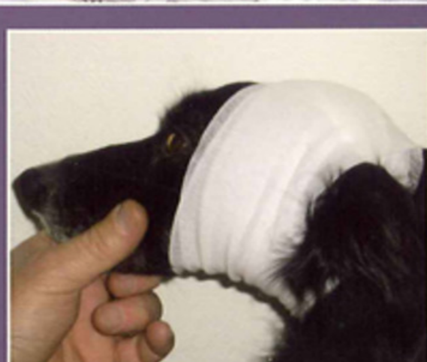
SUE DALLAS

Animal Biology *and* Care

SECOND EDITION







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Second Edition

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Preface

The increasing need for competence and understanding of animal care, both in the home and the work place, were the motivation for writing this book. It is intended as a foundation text for those on animal care, nurse auxiliary and veterinary care assistant courses. I hope that it will also prove of value to a wider range of readers, giving them a useful and enjoyable introduction to the background required, and the skills to develop, when considering the care of any animal.

The book seeks to provide information in a readily accessible layout, and is illustrated with line drawings and photographs. With a better understanding and knowledge of the care required by animals, injury and ill health can be better avoided or managed. The basic principles of nursing and care remain unchanged whether carried out at home, in the work place or within a veterinary practice. Methods for the control or elimination of disease are the same whether one is dealing with a single animal or a large group, for example in a kennel, cattery or animal collection.

The first edition concentrated on the biology, husbandry and care of mammals. This has now been expanded to include more detail on small mammals, birds and fish. Sections on legislation, pet travel, nutrition and parasites have also been updated and/or expanded, providing more detailed information.

The book is divided into three sections, each concentrating on a specific area:

- Section 1 – Animal biology. This introduces the reader to basic cell and tissue structure through to organ structures, systems and function.
- Section 2 – Animal health and husbandry. This takes the reader through the basic requirements for animal health, detailing welfare, care, husbandry, disease recognition and its control.
- Section 3 – Nursing. This covers the nursing procedures for an animal, both before and after professional attention from a veterinary surgeon, with an introduction to medical terminology in common use.

Many thanks go to the staff at Blackwell Publishing for their continued guidance, to family and friends, particularly Peter Roe and David Williams, for their support and encouragement throughout the writing process.

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Section 1
Animal Biology

Chapter 1
Cells and Basic Tissue

Biology – the study of life and living organisms

But what is life?

This is best answered by stating what distinguishes a living organism from a non-living organism. In order to be considered alive, the following are essential:

- *Growth* – from within by a process which involves the intake of new materials from the outside and their incorporation in the internal structure of the organism.
- *Movement* – the organism is capable of moving itself or a part of itself.
- *Excretion* – the removal of the waste products of metabolism.
- *Eating* – taking in materials to maintain life and growth.
- *Responsiveness* – to stimuli in its surroundings.
- *Release of energy* – in a controlled and usable form.

> Therefore considering units of life:
>
> *Cells* form . . .
> *Tissues*, and tissues form . . .
> *Organs*, and organs have a . . .
> *Function* to perform in the living organism!

The cell is the functional unit of all tissues and has the ability to perform individually all the essential life functions. Within the various tissues of the body, the constituent cells show a wide range of specialisations. However, all cells conform to a basic model of cell structure.

The diversity of cells

All cells are not identical (Fig. 1.1) but all have the same basic features:

- Chromosomes
- Mitochondria

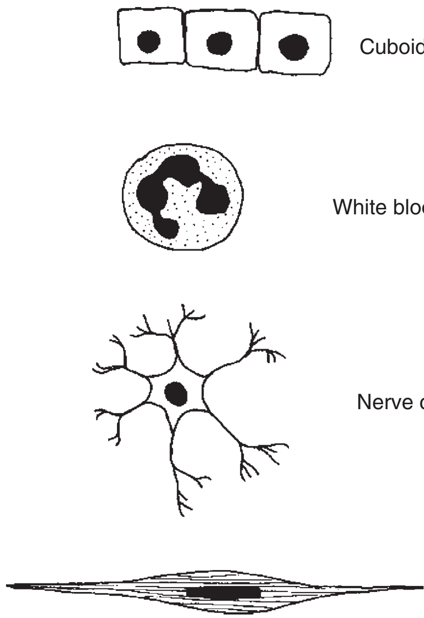

Fig. 1.1 Diversity of cells from their basic form.

- Endoplasmic reticulum
- Ribosomes

The above are common to virtually all cells but the shape, form and contents of individual cells show much variation. The structural characteristics of a particular cell are closely related to its functions.

- *Epithelial cells* – have a shape and form that makes them most suitable for lining the surface of the body and the organs and cavities within it.
- *Glandular cells* – are responsible for producing some kind of secretion, for example mucus to lubricate between tissues.
- *Osteoblasts* – produce bone tissue.
- *Erythrocytes* (*red blood cells*) – have a shape designed to hold the red pigment haemoglobin which conveys oxygen around the body. In order to do this, they are one of the few cells in the body which no longer contain a nucleus.
- *Nerve cells* – or neurones, have slender arm-like processes which will transmit electrical impulses through the nervous system to reach the whole body.
- *Muscle cells* – are also capable of electrical activity accompanied by a muscle contraction for body movement.

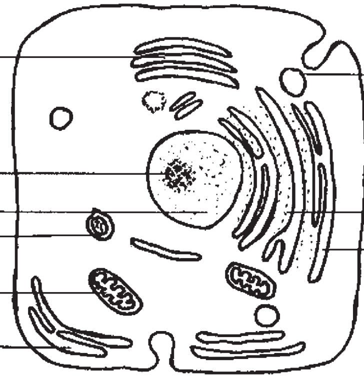

Fig. 1.2 Basic cell structure.

Cells

Cells have the same basic structure no matter what their function is or what organism they are found in (Fig. 1.2). Therefore the single cell which forms the body of an amoeba and the brain cell of a dog have certain features in common. All cells contain:

- A *nucleus* – to control the cell's activities
- *Cytoplasm* – a jelly-like material to support organs
- *Cell membrane* – this encloses the cytoplasm in which lies the nucleus

These three parts make up *protoplasm* – living matter.

For life, cells require:

- Food for energy
- Water (body fluid) to hydrate the cells
- Oxygen to all cells
- Suitable temperature in which to live

The nucleus

At least one nucleus is found in the cells of all organisms. The nucleus of a cell contains rod-shaped objects called *chromosomes.* These are only visible when a cell is about to divide into two. Chromosomes contain a complex chemical called *deoxyribonucleic acid (DNA)*. DNA controls the development of the features that an organism inherits from its parents. In other words, it contains the chemical 'instructions' for making an organism.

The cell membrane

The cell membrane is 0.00001 mm thick and forms the outer boundary of the cell. It is here that all exchanges take place between a cell and its surrounding environment. In a manner which is not yet fully understood, this membrane allows certain chemicals to pass in and out of the cell but prevents the passage of others (referred to as *osmosis*). As a result, the cell membranes are said to be *selectively permeable*.

The cytoplasm

The term *cytoplasm* refers to all the living substances of a cell except the nucleus. Cytoplasm is a jelly-like material containing a large number of important substances, many of which are concerned with metabolism.

- *Organelles* – are the structures visible within the cell other than the nucleus.
- *Mitochondria* – are one of the most important organelles, where chemical reactions of respiration take place. This is the release of energy for cellular function.
- *Rough endoplasmic reticulum* – has ribosomes on it that have been produced in the nucleus. Protein is synthesised here and the cell may transport it for use in the manufacture of digestive enzymes and hormones.
- *Smooth endoplasmic reticulum* – does not have ribosomes but is concerned with the synthesis and transport of lipids (fats) and steroids of body origin.
- *Ribosomes* – are granules rich in ribonucleic acid, in which protein is synthesised.
- *Centrosome* – lies near the nucleus and is made up of two *centrioles*. It is important during cell division and the formation of the cilia and flagella of certain cells (the slender projecting hairs for movement of single-celled organisms).
- *Lysosomes* – are dark round bodies containing enzymes responsible for splitting complex chemical compounds into simpler ones (known as *lysis*, meaning ‘to break up’) followed by digestion. They also destroy worn-out organelles within the cell. These destructive enzymes are stored in tubes in the cell called the *Golgi complex or body*.

Basic tissue

Tissues are a collection of cells and their products, which have a common fundamental function and in which one particular type of cell predominates.

- *Epithelial* – which forms a protective layer both inside and on the surface of the body. Examples of this tissue are skin, glands and the linings of the various body systems.
- *Connective* – which supports tissues and acts as a transport system to move materials vital to tissue cells around the body. Examples of this tissue are:
  - (a) loose connective tissue which surrounds organs
  - (b) dense connective tissue which has great strength and is found as tendons and ligaments
  - (c) blood which transports essential nutrients, gases, waste products, hormones and enzymes to and from all body cells
  - (d) cartilage and bone which provide shape and protection for organs and allow movement.
- *Muscular* – tissues concerned with movement of the skeleton, organ systems and the heart.
- *Nervous* – which transports messages to tissues, connecting the body as a whole for the required response.

Epithelial tissue

This tissue covers all surfaces of the body, both inside and out, be it a surface, a cavity or a tube. It is made up of a diverse group of tissues which are involved in a wide range of activities such as secretion of a special fluid, protection and absorption.

Depending on their function, the cells of this tissue will have a varied shape, structure and thickness. They are classified according to appearance:

- *Number of layers* – a single layer of these cells is called *simple epithelium*; more than one layer is called *stratified epithelium*.
- *Shape* of the cells involved.
- *Specialisations*, such as tiny hairs called cilia or special thickened surface tissue called keratin, which covers the nose and pads of the feet.
- *Glandular* – meaning it is involved in secretion. Secretions which go directly into the bloodstream are called *hormones* and are produced by glands of the *endocrine* or *ductless system*. If the gland has a duct it will secrete onto a surface and belongs to the *exocrine system*; for example, enzymes secreted by the pancreas.

The many and varied functions of epithelial tissue mean that it will take different forms. There are six main types.

Pavement – found lining surfaces involved in the transport of gases (lungs) or fluids (walls of blood vessels) (Fig. 1.3a).
Cuboidal – which lines small ducts and tubes like those of the kidney, pancreas and salivary glands of the mouth (Fig. 1.3b).
Columnar – located on highly absorbing surfaces like the small intestine for the uptake of nutrients (Fig. 1.3c).

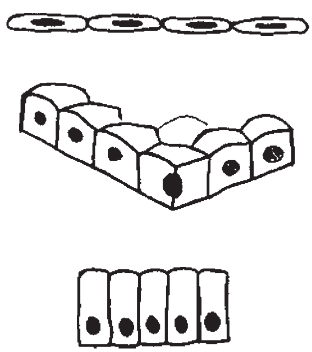

Fig. 1.3 Pavement, cuboidal and columnar tissue.

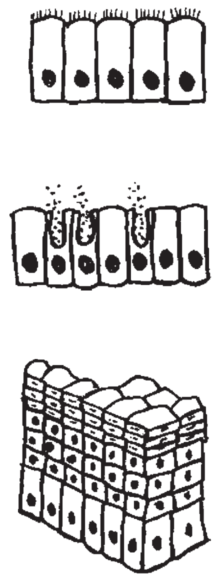

Fig. 1.4 Ciliated, glandular and stratified tissues.

Ciliated – has tiny hair-like projections in parallel rows on the surface of the cell, which beat in a wave-like manner, moving films of mucus or fluid in a particular direction. For example, in the respiratory airway (trachea), they remove unwanted inhaled materials (Fig. 1.4a).
Glandular – which secrete a special fluid containing hormones or enzymes (Fig. 1.4b).
Stratified – this type of epithelium has two or more layers of cells. Its function is mostly protection. Found lining the mouth cavity or as skin (Fig. 1.4c).

Connective tissue

This tissue binds all the other body tissues together. It supports them and acts as a transport system for the exchange of nutrients, metabolites and waste products between tissues and the circulatory system (Fig. 1.5).

Connective tissues occur in many different forms with a wide range of physical properties.

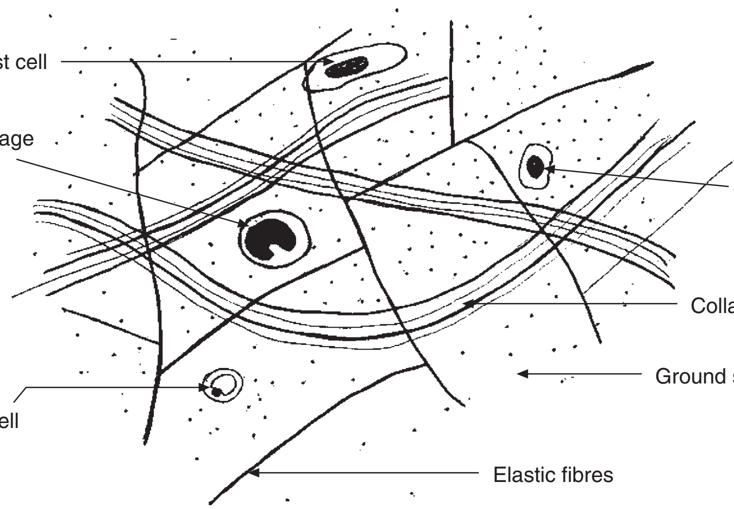

Fig. 1.5 Connective tissue.

- *Loose* connective tissue acts as a type of packing material between other tissues with specific functions.
- *Dense* connective tissue provides tough support in the skin.
- *Rigid* forms of connective tissue, like cartilage and bone, support the skeleton.

Connective tissue also has functions including the storage of fat in adipose tissue, fighting infection with micro-organisms and tissue repair.

Connective tissue has two components.

(1) *Cells*:
  - fibroblasts for repair and maintenance of the tissue
  - fat-storing cells
  - defence and immune function cells called *macrophages*.

(2) Material called *ground substance* which holds together other materials to make up tissue and looks like a semifluid gel.

Connective tissue is composed of two types of fibre.

- *Collagen* – produced by the fibroblasts, is not elastic but has great tensile strength. Tendons by which muscles are attached to bones are composed of collagen fibres.
- *Elastin* – has great elasticity and is found in ligaments which bind bones of the skeleton together.

Connective tissue can be described as a mixture of fibres in different proportions. Its efficiency in binding structures together is achieved by the special grouping of proteins in the ground substance. The particular type and abundance of fibre present depend on the stresses and strains to which the tissue is normally subjected.

Blood

This is a highly specialised tissue consisting of several types of cell suspended in a fluid medium called *plasma*. The cellular constituents consist of:

- Red blood cells (erythrocytes)
- White blood cells (leucocytes)
- Platelets (thrombocytes)

Blood has a varied structure and performs a wide range of functions. One of its main functions is that of transportation, of the red blood cells around the body and all the materials in the plasma. Blood is considered a tissue because it connects all the cells in the body together.

Live animals constantly absorb useful substances like oxygen and food, which must then be distributed throughout their bodies. They produce a continuous stream of waste materials, such as carbon dioxide, which must be removed from their bodies before they reach harmful levels. The distribution of food, oxygen and other substances throughout the body and the removal of any wastes is performed by this transport system tissue.

Composition of the blood

Fluid called *plasma* makes up about 60%. Cells and other material in transit make up the remaining 40%.

If a sample of blood (mixed with an anticoagulant to stop it clotting) was put into a centrifuge and spun to separate out the component parts, it would show at the top of the tube the fluid part (plasma), then the platelets (cell fragments), then the white blood cells and finally the red cells (Fig. 1.6).

Plasma

This is mainly water containing a variety of dissolved substances which are transported from one part of the body to another. To give a few examples, food materials (glucose, lipids and amino acids) are conveyed from the small intestine to the liver; urea from the liver to the kidneys; hormones from various ductless glands to their target organs. Cells are constantly shedding materials into the blood which flows past them and removing materials from it. Plasma provides the medium through which this continual exchange takes place.

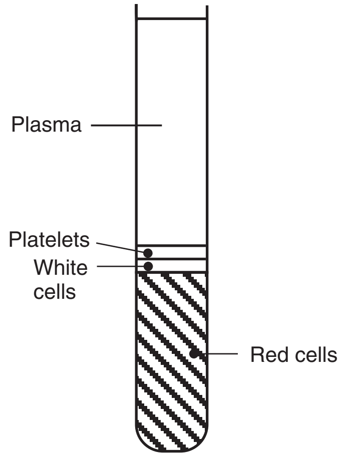

Fig. 1.6 Blood separated into layers.

PLASMA	**SERUM**
FIBRINOGEN (protein for clotting) **plus** water, protein, glucose, lipids, amino acids, salts, enzymes, hormones and waste products	Contains water, protein, glucose, lipids, amino acids, salts, enzymes, hormones and waste products **but** no proteins for clotting (these have been used up)

Plasma carries many more products than the diagram shows, including the plasma proteins called albumin, globulin and fibrinogen. Fibrinogen plays an important role in the process of blood clotting. When it has been used up by clot formation then the fluid part of blood seen at the site of injury is called *serum*. Therefore, serum is plasma with the fibrinogen removed. About 92% of blood is made of water and this same water can be forced into the tissues. It is then called *tissue fluid* because of its location.

It is important to realise that plasma and the tissue fluid derived from it form the environment which keeps body cells alive. In a sense, these fluids are equivalent to a pond or fish tank in which both single-celled organisms and multicelled organisms live and are supplied with their food and oxygen and into which they excrete waste.

Red blood cells (erythrocytes)

These are produced in the red or active bone marrow. The main function of red blood cells is to carry oxygen from the respiratory organ to the tissues and their structure is modified accordingly. These cells have had their nucleus removed, with the result that the cell is sunk in on each side, giving it the shape of a biconcave disc. It is surrounded by a thin elastic membrane and the interior of the cell

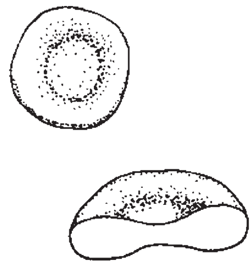

Fig. 1.7 Cross-section of a red blood cell showing its biconcave shape.

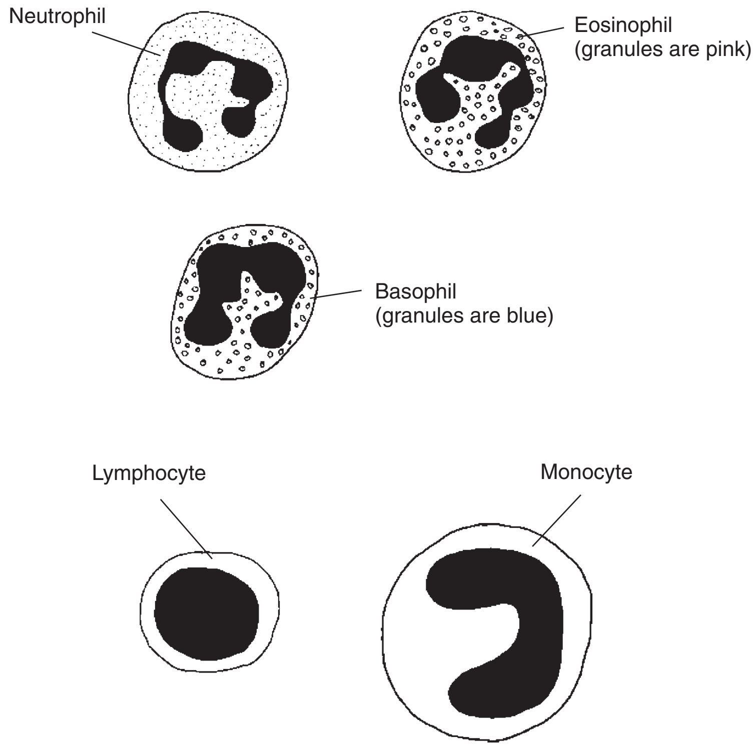

Fig. 1.8 White blood cells.

is filled with the red pigment haemoglobin which combines with and carries oxygen (Fig. 1.7).

White blood cells (leucocytes)

The white cells are fewer in number and have a very different role to play. They fall into two groups (Fig. 1.8).

Granulocytes (granules in the cytoplasm). These are produced in the bone marrow.

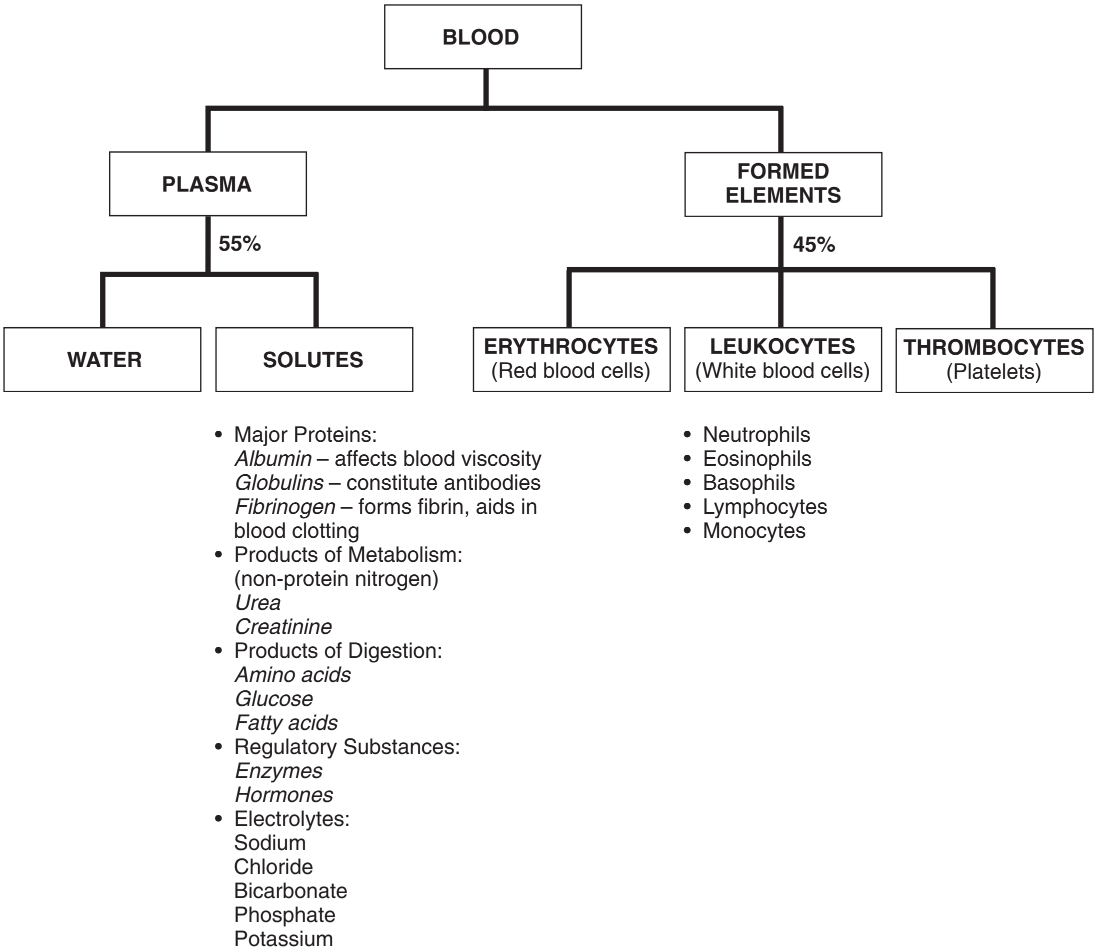

Fig. 1.9 Blood components.

- *Neutrophils* – phagocytic cells
- *Eosinophils* – respond to allergies
- *Basophils* – promote inflammation for healing of tissue

Agranulocytes (no granules in their cytoplasm). Produced in the bone marrow or lymph system.

- *Lymphocytes* – support the immune system
- *Monocytes* – phagocyte cells

Phagocyte or *phagocytic* means 'cell eater'. These cells eat or engulf other cells / materials that may be harmful and destroy them. Red cells will remain in the bloodstream to perform their role of oxygen carrier but white cells will only use the bloodstream as a transporter from their site of origin to the capillaries where they will push through the wall of the blood vessel and into the tissue spaces. Those that are phagocytic will gather in and around wounds and destroy bacteria and any other harmful material. In this manner the cells assist in 'fighting infection'.

Bone and cartilage

There are two kinds of skeletal tissue, bone and cartilage.

Bone

This tissue is closely related to connective tissue, in that it consists of cells embedded in an organic matrix (ground substance). However, this matrix is comparatively hard. The cells of bone are called *osteoblasts* and *osteoclasts*.

Cartilage

This is a dense, clear, blue/white material which provides support for the body and can be elastic or rigid. Found mainly in joints, it has no blood vessels but is covered by a membrane called the *perichondrium* from which it receives its blood supply. The cells of cartilage are called *chondroblasts*.

There are three types of cartilage:

- *Hyaline* – the cells for hyaline production are called *chondrocytes*. They lie within a hyaline matrix with collagen fibres running through. Hyaline is a smooth tissue and forms articular joint surfaces for bones and the C-shaped rings of cartilage that keep the trachea open for air passage into the lungs.
- *Fibrocartilage* – this is stronger than hyaline but with a similar base structure that contains more collagen fibres. It surrounds the articular surface of some bones, for example in the hip joint (acetabulum) and the shoulder joint (glenoid cavity), and is also found in the stifle or knee joint as pads of cartilage called *menisci*.
- *Elastic* – this has a hyaline matrix and many elastic fibres which provide its elastic properties. It is found in the ear flap (pinna) and in the larynx area of the throat.

Muscular tissue

The ability to contract is very well developed in this type of tissue. Muscle cells are usually long, thin and thread-like and are often called *fibres*. There are three main types of fibres:

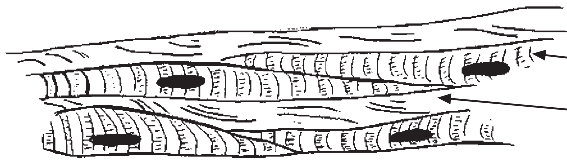

Fig. 1.10 Skeletal (striated) muscle fibre.

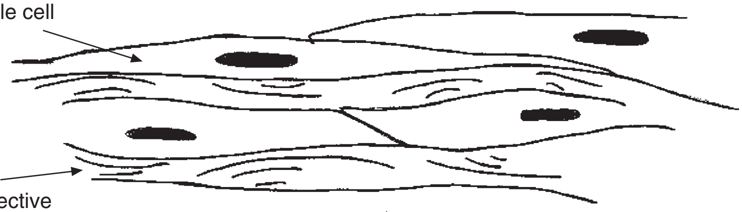

Fig. 1.11 Smooth (non-striated) muscle fibre.

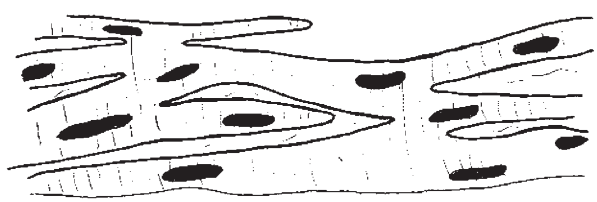

Fig. 1.12 Cardiac muscle fibre.

- *Skeletal* (also called voluntary and striated) (Fig. 1.10)
- *Smooth* (also called involuntary, non-striated and visceral) (Fig. 1.11)
- *Cardiac* (Fig. 1.12)

Skeletal muscle

Found in muscles attached to the skeleton. The cells are cylindrical and vary from about 1 mm to 5 cm in length. Since skeletal muscles respond to the will of the animal, the cells are also called *voluntary* muscle cells.

Skeletal muscles are formed of parallel muscle cells (*fibres*) held together in small bundles by connective tissue. These are collected into larger groups which are also enclosed in connective tissue and ultimately form the muscle which is surrounded by yet more connective tissue commonly called the *muscle sheath*.

When muscles are close to one another, the sheaths may thicken to form an *intermuscular septa*.

All the connective tissue within and around the muscles continues into the connective tissue of the structure to which the muscle is attached, i.e. bone.

Sometimes the muscle appears to attach directly but usually the connective tissue leaves the muscle as a fibrous band known as a *tendon* (i.e. Achilles tendon on the point of the hock) or as a fibrous sheet called an *aponeurosis* (i.e. the sheet of muscle and connective tissue called the diaphragm).

Some muscles are named according to their shape, some according to their functions and others according to their position in the body.

Under the microscope, skeletal muscle cells look striped (they have *striations*).

Smooth muscle

In direct contrast to skeletal muscle, which is specialised for relatively forceful contractions of short duration and under voluntary control, smooth muscle is specialised for continuous contractions of little force but over a greater section of muscle tissue. For example, the smooth muscle of the intestinal wall contracts in continuous rhythm, moving food through the tract by *peristaltic action*.

These fibres are spindle shaped and about 0.5 mm in length or shorter. Under the microscope they look smooth. Only small amounts of connective tissue bind them together to form sheets or layers of muscle tissue. They may also be called *involuntary* muscles because they are not controlled by the will of the animal. These fibres are found in the muscle of organs, hence the alternative name of *visceral* muscle.

Cardiac muscle

This muscle produces strong contractions using a lot of energy and is only found in the heart. The contractions are continuous. In order for this to take place, the fibres have junctions or connections with surrounding fibres which allow very rapid contractions of all nearby tissue. The cells are elongated and are the only muscle cells which frequently branch. They are held together by only very small amounts of connective tissue.

Nervous tissue

The function of this tissue is to transmit electrical messages from one part of the body to another. As a result of this, the nerve cells are interconnected in a very complex way. The cells can transmit and sometimes store information because of this complex link-up with each other.

The cells are called *neurones* (Fig. 1.13) and they connect and communicate to form pathways so that the body can respond to information received. Neurones vary in size and shape depending on where they are in the nervous system. However, all neurones have the same basic structure. They consist of a large cell body containing the nucleus surrounded by cytoplasm, with two types of processes extending from the cell body: a single axon and one or more dendrites.

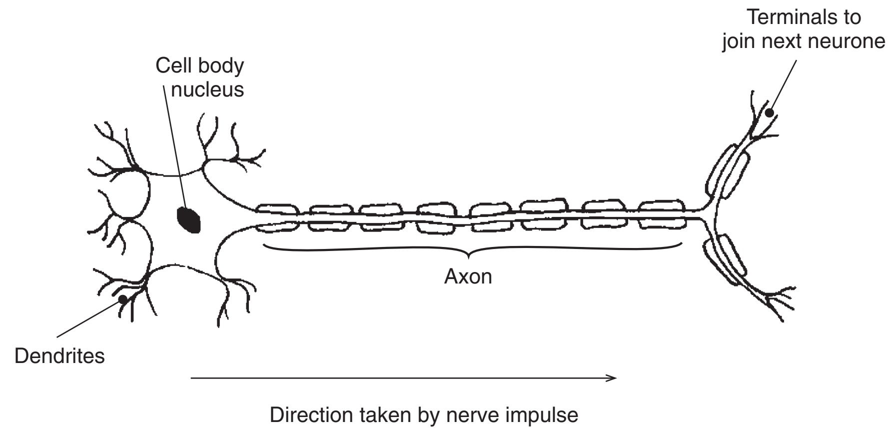

Fig. 1.13 A neurone.

Dendrites are branched, tapering processes which either end in specialised *sense receptors* (information) or form junctions (*synapses*) with neighbouring neurones from which they receive electrical stimuli, which is passed to the cells beyond.

Axons extend from the cell body as a tube-like structure of variable length, carrying stimuli or messages away to the next nerve cell.

Chapter 2

Movement of Materials Within the Body

Time now to look at the processes by which materials get into and out of cells. Exchanges can be examined under the following headings:

(1) Diffusion
(2) Osmosis
(3) Phagocytosis
(4) Active transport

Diffusion

This is the process of movement of molecules from a region where they are at a comparatively high concentration to a region where they are at a lower concentration, requiring no energy in its achievement. Diffusion will always continue until eventually the molecules are uniformly distributed throughout the system. This is very important in the movement of molecules and salts (electrolytes or ions) in and out of cells.

An example of this process is the cell's requirement for oxygen. It is continually being used up in respiration so the concentration of oxygen inside the cell will be lower than it is in the blood and tissue fluids as a result. Oxygen molecules will diffuse into the cell from outside. With carbon dioxide, the reverse is true: its concentration is highest inside the cells, where it is continually being formed. This results in carbon dioxide molecules diffusing out of the cells.

Anything that increases the concentration of a substance in the body will favour diffusion. Blood is involved here to carry away the diffused substance, so encouraging further diffusion.

Osmosis

This refers to the movement of water through a semipermeable membrane while expending no energy (Fig. 2.1).

Although the cell wall membrane is fully permeable to respiratory gases, it is not permeable to all substances. The nature of the membrane means that only molecules that are small enough will diffuse through it unimpeded. Larger molecules either penetrate slowly or not at all. The membrane is therefore called *semipermeable*, permitting the passage of some substances but not others.