

- The fossil record shows that following each mass extinction many new species appear.

9. Evidence from biochemistry and DNA analysis

Chimpanzees and humans share identical amino acid sequences in several enzymes (proteins) found in their respiratory systems. This shows that the DNA base sequence code for these proteins is the same in both species.



Overall, humans and chimpanzees have 98.4% of DNA in common. This and other DNA evidence suggests that humans and chimpanzees shared a common ancestor about 4–5 million years ago. This common [extinct] ancestor was quite different from

both modern humans and chimpanzees. Biologists have established evolutionary trees of organisms based on DNA sequences. These evolutionary sequences show the importance of DNA mutations in the process of evolutionary change.



- The great similarities of some enzymes and DNA of chimpanzees and humans supports evolution, as they point to a recent common ancestor that gave rise to humans and chimpanzees.

Natural selection

In the 1830s Charles Darwin went on a 5 year voyage around the world on a naval ship (*HMS Beagle*). He visited South America, the Galapagos Islands, Australia and South Africa. During the voyage he collected specimens of animals and plants and studied the geology of the places he visited. He made numerous observations of animal anatomy and behaviour and he also collected many fossils. He became convinced that organisms have

... and behaviour and he also collected many fossils. He became convinced that organisms had gradually changed over the long period of Earth's history. Over the next twenty years he used these studies and other collected information to develop a theory to explain the process of evolutionary change. This theory is called the **theory of natural selection**. Independently, Alfred Wallace developed a similar theory.

The theory of



The theory of natural selection

The main points of Darwin's and Wallace's theories are:

1. There is a natural variation in **characteristics** within the population of any species. For example, humans have different hair colour, eye colour, height and many other characteristics. In kookaburras there is a natural variation in beak length, flight muscle strength and claw length.
2. In nature, organisms **struggle to survive**. A herbivore such as an antelope must eat



sufficient grass each day to remain healthy. It must be fast enough to escape from hunting lions. Slow runners may be more readily captured. In times of drought the weaker individuals may die from starvation. This struggle for survival also keeps the population numbers in check. A rapid population rise leads to less grass for each individual. The rise in population also leads to more food for carnivores and they then begin to bring the population of antelopes under control. Disease also keeps a population in check.



3. Organisms with favourable characteristics in a given environment will survive to reproduce. An organism that fails to reproduce is said to be 'reproductively unfit'. The organisms with the favourable characteristics have a better chance in competing for available food and water. Reproductive fitness does not necessarily correlate with physical fitness.



4. The population of future generations of a species will therefore contain a **greater proportion** of individuals who have inherited these favourable characteristics.
5. Gradually the **preservation of favourable characteristics** leads to a change in the characteristics of the natural population. As long as the environment does not change, the species becomes better adapted to its environment. The environment has effectively selected certain characteristics for survival. This is also called *survival of the fittest*.



Survival of the fittest.

Worked example

Q Darwin studied the various finch populations on the different, distant islands of the Galapagos off the coast of South America. The finches were similar in many ways to the mainland finches but on each island there were different finch species. The different finch species varied in their beak shape, body size,



habitat, food requirements and reproductive behaviour. How did Darwin account for these differences?

- A Darwin explained the differences as follows:
- He concluded that the different species of finch on each island were the result of different environmental selecting agents in operation.



- He believed that the ancestors of these finches came from the mainland.
- Within this original population there was a natural variation in characteristics.
- As they migrated to different islands the ancestral finches found quite different environments. Some islands were drier, with tough, drought-resistant plants. Some had different types of shrubs and trees with different fruits and seeds. Each island had different insect populations or sources of food.



- These different environments selected different finch characteristics for survival. The fittest individuals on each island survived and reproduced.
- Over time the population of finches changed on each island. With limited chances of contact due to **geographical isolation**, the finches on each island eventually became different species with different body structures and breeding behaviour.



Modern views of evolution

Scientific theories change as new evidence becomes available. This has happened to Darwin's and Wallace's theories of natural selection. Since Darwin's time, considerable genetic evidence has been collected, which helps to explain how **gene mutations** can lead to evolutionary change.



Gene mutations that occur to the DNA in sex cells can be passed on to the offspring. Some of these gene mutations result in favourable characteristics, while others are unfavourable. These changes lead to further

variation within a species. In some environments these new variations are beneficial and are selected for survival. Over time the population changes so the favourable genes are more common in the gene pool.



Humans

Humans or *Homo sapiens* are the only living members of the genus *Homo*. Together with chimpanzees and apes, they are classified as primates within the larger vertebral class called mammals. All placental mammals feed their young with milk produced from mammary glands. During pregnancy the foetus is attached to the wall of the uterus by a special tissue called the placenta. In this section we will examine some important body systems that humans share with other mammals.



Glossary

Antibodies—proteins produced by the immune system that immobilise and destroy pathogens

Antigens—substances or microbes that stimulate the body's immune response

Cerebellum—part of the brain (at the back of the head) controlling involuntary movements and balance

Cerebrum—part of the brain that controls



higher order thinking, the emotions and voluntary movements.

CNS—central nervous system, comprising the brain and spinal cord

Connector neurones—neurones in the spinal cord that transfer information between sensory and motor neurones

Endocrine system—a control and coordination system that produces chemical messengers called hormones in ductless glands



Lymphocytes—specialised white blood cells involved in the immune system; some produce antibodies and others produce memory cells

Motor neurones—carry nervous impulses to muscles or glands

Pathogen—disease-causing microorganism

Phagocytes—a type of white blood cells that engulf and destroy microbes

Placenta—special tissue linking a developing foetus to the uterine wall of its mother

Sensory neurones—carry electrical impulses from sense organs towards the CNS



Coordination systems in humans

The human body is a complex system of tissues, organs and organ systems. These organ systems collectively function to satisfy the needs of all cells. Such a complex system requires coordination, otherwise the human body cannot function efficiently.

Communication and control systems are needed to ensure that all body systems are coordinated. The two control and coordination systems that we examine are:



- the **nervous system**—the brain is connected to the rest of the body by nerve fibres that transmit and receive information as electrical signals;
- the **endocrine system**—various glands produce chemical messenger molecules



called hormones that control various bodily processes.

The nervous system

The nervous system consists of a network of nerve tissues which transmit electrical information from one site to another.

Nervous tissues are composed of nerve cells called neurones. The nervous system is composed of two parts. These are:



- ... parts. These are:
- the central nervous system (CNS) which consists of the brain and spinal nerve cord;
 - the peripheral nervous system which consists of nerves that connect the CNS to the rest of the body.

a. Structure and types of neurones

Each neurone consists of a cell body with radiating fibres called dendrites. In many types of neurones there is one longer and thicker fibre called the axon. The axon is covered in a fatty insulating layer called the myelin sheath. It prevents nervous impulses from crossing over to neighbouring neurones.



- Axons conduct electrical impulses *away* from the cell body.
- Dendrites conduct electrical impulses received from another neurone *towards* the cell body.

Neurones can be classified into three main types.

- **Sensory neurones**—these neurones carry electrical impulses towards the central nervous system. Our sense organs (eg. the tongue, eyes, ears, skin) have sensory receptors that contain many sensory neurones. They transmit information into the spinal cord.



- **Connector neurones**—these neurones are part of the CNS and are located in the spinal cord. They receive information from the sensory neurones. Some of this information is relayed up the spinal cord to the brain. Other information may be

relayed immediately to muscles (or glands) along motor neurones.

- **Motor neurones**—these neurones carry electrical impulses away from the CNS towards muscles or glands, which then respond. Muscles contract and glands release their hormones.



Figure 3.19 shows the typical structure of the three common types of neurones.

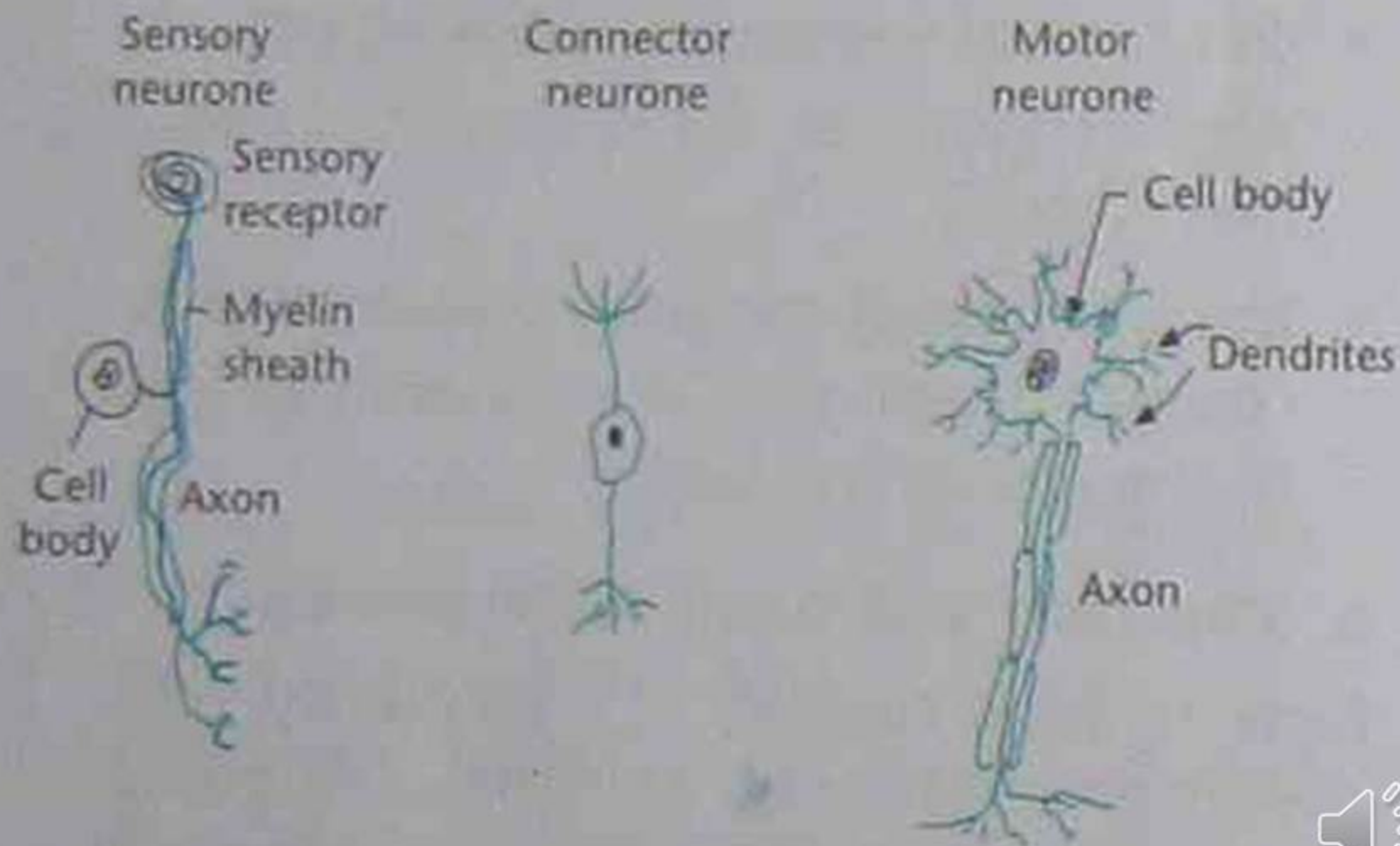


Figure 3.19 Three common types of neurones



b. Structure of the central nervous system

The central nervous system consists of the brain and spinal nerve cord. They are protected by layers of fluid, membranes and bone tissue.

- The brain is protected by the skull.
- The spinal nerve cord is protected by the vertebral bones—nerves from the body enter the spinal cord through small gaps between the vertebrae.



between the vertebrae.

The brain is a control centre. Information received is processed and messages are sent by the spinal cord to various muscles and glands. Figure 3.20 shows some of the important parts of the brain.

Table 3.2 summarises the functions of the parts of the brain.

c. The peripheral nervous system

Information is relayed from the CNS to the body via the peripheral nervous system. Part of this system involves **voluntary** movements and part involves **involuntary** movements.



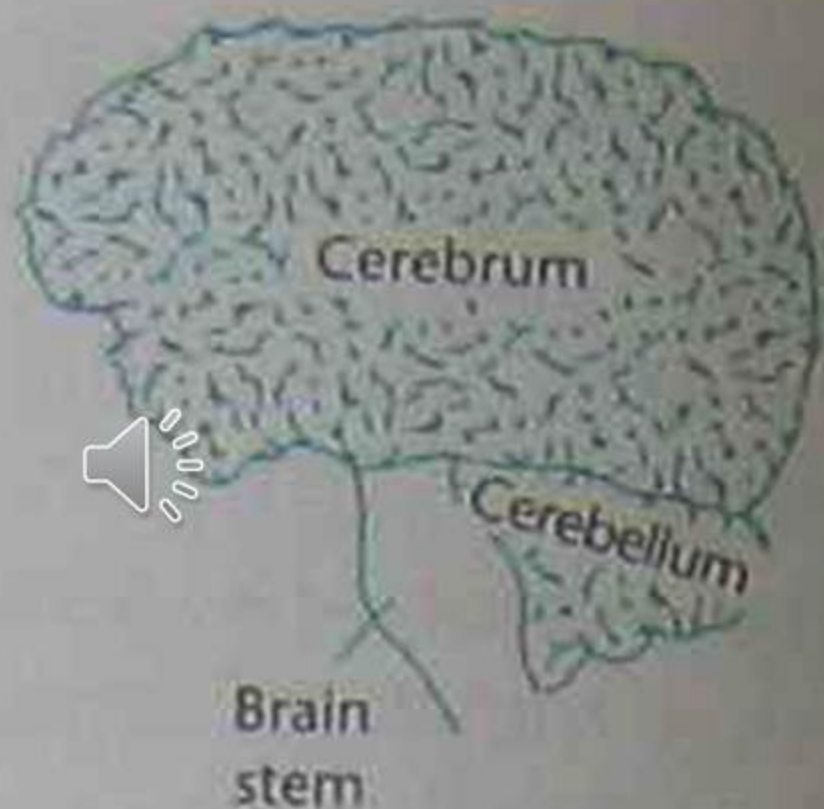


Figure 3.20 Parts of the brain

Table 3.2 Functions of the parts of the brain

Part	Function
Cerebrum	<ul style="list-style-type: none"> • composed of two halves • controls voluntary movements • controls memory, intelligence, behaviour, emotions, speech, vision, smell, touch, hearing
Cerebellum	<ul style="list-style-type: none"> • controls muscles involved in involuntary movements such as balance and fine motor control
Brain stem	<ul style="list-style-type: none"> • connects the brain to the spinal cord; information sorting centre • control centre for breathing, heart rate and swallowing • the hypothalamus (at the top of the brain stem) controls thirst and temperature



- The 43 pairs of **voluntary nerves** from the brain and spine connect to the muscles and sense organs in the head and body. Voluntary movements of the arms, leg and head are controlled by these nerves.
- The system of **involuntary nerves** regulates many functions including:
 - heart muscle control
 - iris muscle control
 - bladder and bowel muscle control (can be controlled with training)
 - responses to danger.



- The body has various automatic (involuntary) movements called **reflex arcs**. If a sensory neurone is stimulated, messages are sent via the connector neurones in the spinal cord direct to the motor neurone and an **effector** muscle or

gland. This leads to a rapid response that is important in many situations.



Example

If you tread on a sharp thorn with bare feet your body immediately responds by raising your foot away from the danger. This response is not controlled by the brain, although the brain does register the event and the pain associated with it.

Figure 3.21 shows an example of the movement of nerve impulses in a reflex arc.

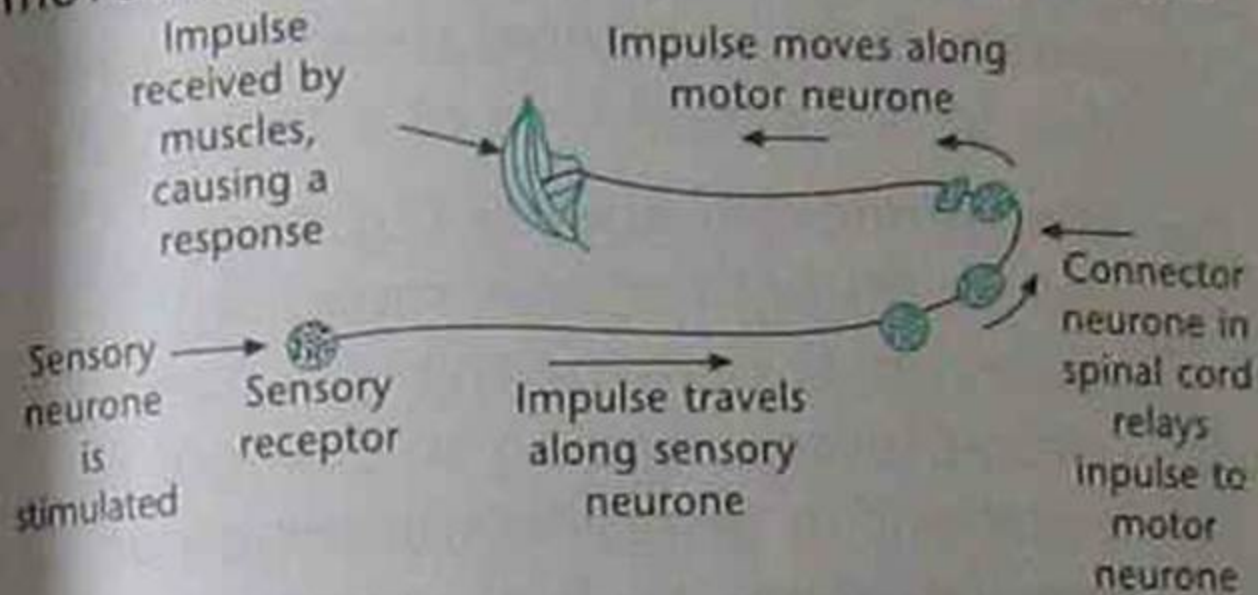


Figure 3.21 Nerve impulse movement in a reflex arc