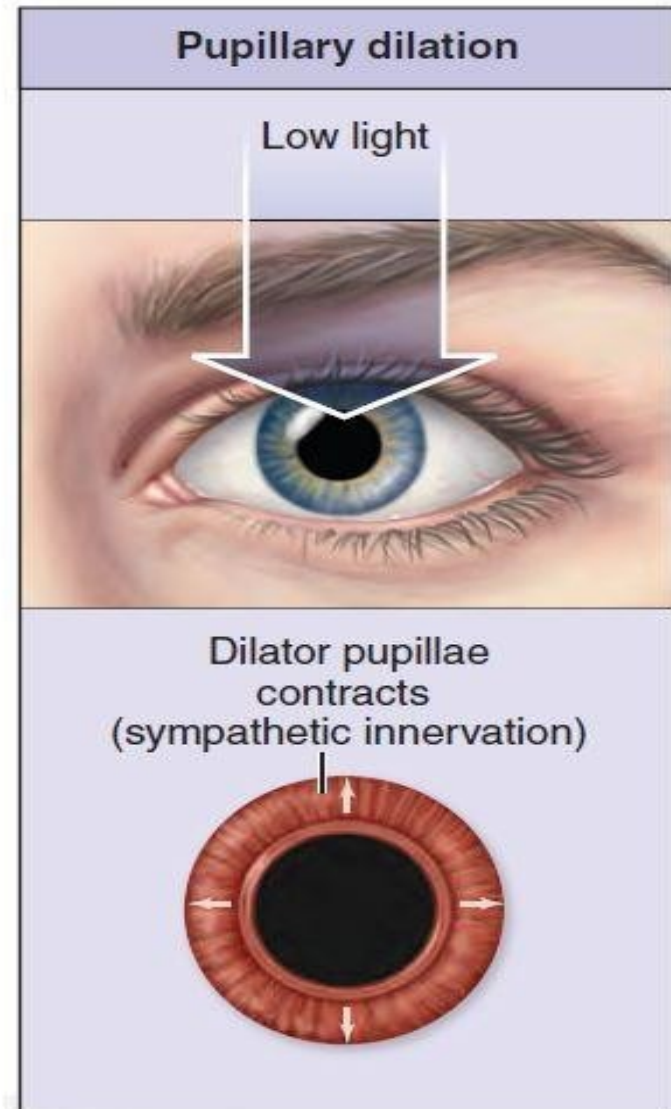
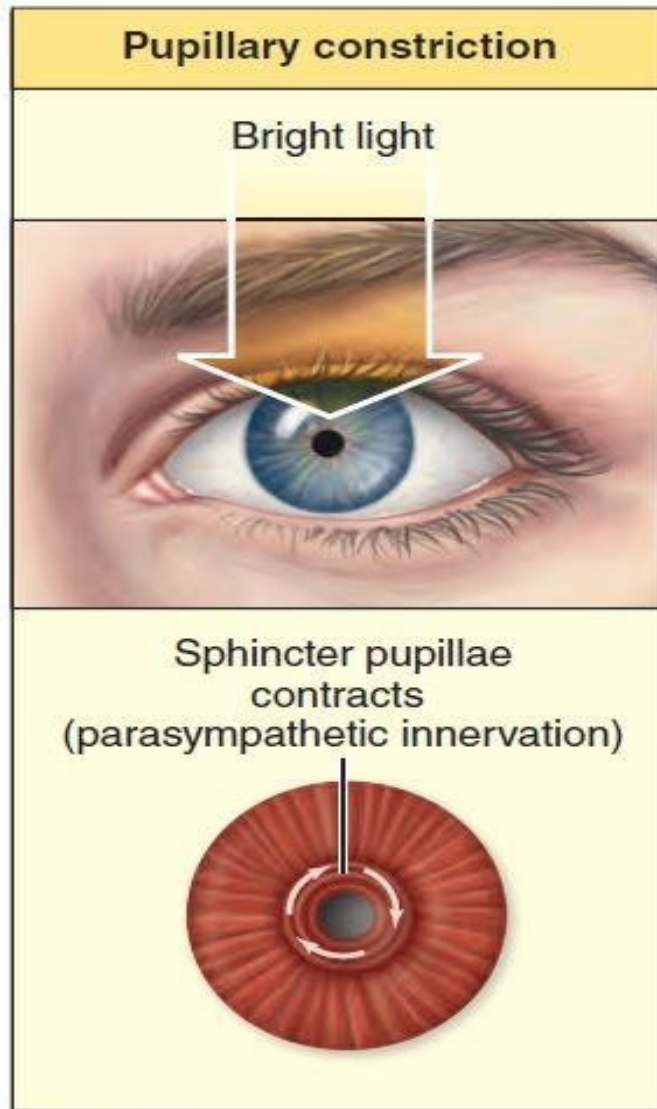


**Figure 5.25** Figure showing the constriction and relaxation of pupil

- ❖ When an image is produced on the retina, the light-sensitive cells are stimulated.
  - ❖ They send impulses to the brain along **afferent** (sensory) neurons in the optic nerve.
  - ❖ When the brain receives these messages it interprets the information and enable the person to see.
  - ❖ At the point where your optic nerve leaves the eye there is no retina but there is a **blind spot**.
- 

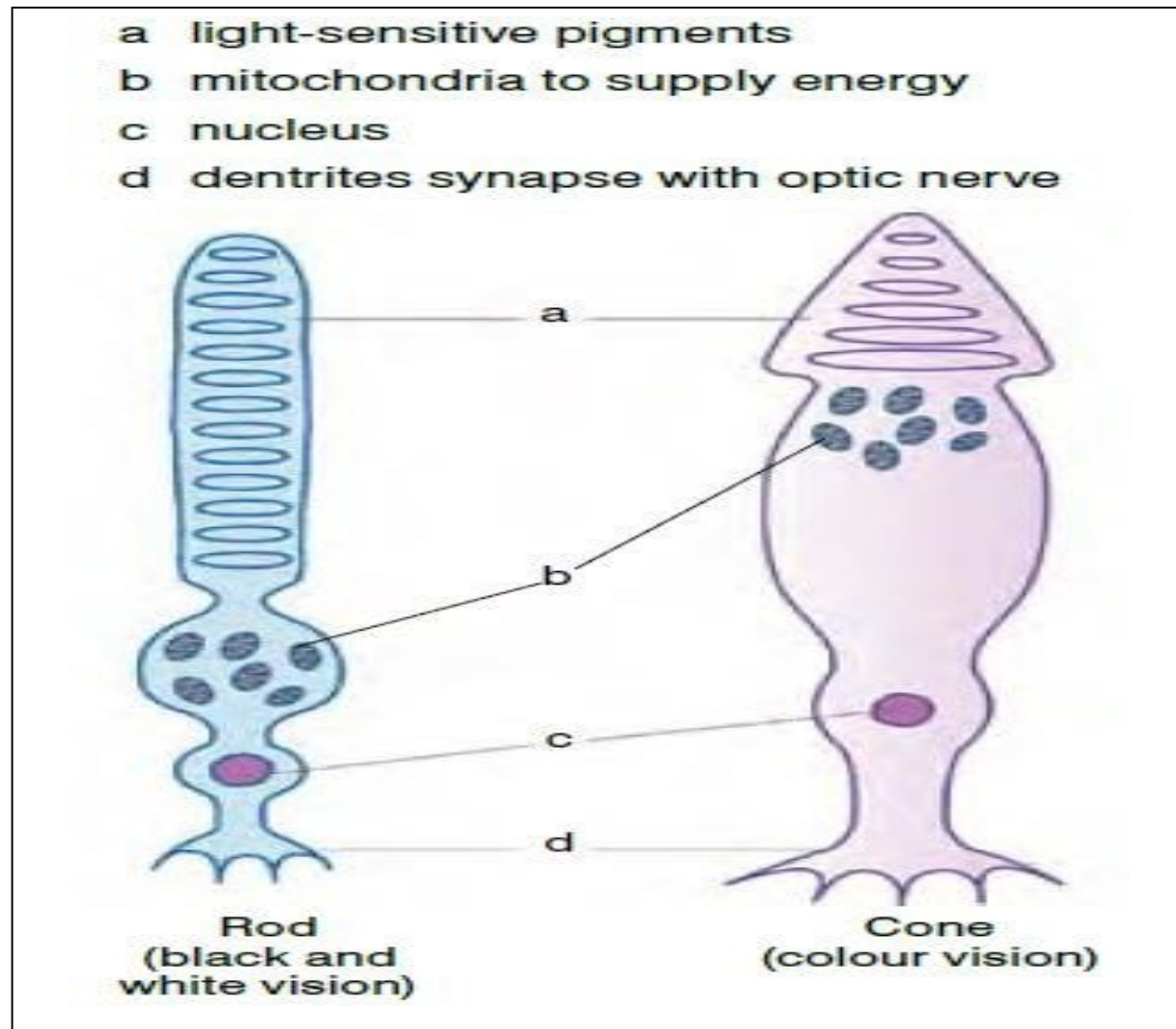


**Figure 5.26** The rods and the cones in the retina of human eye

- ❖ **Aretinal** depression known as the **fovea centralis** (see Figure 5.21) is located adjacent to the optic disc (blind spot) in the temporal section of the fundus.
- ❖ This area is surrounded by the macula, which appears darker than the rest of the fundus.

- ❑ The fovea **centralis** and macular area are highly concentrated with cones and form the area of highest visual resolution and color vision.
- ❑ The eyeball contains several chambers that serve to maintain structure, protect against injury, and transmit light rays.
- ❑ The **anterior chamber** is located between the cornea and iris, and the **posterior chamber** is the area between the iris and the lens (see Figure 5.24).

- ❖ These chambers are filled with aqueous humour, a clear liquid substance produced by the ciliary body.
- ❖ **Aqueous humour** helps to cleanse and nourish the cornea and lens as well as maintain intraocular pressure.
- ❖ The aqueous humour filters out of the eye from the posterior to

- ❖ the **anterior** chamber then into the *canal of **Schlemm*** through a filtering site called the
- ❖ *trabecular meshwork.*
- ❖
- ❖ Another chamber, the **vitreous chamber**, is located in the area behind the lens to the retina.
- ❖ It is the largest of the chambers and is filled with a clear and gelatinous **vitreous humour**.

## 5.55 The structure, function, and defects of the ear

- ❖ Ears are specialized organs for hearing.
- ❖ They are also concerned with the balance and position of the body.
- ❖ The ear is divided into three regions: **the outer ear, middle ear and inner ear.**
- ❖ The outer ear consists of a flap called a **pinna (auricle).**
- ❖ Leading from the pinna is a tube, the **ear canal.**
- ❖ In a human being, this is about 2 cm long.
- ❖ The pinna helps to trap and funnel sound into the ear.
- ❖ This is particularly important in animals, which can move the pinna to pick up sounds.

- ❖ At the end of the ear canal that closes the tube is a sheet of very thin membrane called the **eardrum** or **tympanum**

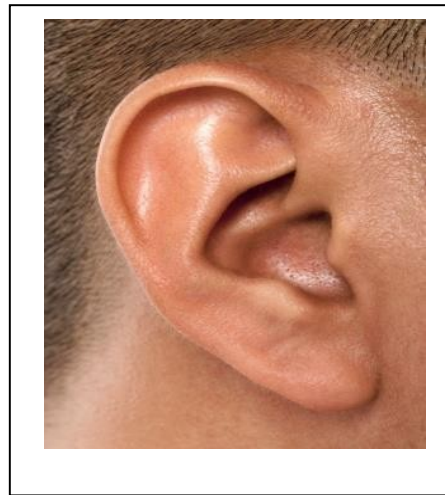
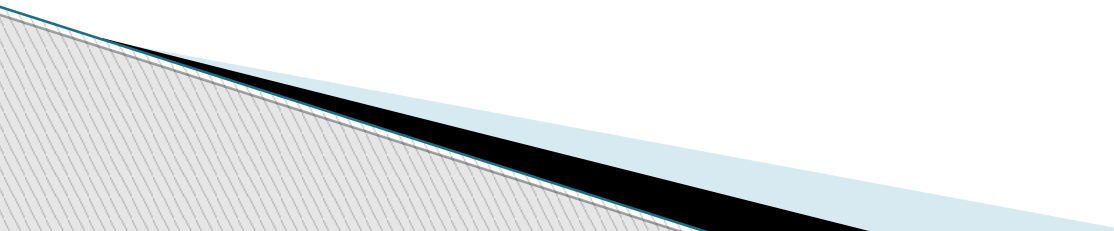


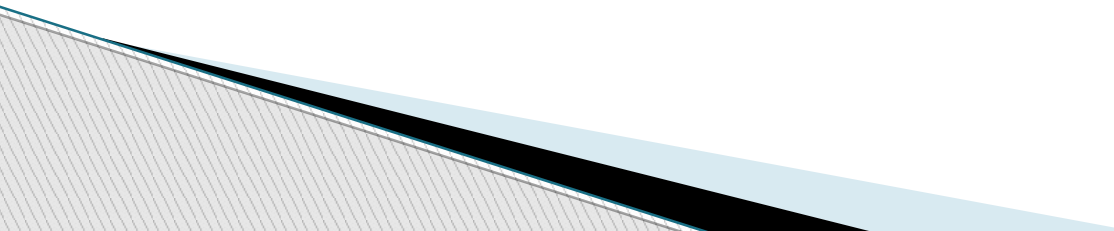
**Figure 5.27** The pinna of human ear

- ❑ **Outer ear** *the part of the ear visible externally*
  - ❑ **Middle ear** *the main cavity of the ear, between the eardrum and the inner ear*
  - ❑ **Inner ear** *a complex system of interconnecting cavities, concerned with hearing and equilibrium*
- 

- ❖ The **pinna**, ear canal and the **eardrum** form the outer part of the human ear.
- ❖ At the entrance of the ear canal are a number of small hairs.
- ❖ These filter out dust particles from the air entering the **ear canal**.
- ❖ The cells lining the ear canal produce waxy material which traps dust and **germs**, and **lubricates** the eardrum

- ❖ Behind the eardrum is a cavity filled with air. This cavity contains three tiny bones and forms the middle ear.
- ❖ The three tiny bones– called the **malleus** (**hammer**), the **incus** (**anvil**) and the **stapes** (**stirrup**) (see Figure 5.28) are the smallest bones in the human body.
- ❖ They form joints with one another, with the malleus attached to the eardrum and the stapes to the oval window.
- ❖ The cavity of the **middle ear** is connected to the throat by a tube called the **Eustachian tube**.

- This is usually closed but when the pressure in the **middle** ear increases, the tube opens until the air pressure in the **middle** ear is equal to that in the throat and therefore to the atmosphere.
- At one end of the middle ear, opposite to the **eardrum**, there are two openings.
- one of them is oval in shape and hence it is called the oval window.

- ❖ The other is round and is called the round window.
  - ❖ The inner ear consists of a cavity filled with a fluid, two sac-like structures called the **sacculus** and **utricle**, three semicircular canals and a coiled tube called the **cochlea**.
  - ❖ The **sacculus**
  - ❖ The openings are covered by very thin membranes.
- 

- ❖ **utrículuss** and **semicircular canals** and the cochlea are filled with a liquid.
- ❖ The **sacculus**, **utrículuss** and **semicircular** canals are part of the balancing system. A cross section of the **cochlea** reveals that it is made up of three tubes in one (Figure 5.29).
- ❖ The floor of the middle tube is lined with sensory cells linked to **affector** neurons.
- ❖ These nerve fibers join to form the auditory nerve which leads to the brain.

## ❖ **Key Words**

- ❖ **Malleus (hammer)** *is the ossicle attached to the eardrum*
- ❖ **Incus (anvil)** *is the ossicle between the malleus and the stapes*
- ❖ **Stapes (stirrup)** *is the stirrup-shaped ossicle that transmits sound from the incus to the cochlea*
- ❖ **Ampullae** *is the swelling at the base of each semicircular canal, containing sensory cells which detect movement of the fluid within the canals*

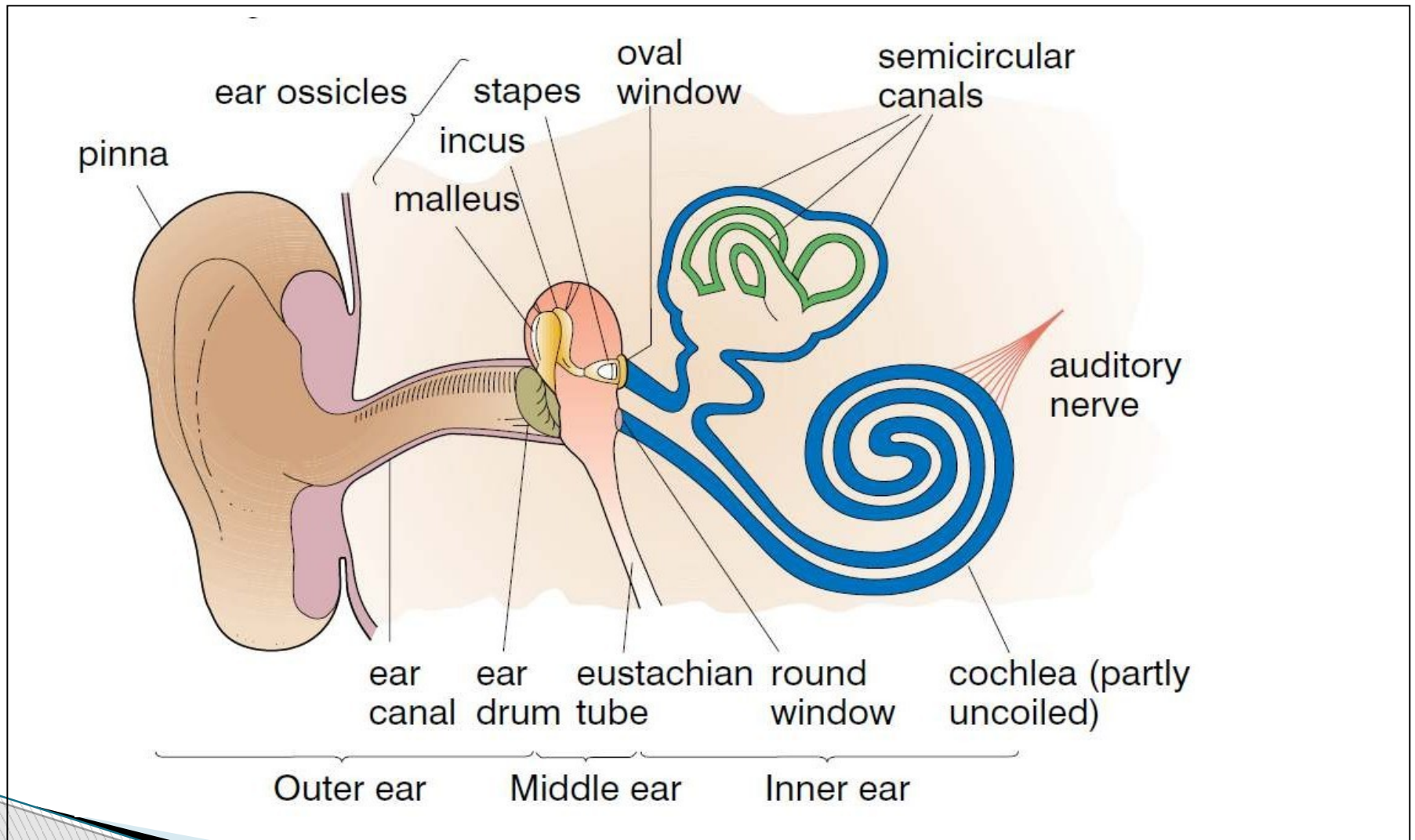


**Figure 5.28** Structure of human ear

# The mechanism of hearing

- ❑ The pinna collects sound waves and directs them to the eardrum through the ear canal.
- ❑ When sound waves hit the eardrum, it vibrates. This magnifies the vibrations which are then transmitted through the ear ossicles (the small bones) to the oval window.
- ❑ The three tiny ossicles are

- ❑ These impulses are transmitted to the brain for interpretation.
- ❑ The human ear is **sensitive** to **vibrations** ranging from those of a very low note of about **20 vibrations per second**, to a very high note of about 30 000 vibrations per second.
- ❑ High notes are detected in the first part of the **cochlea** and low notes are recorded in the last

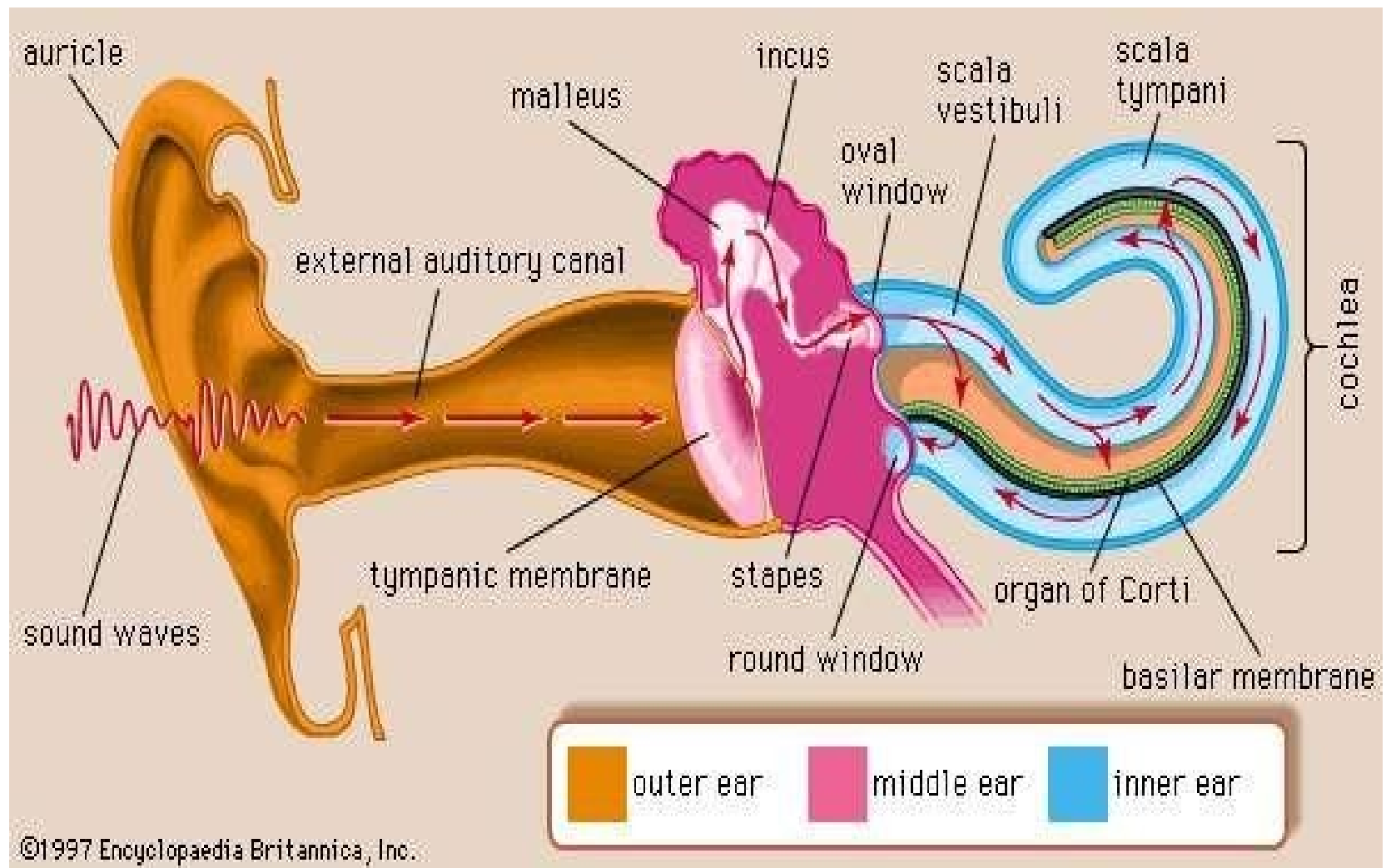


Figure 5.29. hearing processes

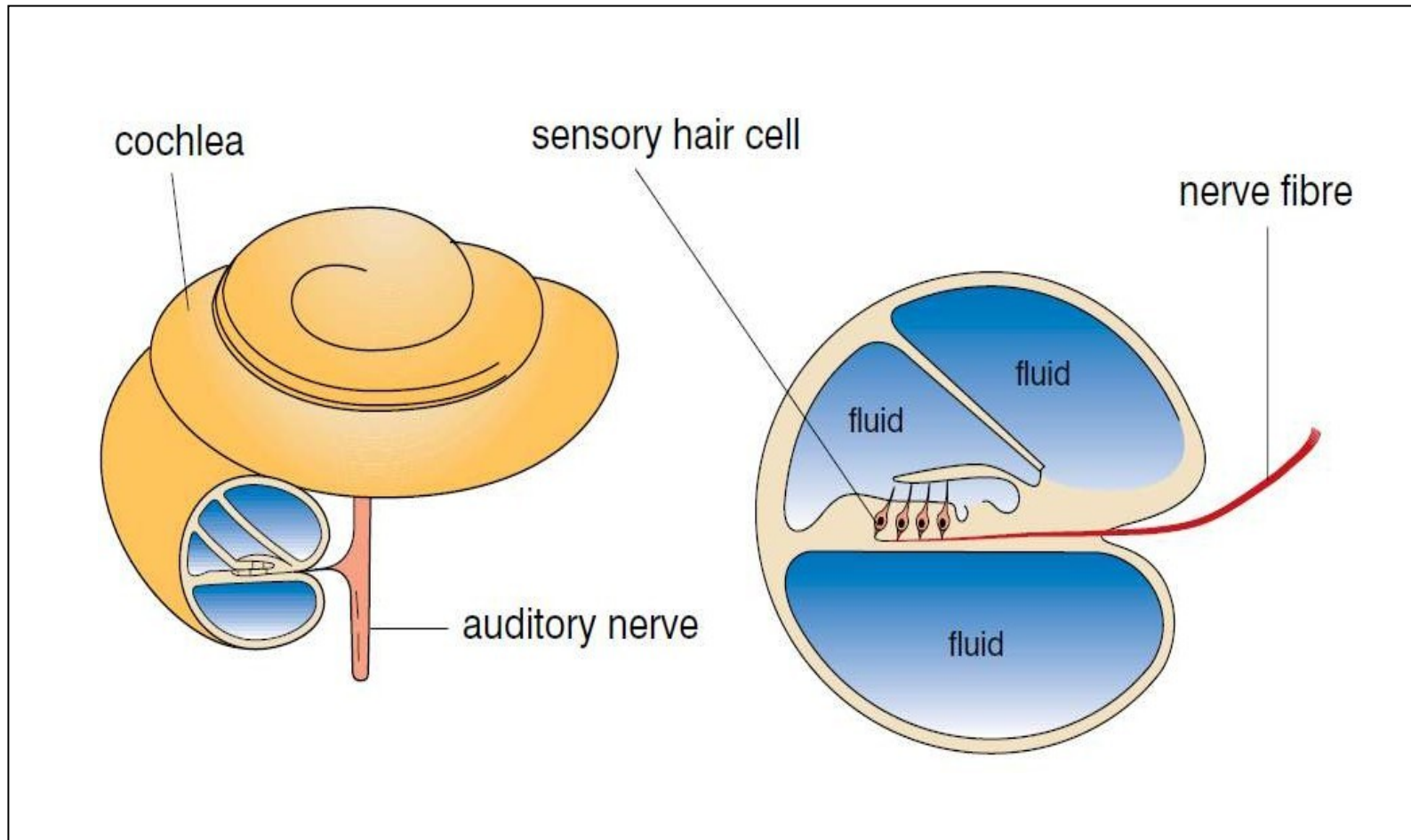


**Figure 5.29** The cross section of a cochlea

## ❖ **The sense of balance and movement**

- ❖ The semicircular canals in the inner ear are concerned with the detection of motion.
- ❖ The swellings on each of the semicircular canals (the **ampullae**) contain sensory cells attached to the sensory nerve endings.
- ❖ The **sensory cells** have hairs which are enclosed in a core of jelly substance called a **cupula** (Figure 5.30).
- ❖ Whenever the body or the head moves,

- ❖ the **semicircular** canals move with the head.
- ❖ The fluid in the semicircular canals also starts to move but it lags behind in its motion,
- ❖ so it apparently moves in the opposite direction.
- ❖ The moving fluid causes the **cupula** to tilt, thus pressing the hairs of the **sensory cells**.
- ❖ The pressing of the sensory hairs creates nerve impulses in the sensory nerve endings

- ❑ The **nerve impulses** are transmitted to the brain. The brain then interprets the direction and speed of the motion of the body or head.
- ❑ The **semicircular canals** are all at right angles to each other, so each one is sensitive to movement in a different plane.
- ❑ One canal responds to nodding, one to shaking and one to head tilting.

This is because the **fluid** in the **semicircular** canals keeps on moving after the spinning has stopped

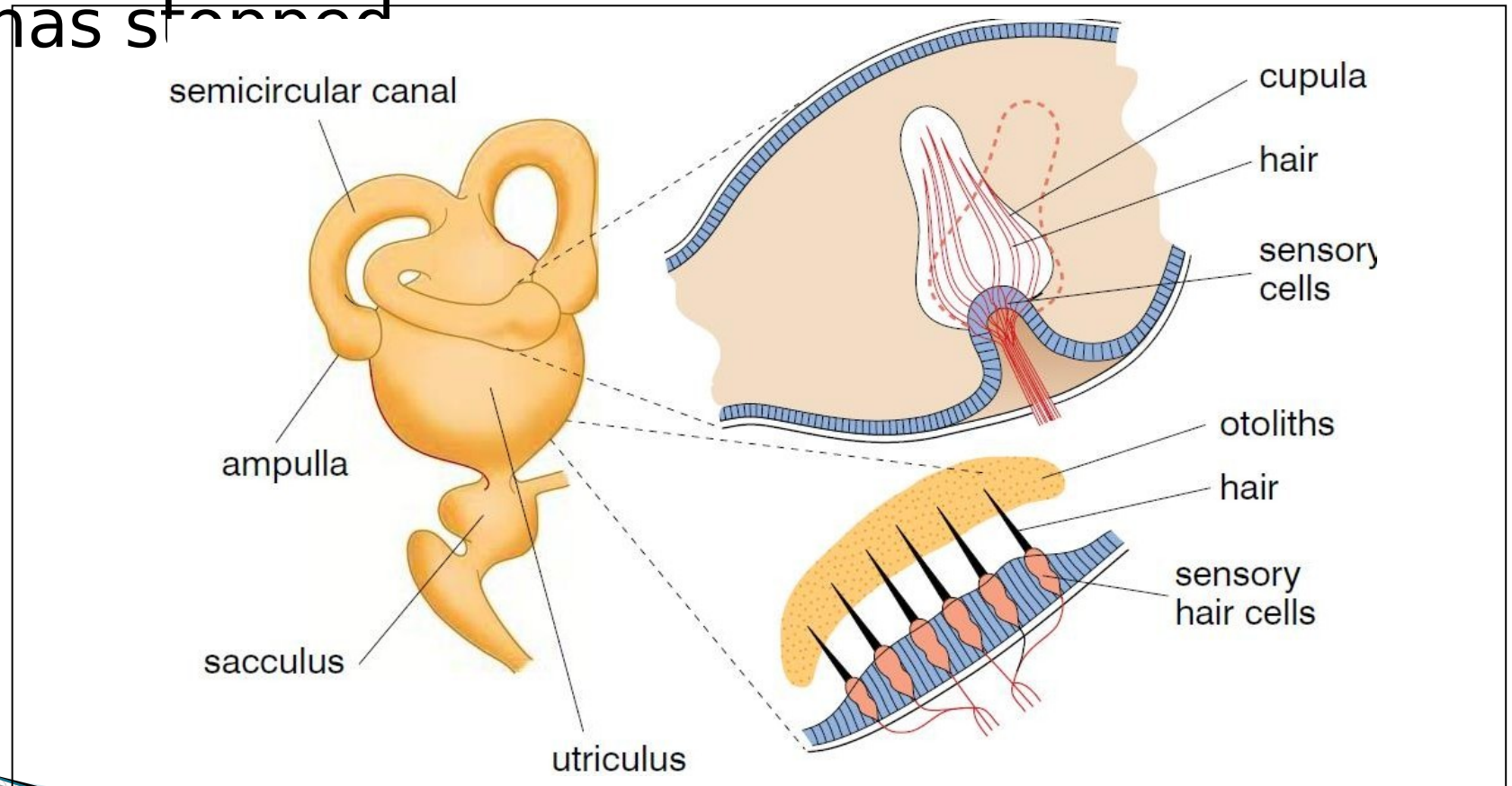


**Figure 5.30** The balance organs of the ear

## 5.6The endocrine system

### 5.6.1The endocrine glands

- ❖ The **endocrine** system interacts with the nervous system to coordinate and integrate body activities by means of **hormones**.
- ❖ Endocrine tissues and organs secrete **hormone** into the body fluids (mainly blood and lymph) directly using diffusion.

- ❑ **Hormones** act as chemical messages that are produced in one part of the body, but they have an effect somewhere entirely different
- ❑ . Glands are structures which produce hormones and other useful substances.
- ❑ The **endocrine glands** that produce hormones have no ducts, so they are sometimes known as ductless glands. They secrete hormones directly into the blood, and the chemicals are carried from glands to the body parts throughout the bloodstream.

# ❖ **Hormones**

*chemicals produced  
in one part of an  
organism which  
produce specific  
effects on a different  
part of the organism*

- ❖ Most **hormones** only affect certain tissues or organs – their **target organ** and the **hormone** is picked up from the blood by receptors in the cell membranes.
- ❖ They can act very rapidly, but often their effects are slower and longer lasting

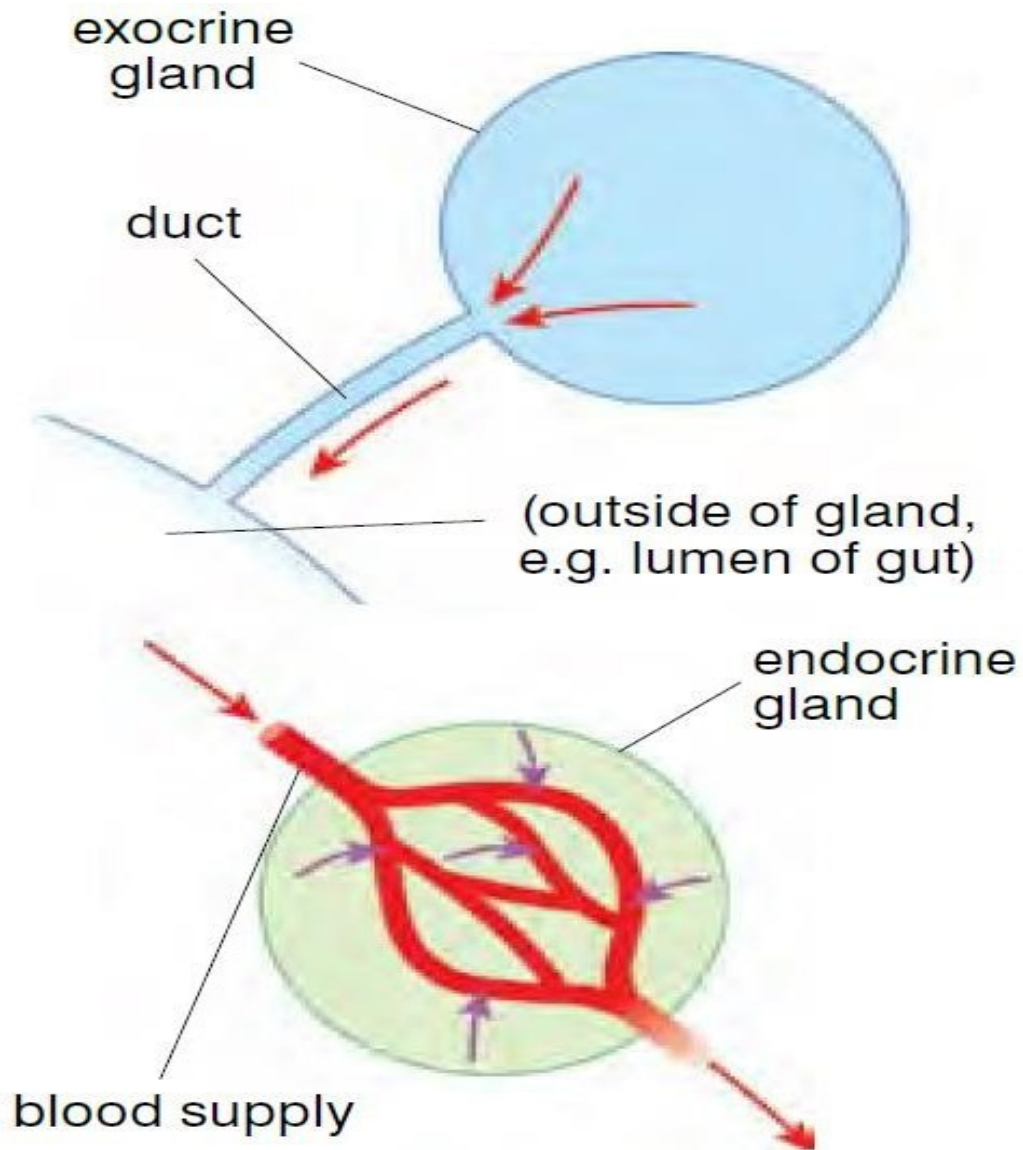


**Figure 5.31** Figure showing differences between exocrine gland and endocrine gland, and their secretions

- ❖ in the cytoplasm of **target cell**. The product of these reactions is a substance known as the “**secondary messenger**” (usually cyclic adenosine monophosphate or **cAMP**), which acts on behalf of the protein hormone, causes a potent effect in the **target cell** (usually within the cytoplasm). Since protein hormones never diffuse to the **DNA** of target cells, no new proteins or enzymes are

## Protein Hormones (cAMP second messenger)

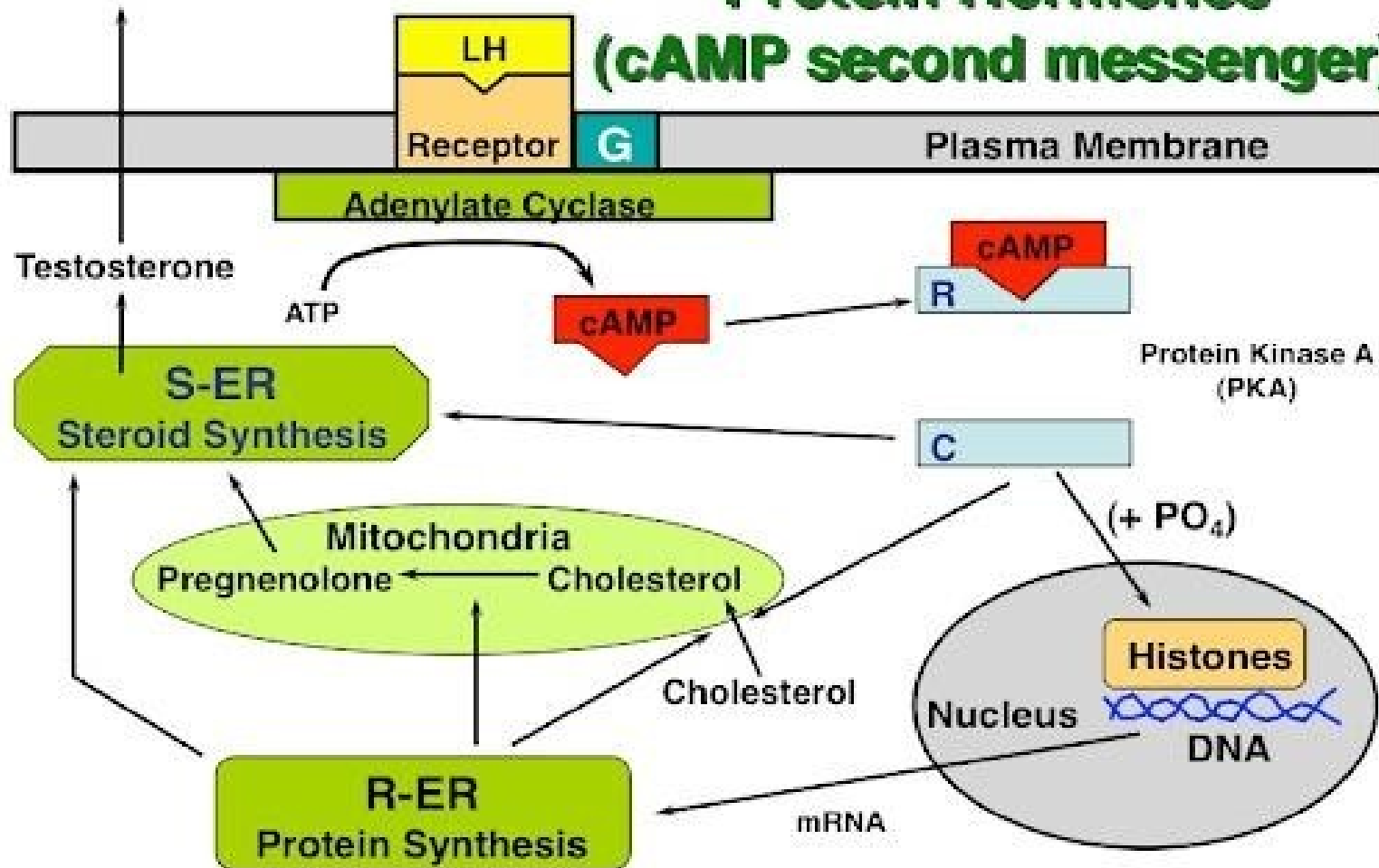


**Figure 5.32** Mechanism of Protein Hormone action

## Actions of steroid hormones

- ❖ **Steroid hormones** bind to a protein transporter during the transport in blood of lymph. When they have arrived at the target cells, the **protein transporter** (being fat-insoluble) is repelled by the cell membrane, whereas, the steroid hormone (being fat-soluble) diffuses into the cytoplasm of **target cell**.

- ❖ **Steroid hormone** also diffuses across the nuclear envelope and enters into the nucleus of target cell.
- ❖ They can bind to a specific receptor located on a particular gene of target cell's DNA.
- ❖ This binding alters the genetic information within that gene, resulting in a new messenger RNA (mRNA) to be produced

❖ This new **mRNA** will be translated into a new protein (or enzyme) in the cytoplasm of target cell. The **new protein** or enzyme causes a specific effect to occur within the **target cells**.

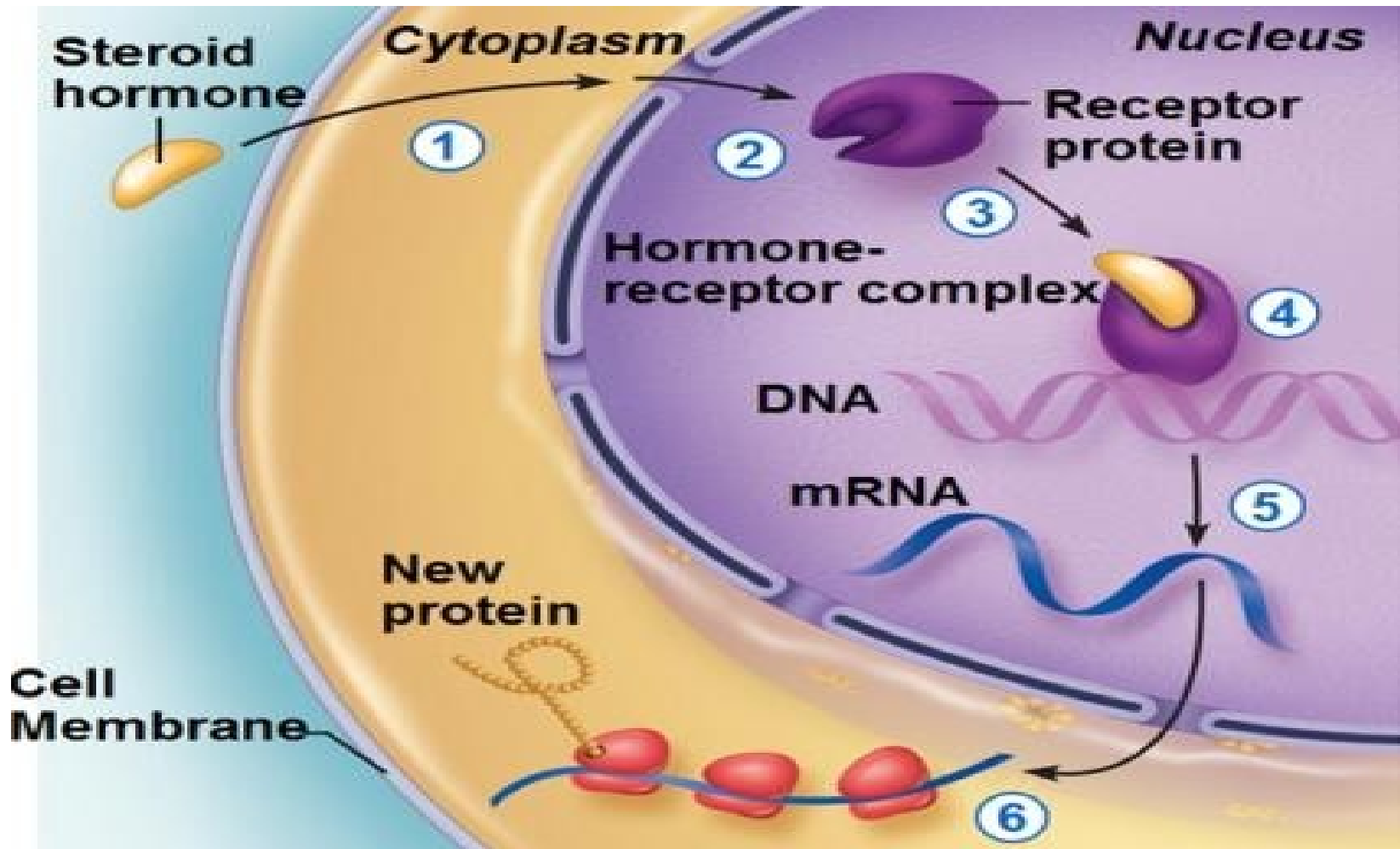


**Figure 5.33** Mechanism of the interaction between a steroid hormone and its receptor

# The major endocrine glands

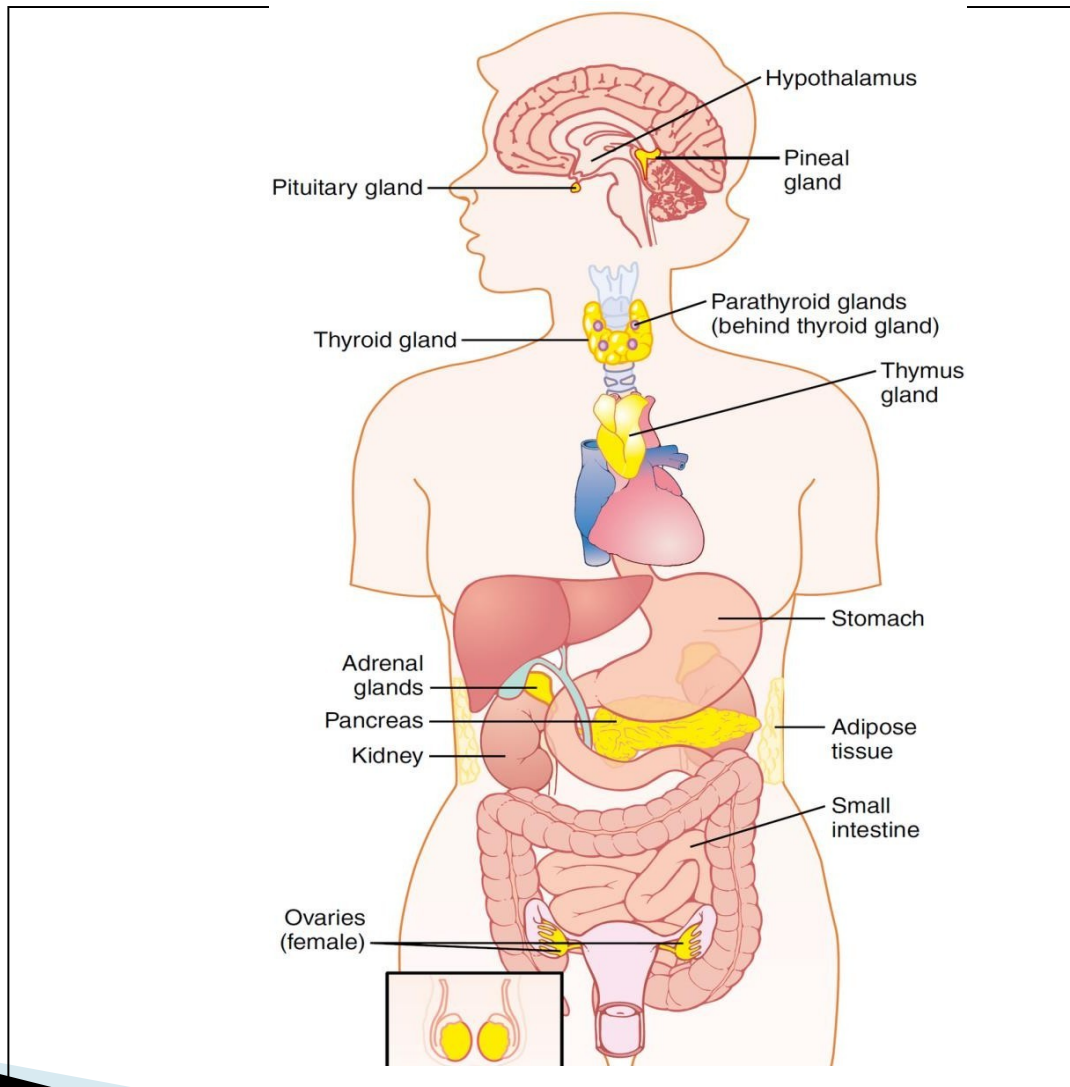


**Figure 5.34** The location of endocrine glands in human body

## 5.5.2 Hypothalamus

- ❑ The **hypothalamus** connects the nervous system to the endocrine system.
- ❑ It receives and processes signals from other brain regions and pathways where the hypothalamus translates them into **hormones** that are the chemical messengers of the endocrine system.
- ❑ These hormones flow to the pituitary gland, by the infundibulum.
- ❑ Some hormones are stored in the **pituitary** stores for later release; others

❖ The **hormones** are released by the pituitary gland whereas the hypothalamus controls the other endocrine glands and regulate all the major

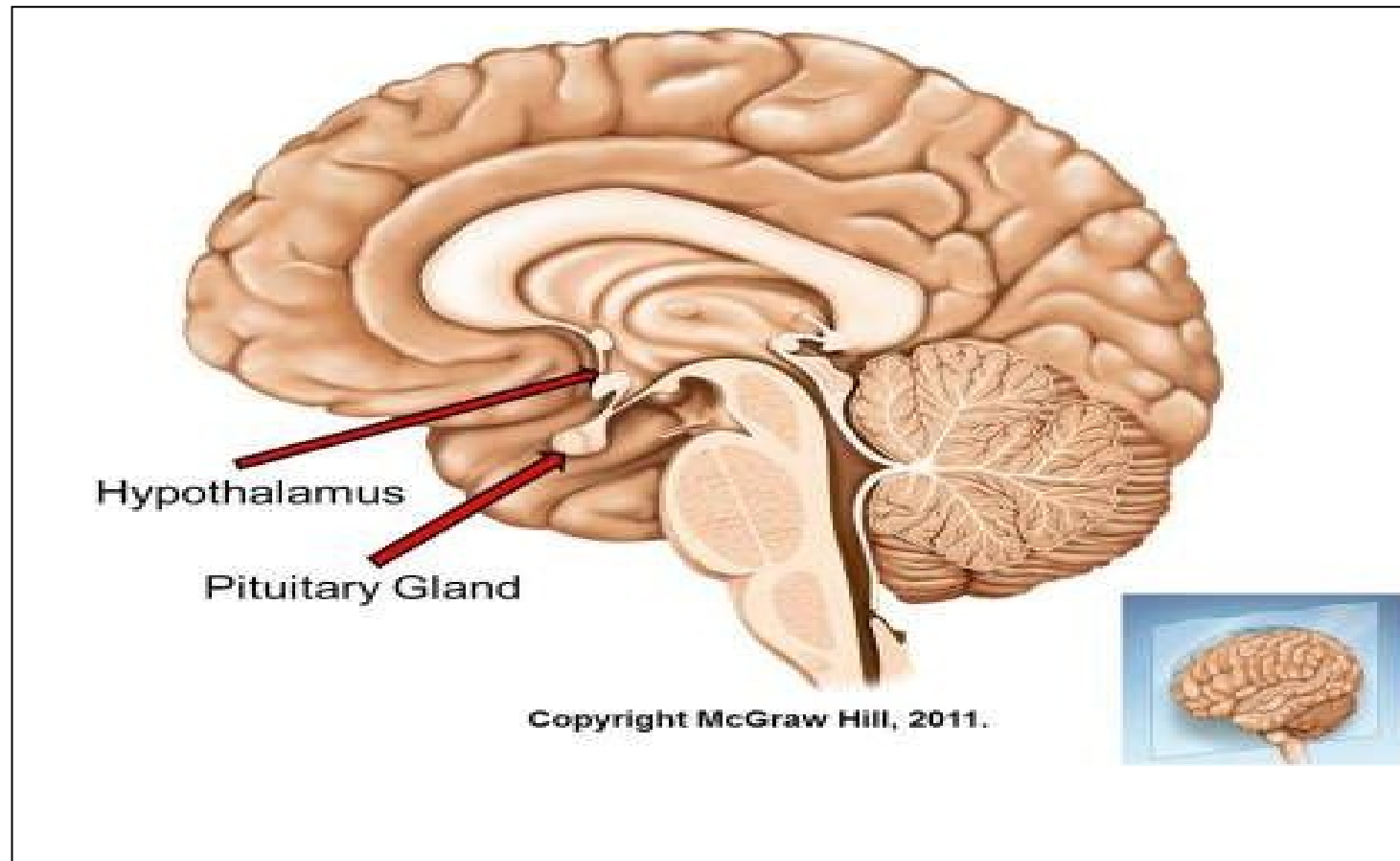


**Figure 5.35** Hypothalamus and pituitary gland

## 5.6.3 The pituitary

- ❖ The **pituitary** gland, found in the brain and about the size of a pea, is sometimes described as the controller of the endocrine orchestra (master gland).
- ❖ The hormones made in this tiny gland control the secretion of many other **hormones**.
- ❖ Because of its position in the brain, it is also involved in the co-ordination between the **nervous** and **hormonal** systems of control.

❖ It is divided into **anterior lobe** (**adenohypophysis**) and **posterior lobe** (**neurohypophysis**).

❖ Anterior lobe is about 3 times larger than the posterior lobe

- ❖ **Anterior pituitary** is under hormonal control by the hypothalamus where blood vessels transport “releasing hormones” to the anterior lobe.
- ❖ Anterior pituitary contains 5 types of glandular cells that produce different types of hormones.
- ❖ **Posterior pituitary** is under nervous control by the hypothalamus where nerve fibers innervate the posterior lobe for its release of hormones (posterior pituitary does not produce hormones; it only releases hormones made by the

## 5.6.4 Thyroid gland

- ❖ The thyroid gland is a small, butterfly-shaped gland located inferior to the larynx (voice box) and attached to the trachea. It is divided into two lateral lobes.
- ❖ Thyroid follicles utilize iodine and synthesize **thyroglobulin (TGB)** to be stored in the colloids.
- ❖ Upon stimulation of TSH, TGB is converted into two hormones:  
**Triiodothyronine (T3)** and  
**Thyroxine (T4)**

- ❖ Hypo secretion causes hypothyroidism (goiter, cretinism and myxedema) and hyper secretion causes hyperthyroidism that result in Graves' disease.
- ❖ Thyroid gland also secretes Calcitonin to lower blood calcium and phosphate levels and regulate digestive hormones.
- ❖ Both hypo secretion and hyper secretion would affect the normal

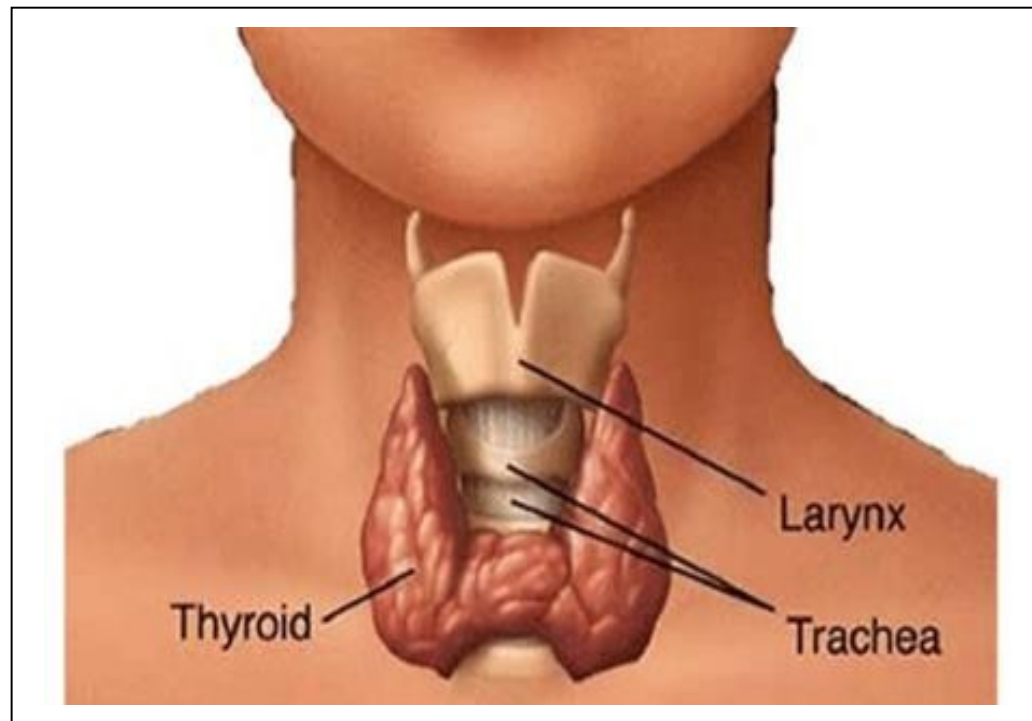


**Figure 5.36** The thyroid gland

## 5.6.5 Parathyroid glands

- ❖ Four oval-shaped glands are embedded in the posterior surface of the thyroid gland.
- ❖ Each parathyroid gland is normally about the size of a grain of rice (about 3-5 millimeters in diameter and 30 - 60 milligrams in weight).
- ❖ **Parathyroid glands** release **parathyroid hormone (PTH)** which controls the calcium levels in the blood stream. Other areas of the body, especially the bones, kidneys and small intestine, respond to PTH by increasing the calcium levels in the blood. Calcium is very important for our bodies, especially for muscle and nerve function. Hypo secretion causes **tetany**, and hyper secretion causes **osteitis fibrosa cystica**.

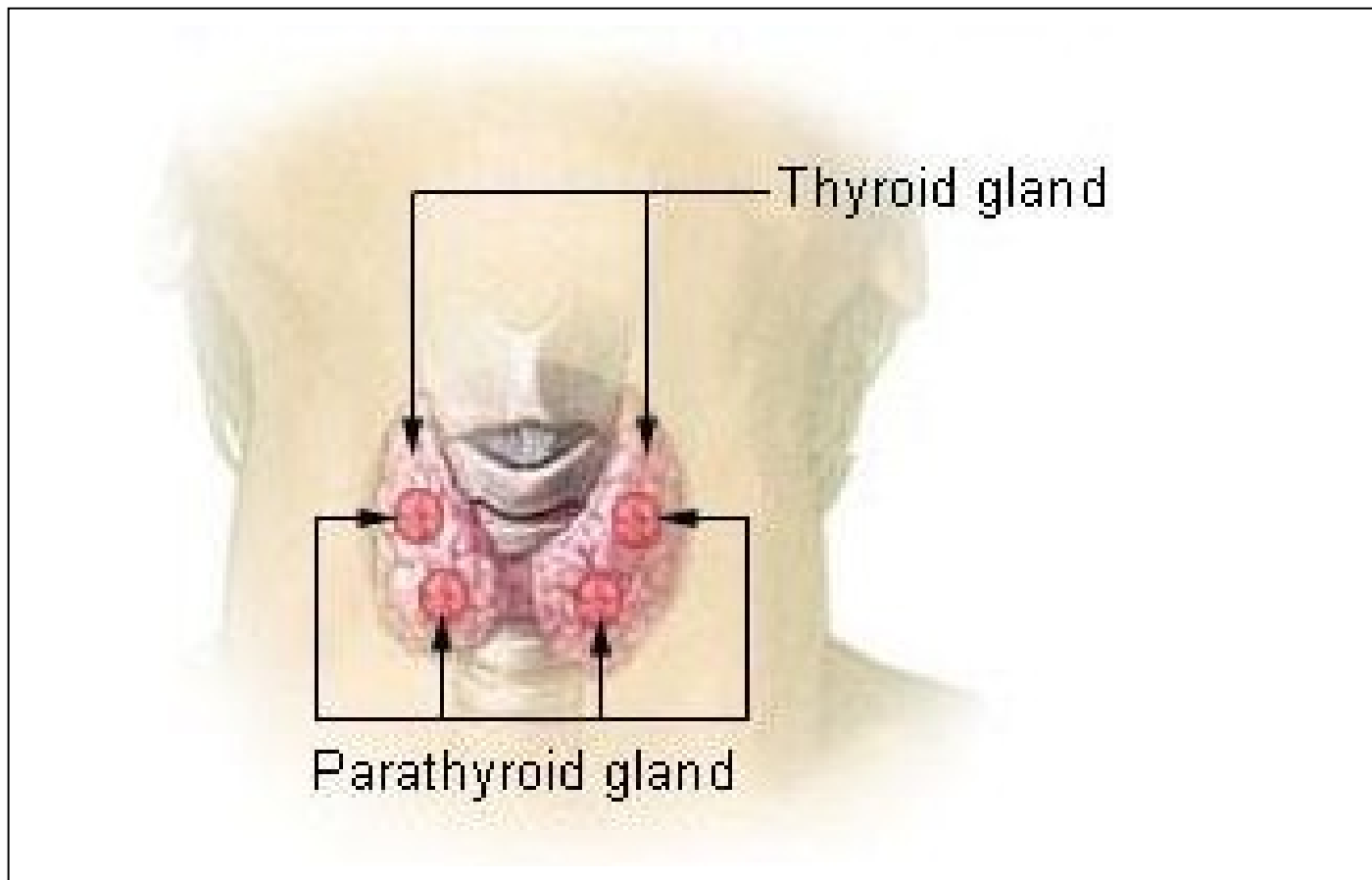


**Figure 5.37** Parathyroid gland

## 5.6.6 Adrenal gland

- ❖ Adrenal glands, also known as suprarenal glands, are small, triangular-shaped glands located on the top of both kidneys.
- ❖ Adrenal glands are composed of two parts. The cortex and the medulla-which are responsible for the production of different hormones

**A .Adrenal Cortex:** is the outer portion of the adrenal gland which is attached to the superior surface of the kidney. It is divided into 3 regions, from outside to inside: **Zona glomerulosa**, **Zona fasciculate** and **Zona reticularis**. Adrenal cortex secretes over 30 steroid-based substances and several steroid hormones, all crucial for normal

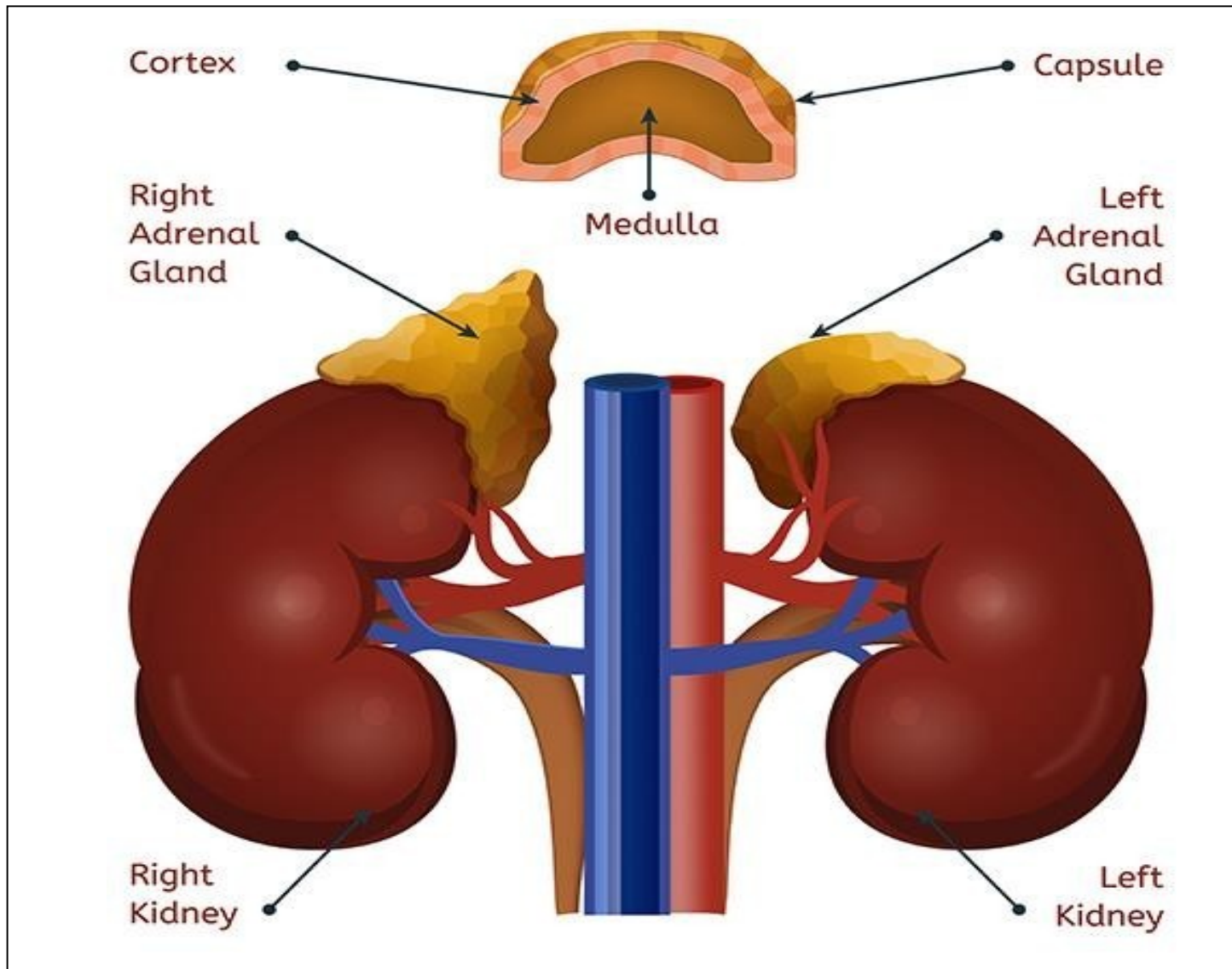


**Figure 5.38** Adrenal gland

- ❖ **B .Adrenal Medulla:** This is the inner portion of the adrenal gland.
- ❖ It is made of modified nerve tissue that is under direct regulation of sympathetic nerves of the autonomic nervous system. Contains glandular cells called **chromaffin** cells which secrete 2 closely related hormones- **Epinephrine (adrenaline)** and **Norepinephrine**

- ❖ **Adrenaline** is a well-known hormone produced by your adrenal glands. It is the hormone of
- ❖ 'fight or flight'. If you are stressed, angry, excited or frightened your adrenal glands will secrete lots of adrenalin.
- ❖ Carried rapidly round in your blood, adrenalin affects many different organs from the pupils of your eyes (it dilates them) to the beating of your heart (it speeds it up).
- ❖ **Adrenalin** basically prepares your body for action so that you can run fast to

## 5.6.7 Pancreas

- ❖ Pancreas is a small pink organ found below the stomach. It is both exocrine and endocrine in physiology.
- ❖ In its exocrine aspect, 99% of its mass is composed of cells called acini which secrete digestive enzymes and fluids into the small intestine through the pancreatic ducts.
- ❖ In its endocrine aspect, 1% of its mass is little groups of cells called **islets of langerhans (or pancreatic islets)** secrete hormones to regulate blood

- ❖ In each pancreatic islet, **alpha cells** ( **$\alpha$  cells**) secrete **glucagons** to raise blood glucose level, **beta cells** ( **$\beta$  cells**) secrete **insulin** to lower blood glucose level.
- ❖ Hypo secretion causes **diabetes mellitus** and hyper secretion causes **hyperinsulinism**. **Delta cells** ( **$\delta$  cells**) secrete **somatostation** or **growth hormone inhibiting hormone (GHIH)** which helps regulate

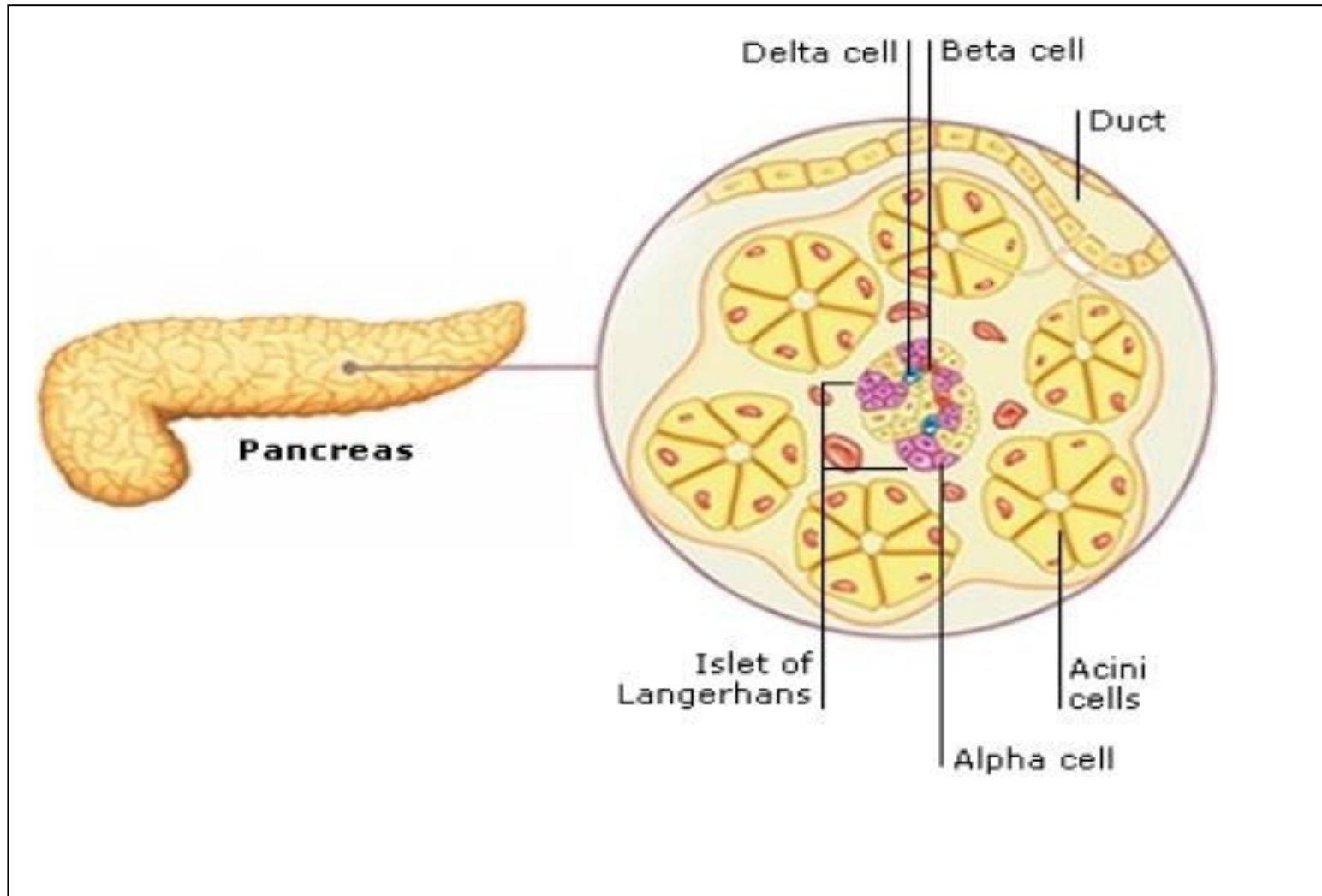


**Figure 5.39** Islets of Langerhans in pancreas

# ❖ Key Words

- ❖ **Pancreas** is a gland that produces digestive enzymes and manufactures hormones, including insulin and glucagon
- ❖ Insulin is a hormone that lowers the blood glucose level
- ❖
- ❖ **Glucagon** is a hormone that raises the blood glucose level
- ❖
- ❖ **Glycogen** is a form of carbohydrate stored primarily in the liver and broken down into

## The gonads: Ovary and testis

- ❖ The **gonads** are the endocrine glands which produce some of the sex hormones.
- ❖ These are the **testes** in boys and **ovaries** in girls who become active at the time of puberty. When the big physical changes take place, boys and girls look very different at which the body

- ❖ The changes come about in response to hormones released by the **brain** and by the **gonads** themselves.

## ❖ **The role of the ovaries**

- ❖ The female **gonads** are the ovaries, two walnut-sized organs found low in the abdomen in either side of the uterus. **Ovaries** produce eggs and hormones.
- ❖ Girls often go into puberty slightly earlier than boys. Between the ages of 8-14 most girls begin the changes which will take their bodies into sexual maturity.

- ❖ Although it is different for everyone, and everyone ends up a slightly different **shape** and **size** – the basic changes which take place are the same.
- ❖ Puberty in girls is controlled by **hormones** from the pituitary gland in the brain and from the gonads themselves – in this case the ovaries.
- ❖ **FSH** from the brain stimulates the ovaries to become active and start producing the female sex hormone **oestrogen**.
- ❖ As the levels of **oestrogen** rise and the body responds, all kinds of changes are triggered and the **female secondary sexual characteristics** develop.

# The role of the testes

- ❖ **Testis** is the male sex organ that also serves as an endocrine gland.
- ❖ It contains interstitial cells (or leydig's cells) that secrete **testosterone** to develop male secondary sexual characteristics.
- ❖ Puberty in boys usually begins somewhere between the ages of 9 and 15 years old.
- ❖ It may happen very rapidly, or it may take place much more slowly over a

- ❖ The chemical changes which **trigger puberty** are unseen, which is another important example of hormonal co-ordination and control.
- ❖ The **pituitary** gland in the brain starts to produce increasing amounts of **FSH**.
- ❖ This in turn stimulates the male gonads or testes to begin developing and producing the male sex hormone **testosterone**.
- ❖ The rising levels of testosterone trigger the many changes which affect the body during **puberty**, causing the development

## 5.6.9 Pineal gland

- ❖ Pineal gland is pine cone shaped located deep in the cerebrum.
- ❖ It secretes **melatonin** to regulate circadian rhythms which are necessary to keep track of day or night cycles. sleep/wake rhythm,

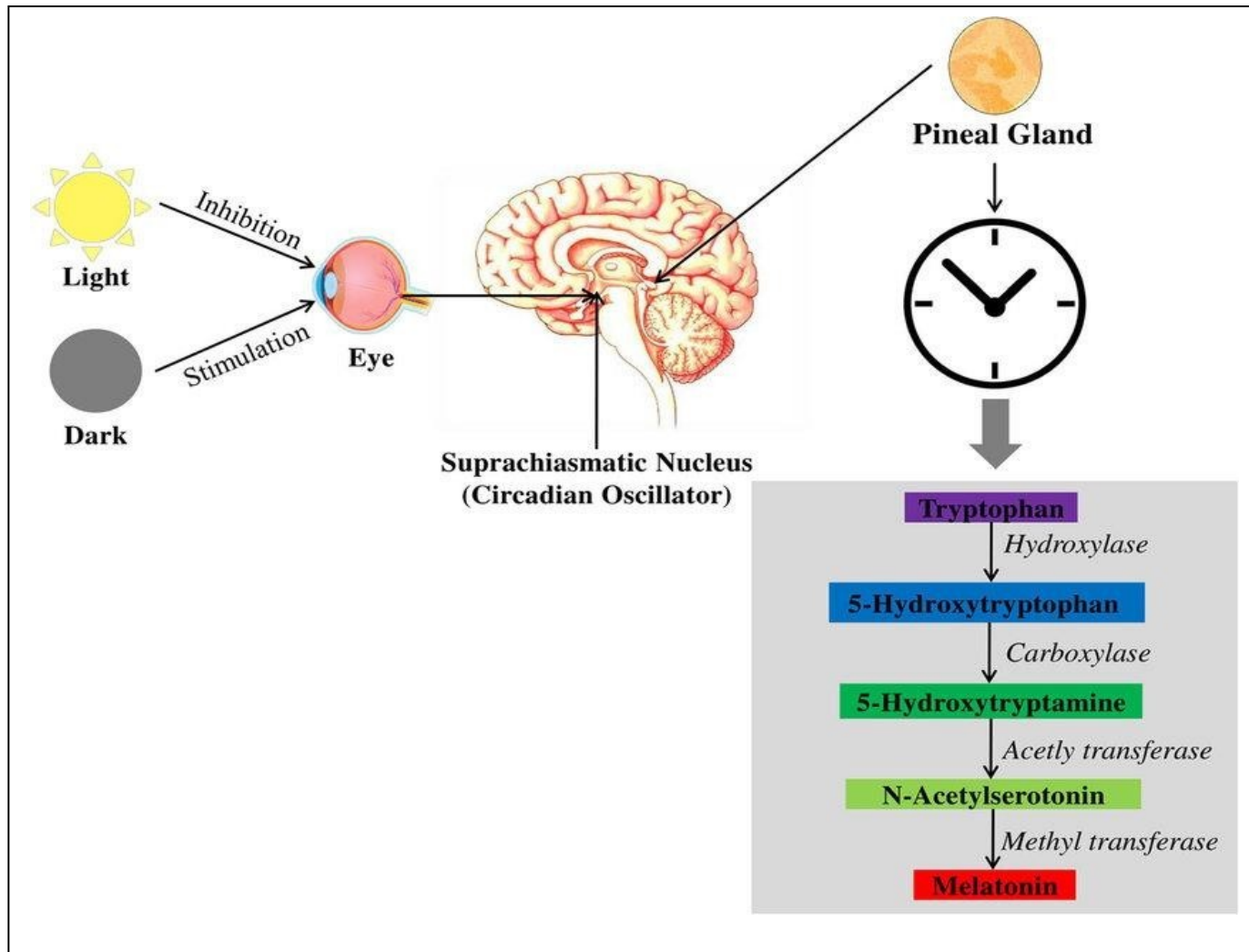


**Figure 5.40** Pineal gland

# Thymus gland

- A thymus gland is a diminishing gland (over time) located between the lungs.
- It secretes a group of hormones, such as **thymosin**, to affect the production and maturation

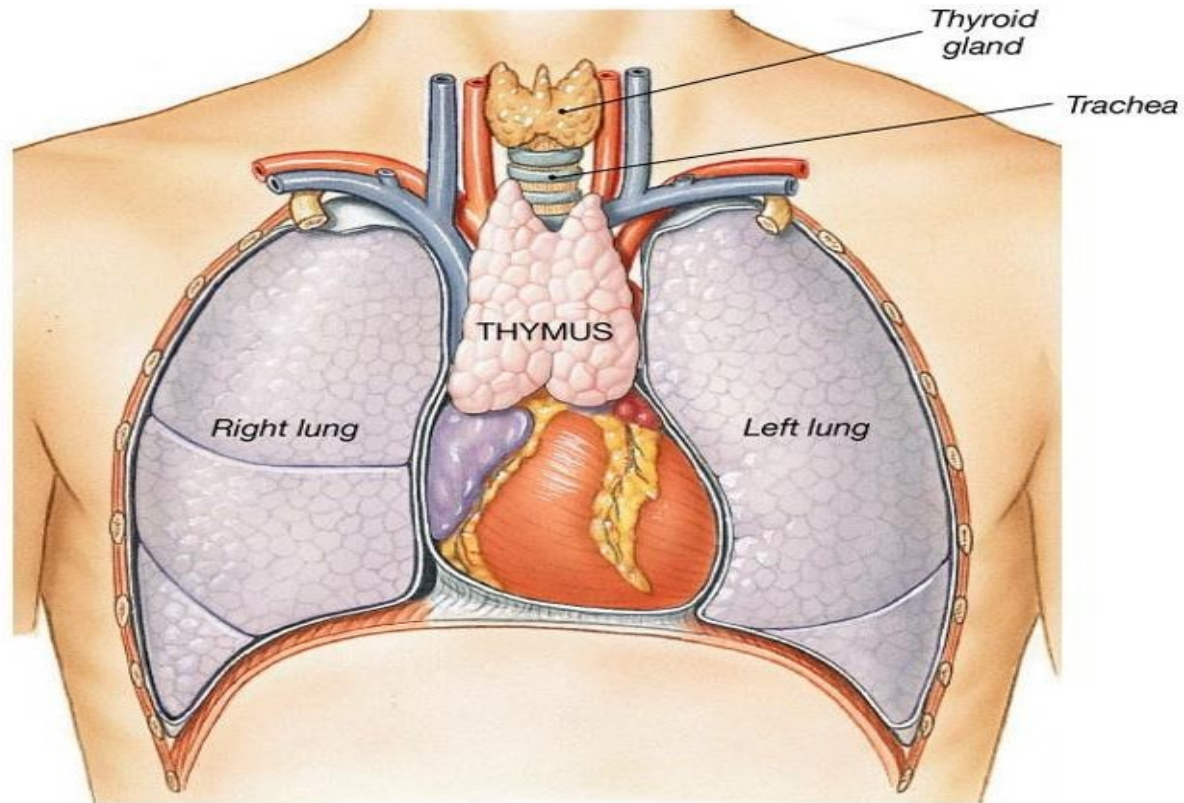


**Figure 5.41** Thymus gland

## 5.7 Exocrine glands

- ❖ Many glands in the body are **exocrine glands**. These glands are glands that secrete substances onto an epithelial surface by way of a duct.
- ❖ This means that they have a special tube or **duct** that carries the secretion from the gland where it is made to the place where it is needed.
- ❖ Exocrine glands, such as **salivary glands**, and **sebaceous glands** secrete chemical

- ❖ Sweat glands, salivary glands, **ceruminous**, lacrimal, sebaceous, prostate and mucous as well as mammary glands are all examples of **exocrine glands**.
- ❖ The liver and pancreas are both exocrine and endocrine glands.
- ❖ they are exocrine glands because they secrete products such as bile and pancreatic juice into the **gastrointestinal**

- ❖ tract through a series of ducts, and endocrine because they secrete other substances directly into the bloodstream

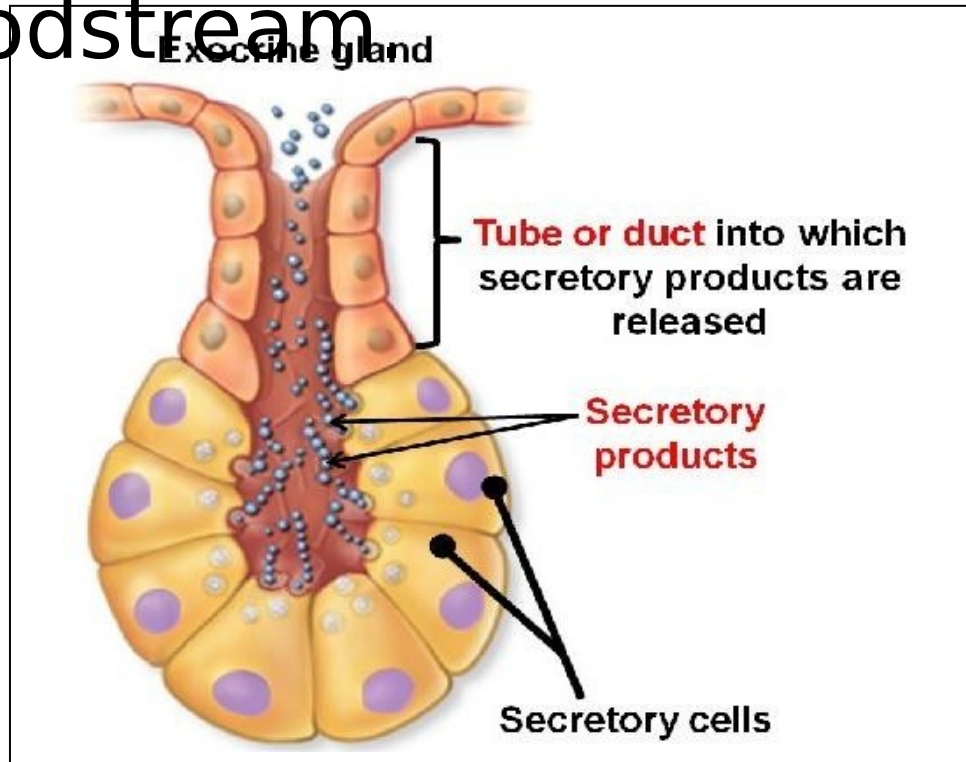


**Figure 5.42.** Anatomy of an Exocrine (duct) gland

## 5.8 Homeostasis in the human body

- ❖ At the end of this section, the learner will be able to:
- ❖ Define homeostasis
- ❖ Explain the regulatory mechanisms of body temperature, sugar level, water balance
- ❖ Discuss the structures and functions of the human kidney
- ❖ Investigate traditional mechanisms in your locality used to regulate body

## 5.8.1 The structure and function of the human kidney

- ❑ The kidneys are a pair of bean-shaped organs just
- ❑ above the waist. They are important **organs** with many functions in your body, including
- ❑ producing hormones, absorbing minerals, and filtering blood and producing urine. Internally, the kidney has three regions: **an outer cortex, a**
- ❑ **medulla in the middle, and the renal pelvis**, which is the expanded end of the ureter.
- ❑ The renal cortex contains the **nephrons**,

- ❑ collects the **urine** and leads to the **ureter** on the outside of the kidney. The ureters are urine- bearing tubes that exit the kidney and empty into the **urinary bladder**.
- ❑ Blood flows into the kidney along the renal artery.
- ❑ The blood is **filtered**, so fluid containing water, salt, urea, glucose and many other substances is forced out into the **kidney tubules**.
- ❑ Then everything the body needs is taken

- The amount of water reabsorbed depends on the needs of the body. The waste product urea and excess ions and unwanted water of the body are released as urine.
- Each kidney has a very rich blood supply and is made up of millions of tiny microscopic tubules (nephrons) where all the filtering and reabsorption takes

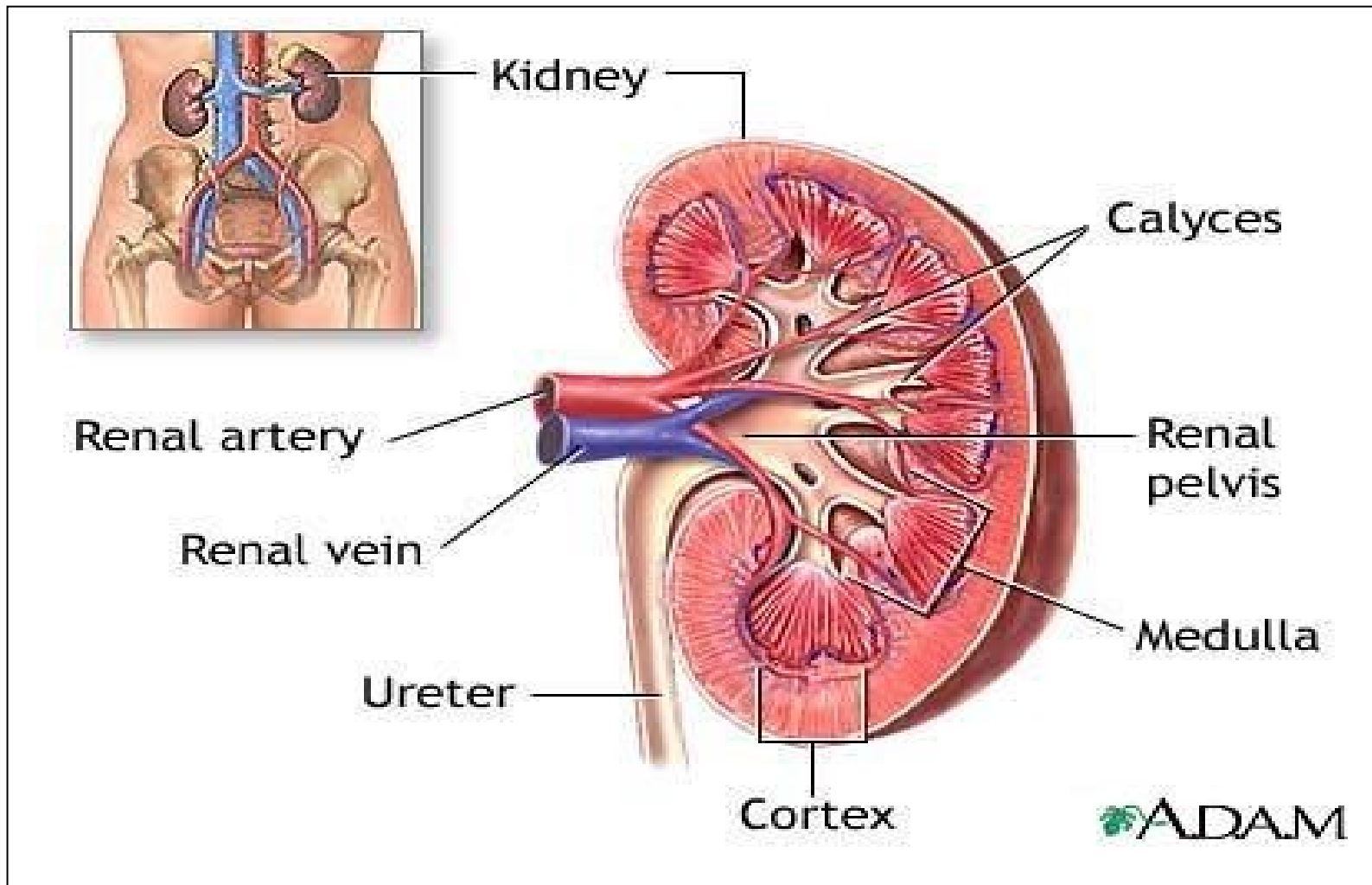


**Figure 5.43** The anatomy of human kidneys

- ❖ The roles of the different areas of a single **kidney tubule** in the production of urine are described below:
- ❖ **Bowman's capsule** is the site of the ultrafiltration of the blood.
- ❖ The blood vessel feeding into the capsule is wider than the vessel leaving the capsule, which means the blood in the capillaries is under a lot of pressure

- ❑ Several layers of cells, the **wall** of the blood capillaries and the wall of the capsule act as a filter and the blood cells and the large blood proteins cannot leave the blood.
- ❑ vessels as they are too big to fit through the gaps.

However, water, salt, **glucose**, **urea** and many other substances are forced out into the start of the **tubule**.

In fact, the concentration of substances in the liquid in the **capsule** is the same as that in the blood itself.

- This process is known as **ultrafiltration** –

- **Glomerulus:** This is the knot of blood vessels in the Bowman's capsule where the pressure builds up so that ultrafiltration occurs.
- The volume of the blood leaving the glomerulus is about **15%** less than the blood coming in which is a measure of the liquid which

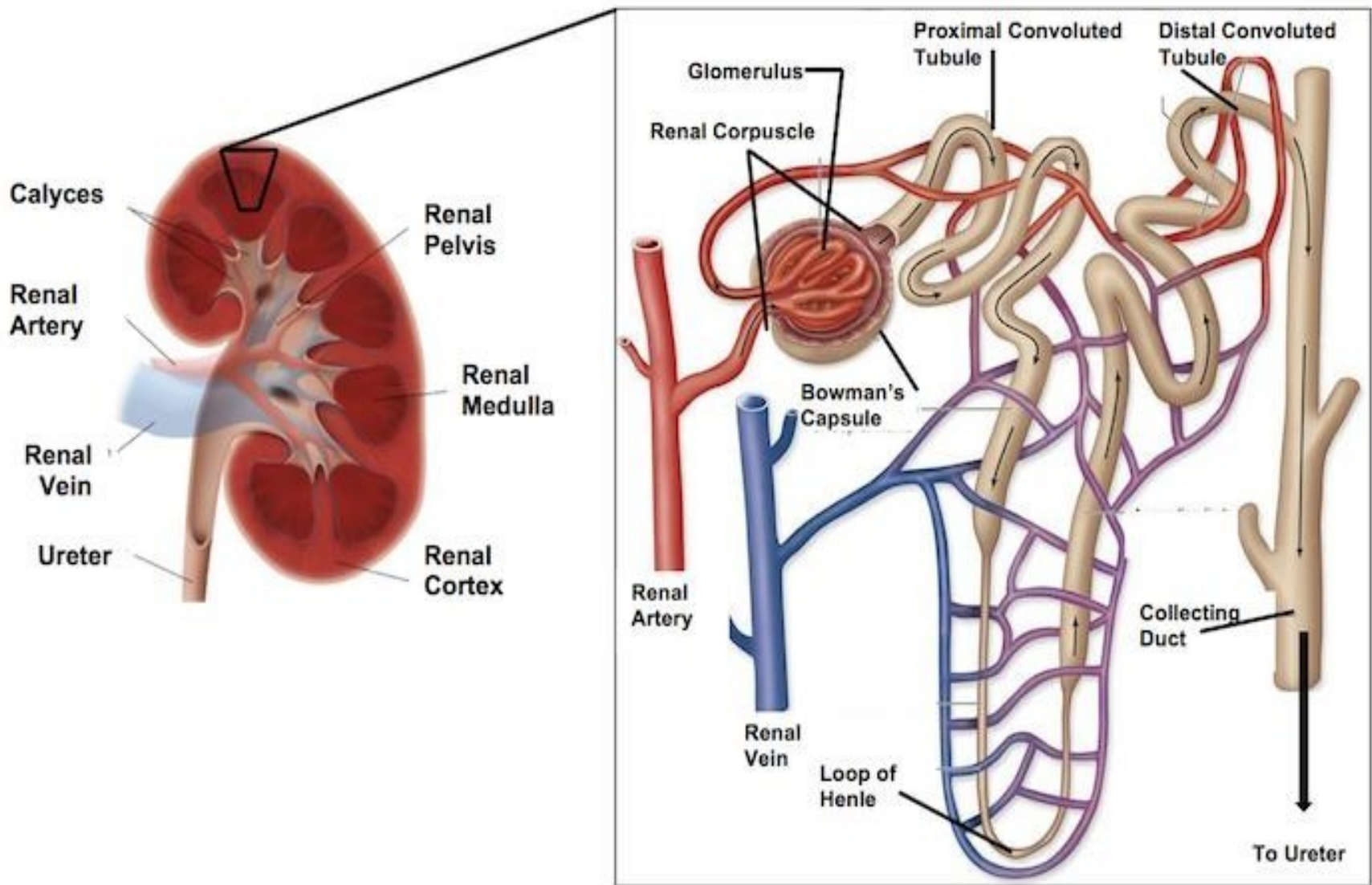


**Figure 5.44** The kidney filters the blood and removes waste materials.

- ❖ **First coiled (convoluted) tubule:** This is the liquid which enters this first tubule is known as the glomerular filtrate.
- ❖ The first tubule is where much of the reabsorption takes place. All of the glucose is actively taken back into the blood along with around **67%** of the sodium ions and around **80%** of the water.
- ❖ It has many microvilli to increase the surface area for absorption.

- ❖ **Loop of Henlé:** is part of a kidney where the urine is concentrated and more water is conserved.
- ❖ **Second coiled (convoluted) tubule:** is part of a kidney where the main water balancing is done.
- ❖ If the body is short of water, more is reabsorbed into the blood in this tubule under the influence of the **anti-diuretic hormone** or **ADH**.
- ❖ (Diuresis means passing urine, so anti-diuresis means preventing or reducing

- ❑ Also ammonium ions and some drugs (if they have been taken into the body) are secreted from the blood into this tubule to get rid of them.
- ❑ By the end of this second coiled tubule all of the salt which is needed by your body has been reabsorbed, leaving the excess in the filtrate along with most of the urea

- ❖ **Collecting duct:** is also part of a kidney where the liquid (essentially urine) is collected.
- ❖ It contains about **1%** of the original water, with no glucose at all. The level of salt in the urine will depend on the amount of salt in your diet and the water content of the urine.
- ❖ There is also a much higher **concentration of urea** (about 60 times more) in the urine than in the blood. But, if your body badly needs more water, more may be reabsorbed along the collecting duct again under the influence of **ADH** – until the urine

- ❖ **Urine** is formed constantly in your kidneys as it drips down to collect in your bladder.
- ❖ The **bladder** is a muscular sac which can hold between **600** and **800** cm<sup>3</sup> urine, although we usually empty it when it contains only **150-300** cm<sup>3</sup>.

- ❑ The amount of water lost from the **kidney** in the **urine** is controlled by a sensitive feedback mechanism involving the hormone ADH.
- ❑ If the water content of the blood is too low (so the salt concentration of blood increases) special sense organs known as **osmoreceptors** in the brain detect this.
- ❑ They stimulate the pituitary gland in the brain to release **ADH** into the blood.
- ❑ This **hormone** affects the second coiled tubules of the **kidneys**, making them more permeable so more water is reabsorbed back into the blood.

❖ means less **water** is left in the kidney tubules and so a more concentrated urine is formed. At the same time the amount of water in the **blood** increases so that the concentration of salts in

❖ This system of osmoregulation is an example of negative feedback. As the water concentration of the blood falls, the level of **ADH** produced rises.

❖ Then as the water concentration of the blood

❑ On an average day the **kidneys** will produce around **180 l** (that's about 50 gallons) of liquid filtered out of the blood in the **glomerulus** (glomerular filtrate) – but only about 1.5 l (just over 2.5 pints) of urine.

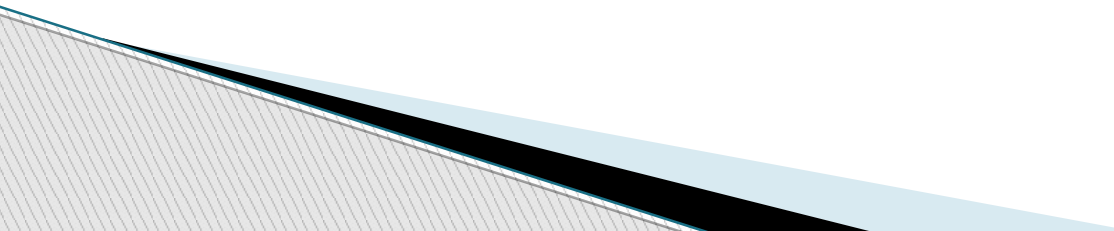
❑ So more than **99%** of the liquid filtered out of the blood is eventually returned to it

## 5.8.1 Thermoregulation

### ❖ **Thermoregulation**

- ❖ It is vitally important that wherever we go and
- ❖ whatever we do our body temperature is maintained at the temperature (around 37 °C) at which our enzymes work best.
- ❖ It is not the temperature at the surface of an organism which

► What types of mechanisms do humans use to regulate their body temperature?



- ❖ **matters** as the skin temperature can vary enormously without causing harm.
- ❖ It is the temperature deep inside the body, known as the **internal** or **core** body temperature, which must be kept stable.
- ❖ Human beings are good examples of **homeotherms**.
- ❖ The body temperature is controlled by a number of **physiological**

## 7.1.1 Osmoregulation

- ❖ If the concentration of the body fluids changes, water will move into or out of the cells by **osmosis** and they could be damaged or destroyed.
- ❖ Yet some days you may drink several liters of water or liquid and other days much less. How is the balance maintained?
- ❖ We gain water when we drink and eat.
- ❖ We lose water constantly from the lungs when we **breathe** out, when water evaporates into the air in the lungs and is breathed out.
- ❖ This water loss is constant.

- ❖ Whenever we exercise or get hot we **sweat** and lose more water.
- ❖ The water balance is maintained by the **kidneys**.
- ❖ They remove any excess water which leaves the body as **urine**.
- ❖ If we are short of water we produce very little **urine** and most water is saved for use in the body.
- ❖ If we have too much water then our **kidneys** produce lots of urine to get rid of the excess. The ion concentration of the body – particularly ordinary salt – is also

- ❑ We take in **mineral** ions with our food.
- ❑ Some are lost via our skin when we sweat. Again the **kidney** is most important organ to keep an ion balance.
- ❑ Excess mineral ions are removed by the **kidneys** and lost in the urine.
- ❑ The balance of water and salts in the body is very important because of the osmotic impact of the cells.
- ❑ If the balance is wrong controlling this balance is known as **osmoregulation**.
- ❑ The **kidneys** as discussed above are vitally important in two aspects of homeostasis, both in **excretion** and in **osmoregulation**.

# 7.1.2 Chemical regulation

- ❖ Human liver plays a vital role in maintaining a constant internal environment.
- ❖ It is the largest individual organ in the body that makes up around 5% of the body mass.
- ❖ The liver cells are very active in carrying out a wide range of functions, many of which help to maintain a constant internal environment.
- ❖ The liver has a very special blood supply in addition to the usual artery and vein (hepatic artery and vein) there is another blood vessel which comes to the liver directly from the gut.
- ❖ This is the hepatic portal vein and it brings the

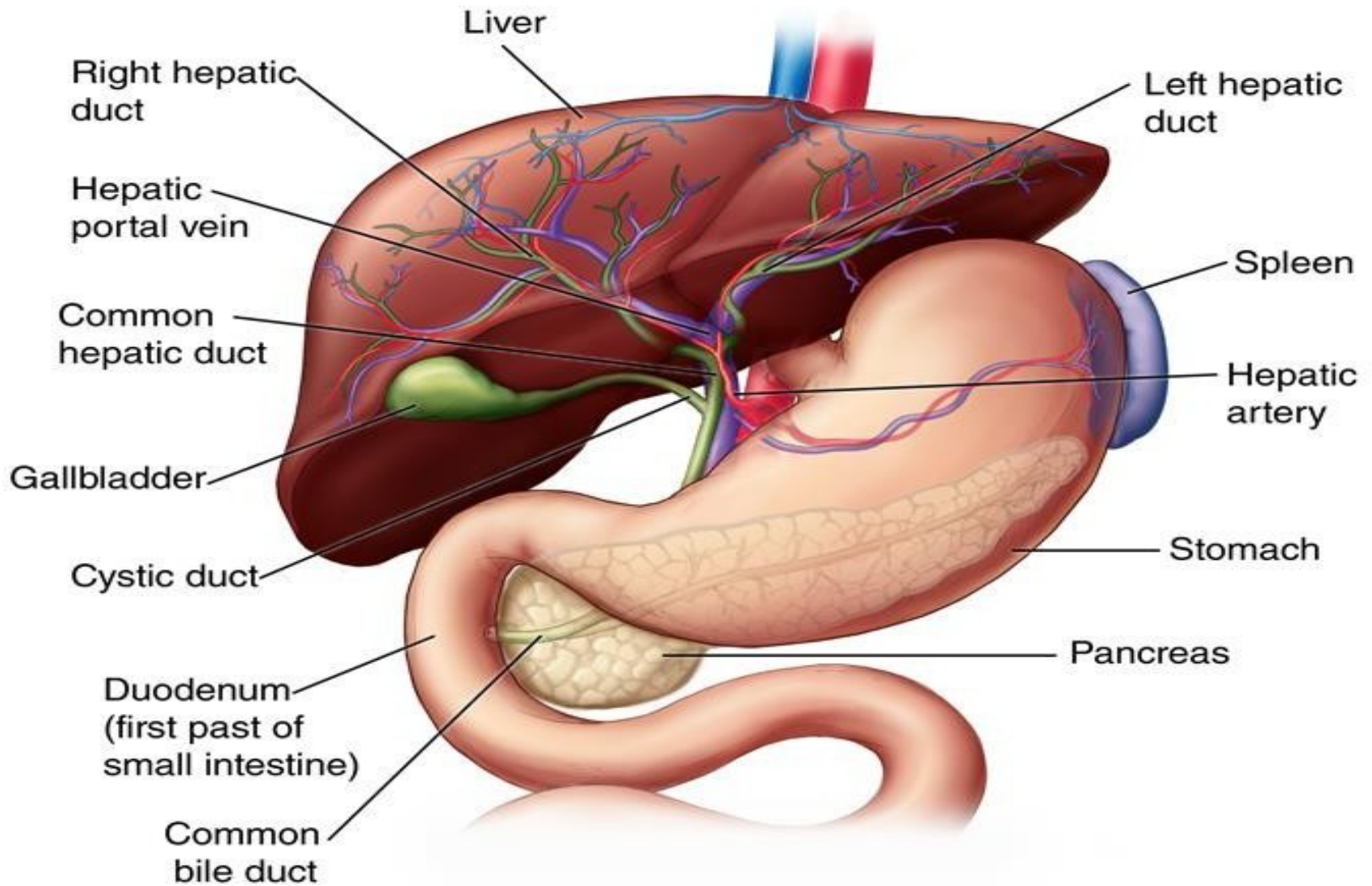


**Figure 5.45** The liver is one of the most active organs in the body

- ❖ A large number of reactions take place in the **liver**. Many of them are involved in **homeostasis** in one way or another. It plays a part in all of the following functions:
- ❖ It controls the sugar levels in the body (through stored **glycogen** in the liver itself).
- ❖ It controls and balances the fats that you eat and the **cholesterol** levels in the blood.
- ❖ It is an important organ where

- ❖ The **liver** breaks down excess amino acids and forms urea.
- ❖ If you eat more **carbohydrate** or fat than you need in the diet the body simply stores the excess energy as fat. If you eat too much protein, it isn't so easy.
- ❖ The body cannot store the excess amino acids or simply convert protein to fat.
- ❖ Instead the amino acids which make

- ❖ The **amino** (nitrogen containing) part of the amino acid molecule is removed and converted into **ammonia** and then urea in the liver.
- ❖ The rest of the amino acid can be used in **cellular respiration** or converted to fat for storage.
- ❖ The process of removing the amino group from excess amino acids is known as **deamination**.
- ❖ This it is a very important function of the **liver**.

- ❑ It carries out the breakdown of worn-out **red blood** cells – in particular the red pigment hemoglobin.
- ❑ It is vital **organ** for the formation of bile which is made in the liver and stored in the gall bladder before it is released into the **gut** to **emulsify** fats and help in their digestion.
- ❑ It controls **toxins**. The liver breaks down most of the poisons you take into the body, including alcohol.
- ❑ This is why the **liver** is so often damaged when people drink heavily

- ❖ It is used to control **temperature**. Around 500 different reactions take place in the liver at any time. For many years it has been believed that as a result of all these reactions the liver generates a lot of **heat** which is then spread around the body by the **bloodstream**.
- ❖ The regulation of tissue oxygenation is another typical example for chemical **regulation** in the body.
- ❖ The respiratory chemoreceptors

❖ through the **concentration** of hydrogen ions. Because most carbon dioxide is converted to carbonic acid (and bicarbonate) in the **bloodstream**, chemoreceptors are able to use blood **pH** as a way to measure the carbon dioxide levels of the bloodstream.

❖ The main **chemoreceptors** involved in respiratory feedback are:

- ❖ Central **chemoreceptors**: These are located on the **ventrolateral** surface of medulla oblongata and detect changes in the pH of spinal fluid.
- ❖ They can be desensitized over time from **chronic hypoxia** (oxygen deficiency) and increased carbon dioxide.
- ❖ Peripheral **chemoreceptors**:
- ❖ These include the aortic body, which detects changes in blood oxygen and carbon dioxide, but not in the pH, and the **carotid** body which detects all three.
- ❖ They do not desensitize, but they have less impact on the respiratory rate

- The need for different levels of **respiration** varies with the **physiologic** state of the organism (e.g., sleep, excitement, exercise).
- The respiratory system must try to maintain constant levels of **O<sub>2</sub>**, **CO<sub>2</sub>** and  $H^+$  in the arterial blood which then ensures relatively constant levels of these important substances in the **interstitial** fluid.
- For **O<sub>2</sub>**, one needs an adequate supply to meet cellular **metabolic** requirements. For **CO<sub>2</sub>** and  $H^+$ , one needs to maintain the **acid-base** status of the body's cells

- ❖ The **respiratory** system provides a rapid, but usually incomplete, compensation for acid-base disturbances through altered partial pressure of **CO<sub>2</sub>**. (**PCO<sub>2</sub>**).
- ❖ Changes in the levels of **O<sub>2</sub>**, **CO<sub>2</sub>** and H<sup>+</sup> in the blood cause compensatory changes in the level of

## **7.2 The side effects of drugs on the normal functioning of nervous and endocrine systems**

- ❖ a small Make group as per the instruction of your teacher and research about the effects of drugs (smoking, alcohol use, chewing khat and cannabis) on the normal functioning of the nervous system and endocrine system.
- ❖ You are advised to prepare a questionnaire and an interview for drug users and health professionals in your locality. Report your findings to the class.