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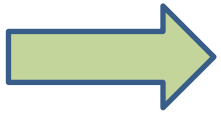

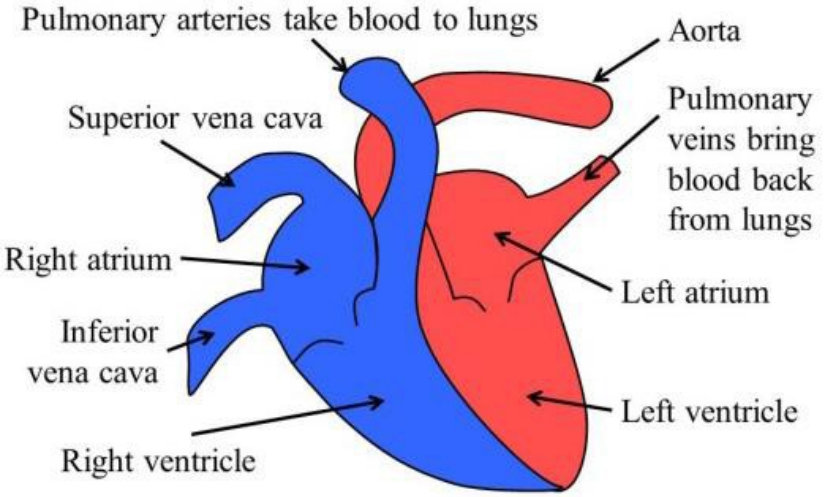

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2.1. Medical and Anatomical Terminology

Sally Schaffer & Louise Ainscough, School of Biomedical Sciences, Queensland University of Technology

2.1.1 Introduction

Becoming familiar with medical and anatomical terminology is the key to understanding the concepts in anatomy and physiology, so try to learn new words as they arise during your course.
Anatomy is the study of the ***structure*** of the body parts, whereas ***physiology*** is the study of the ***function*** of the body.

2.1.2 Medical Terminology

Most anatomy and physiology terms are built from two or more of the following three basic parts:

Prefix = The beginning of the word
Root = The main part of the word
Suffix = The end of the word

Table 2.1.2 shows you some examples of different prefixes, roots and suffixes.

Prefixes	**Root**	**Suffixes**
a/an- = without/not	*adip = fat*	*-aemia = in the blood*
auto- = self	*angi = vessel*	*-ase = enzyme*
dys- = disordered/difficult	*carcin = cancer*	*-cyte = cell*
endo- = within	*cardio = heart*	*-ectomy = removal/cut out*
epi- = upon	*cerebro = brain*	*-itis = inflammation*
hetero- = different	*crani = skull*	*-oma = tumour*
hom- = same	*erythr = red*	*-opathy = abnormal state*
hydro- = water	*haem = blood*	*-osis/ia = state/condition*
hypo- = under/below	*hepat = liver*	*-megaly = large*
hyper- = over/above	*leuco = white*	*-plasia = growth/development*
mega- = large	*myo = muscle*	
neo- = new	*nephr/reno = kidney*	
	neur = nerve	
	osteo = bone	
	path = disease	
	pulm = lung	

Table 2.1.2 Examples of some common prefixes, roots and suffixes

Let's have a go at putting some words together e.g. combining "hydro" and "phobia" we get the term hydrophobia, meaning a fear of water. If we combine "***cardio***" and "***megaly***" we get the term ***cardiomegaly***, meaning the enlargement of the heart. So a ***crani***al nerve is a nerve found in the skull. What do you think is the meaning of "hepatitis", "neoplasia" or "adipocyte"?

2.1.3 Anatomical Terminology

Anatomical position refers to a standard body position that is used universally as a reference point for the positions of the body structures. To assume the anatomical position:

- Stand straight
- Look forward
- Toes pointing forward
- Arms hanging to your sides
- Palms facing forward

Notice that the person in Figure 2.1.1 is standing in the anatomical position.

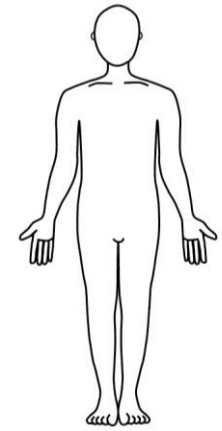

Figure 2.1.1. Anatomical position (Copyright, QUT)

2.1.4 Directional terms

Let's look now at some ***directional terms***. These are terms used to describe the position of one body part relative to another. For example, how can we describe the location of the shoulders in comparison to the head or stomach? The first pair of directional terms is ***superior*** and ***inferior***. Superior means towards the top, whereas inferior means towards the bottom. So the shoulders are superior to the stomach, meaning that they are closer to the top of the body than the stomach. See Figure 2.1.2.

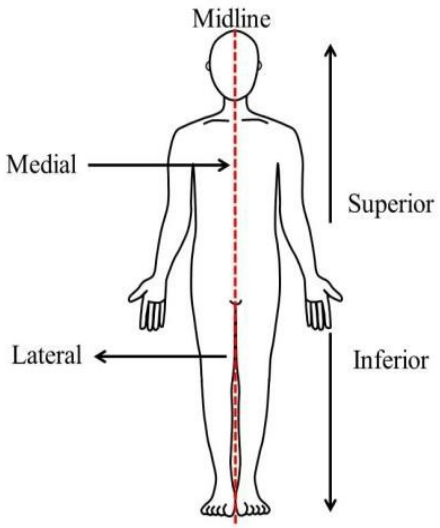

Figure 2.1.2. Some directional terms (Copyright, QUT)

We can also define the location of a body structure using the terms ***medial*** and ***lateral*** (Figure 2.1.2). Medial is towards the middle (the midline), and lateral means toward the sides. For example, the sternum (breastbone) is medial to the lungs, meaning the sternum is closer to the middle of the body than the lungs. The lungs are also lateral to the heart, meaning that the lungs are towards the side of the body when compared with the heart.

We can use the terms ***anterior*** or ***posterior*** as well as ***ventral*** or ***dorsal*** (Figure 2.1.3). Anterior and ventral both mean towards the front, whereas posterior and dorsal mean towards the back. The stomach is anterior (ventral) to the spine because it is closer to the front of the body than the spine. The heart is posterior (dorsal) to the sternum.

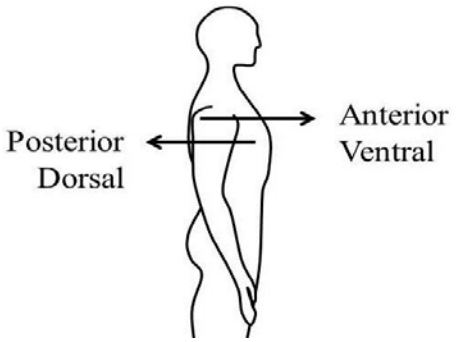

Figure 2.1.3 Some more directional terms (Copyright, QUT)

Body positions can also be described using the terms ***superficial*** and ***deep*** (Figure 2.1.4). A body structure is superficial if it is close to the surface and deep if it is away from the surface. So the skin is superficial when compared to the brain which is deep.

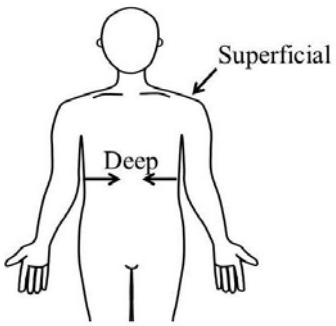

Figure 2.1.4 More directional terms (Copyright, QUT)

Our last directional terms are ***proximal*** and ***distal*** (Figure 2.1.5). A body structure is proximal if it is closer to a point of origin or attachment, and distal if it is further away from the point of origin or attachment. The point of origin for a limb is the place where the limb attaches to the trunk. So the hand is distal to the elbow because the hand is further away from the point where the arm attaches to the truck of the body. In contrast, the elbow is proximal to the hand because it is closer to the point where the arm attaches to the trunk.

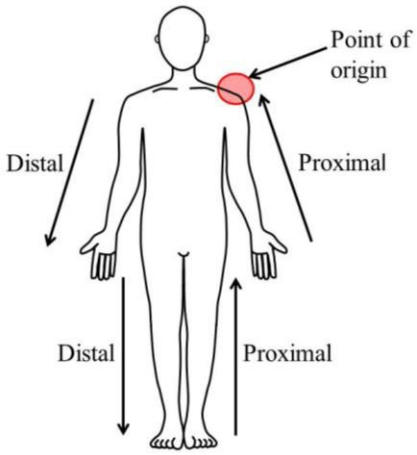

Figure 2.1.5 The last of our directional terms (Copyright, QUT)

2.1.5 Planes

Anatomists can divide the body into ***planes***. A ***plane*** is an imaginary line that passes through the body. There are three main planes. A ***sagittal*** plane divides the body into left and right sides (a ***midsagittal*** section would divide the body into two equal halves). A ***coronal*** or ***frontal*** plane divides the body into front (anterior) and back (posterior) regions. A ***transverse*** or ***horizontal*** plane divides the body into upper (superior) and lower (inferior) parts (Figure 2.1.6). Cutting the body along a plane produces a section e.g. a sagittal section of the brain.

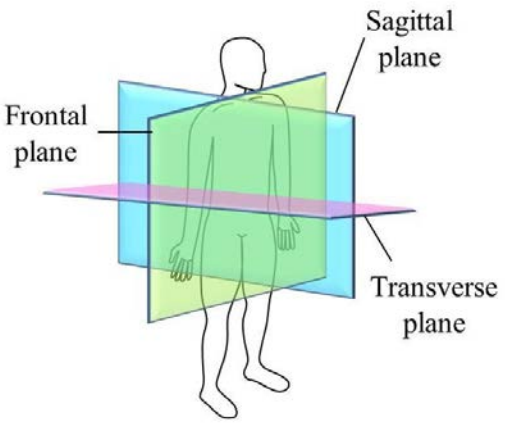

Figure 2.1.6 Planes of the body (Copyright, QUT)

2.1.6 Body regions

The body is divided into a number of major regions: cephalic (head), cervical (neck), trunk or torso and upper and lower limbs. The trunk consists of the thoracic (chest), abdominal (abdomen) and pelvic (pelvis) regions.

2.1.7 Body Cavities

The body can be divided internally into two body cavities. These cavities are closed to the outside and provide protection for our organs. Let's look firstly at the ***dorsal body cavity***.

The dorsal body cavity protects the organs of the nervous system. There are two subdivisions in the dorsal body cavity. The ***cranial cavity*** is within the skull and encases the brain. The ***vertebral cavity*** is within the vertebral column (backbone) and encloses the spinal cord.

We also have a ***ventral body cavity***, which has two subdivisions: the ***thoracic cavity*** and the ***abdominopelvic cavity***. The thoracic cavity is surrounded by the ribs and muscles of the chest. It encloses and protects the lungs and heart. The abdominopelvic cavity can be further subdivided into the ***abdominal cavity*** (containing digestive organs, spleen and kidneys) and the ***pelvic cavity*** (containing the bladder, reproductive organs and rectum). See Figure 2.1.7.

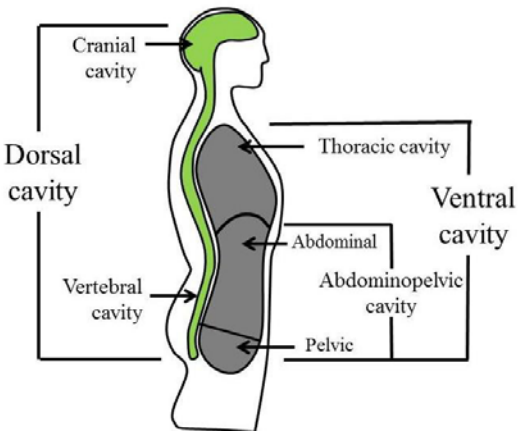

Figure 2.1.7 Dorsal and ventral body cavities and their subdivisions (Copyright, QUT)

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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2.2 Cells to Tissues

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2.2.1 Introduction

This resource aims to provide you with an introduction to the basic concepts associated with the structural organisation of the body. It further aims to briefly describe the properties of cells and how they contribute to formation of larger structures such as tissues.

2.2.2 Levels of Structural Complexity

There are many ***levels of structural organisation*** within the human body. In our body the simplest building blocks are atoms which combine to form more complex molecules. Molecules connect to form organelles, which work together to form cells, the smallest living units within the body. Cells may function individually but often group together to form structures called tissues. Complexity continues to increase as different tissue types come together to form organs, leading to organ systems and eventually the most complex structure – a living organism. See Figure 2.2.1.

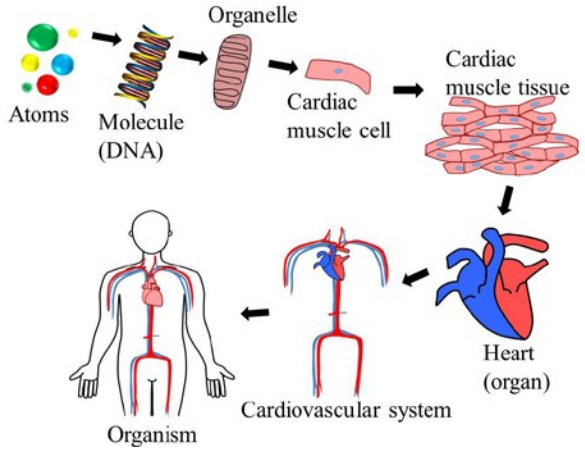

Figure 2.2.1 The levels of structural organisation within the human body (Copyright, QUT)

2.2.3 Atoms

Atoms are the simplest structures which make up all matter. They are very, very small! Atoms are made up of a central nucleus which contains positive particles, neutral particles and orbiting electrons, which carry a negative charge. Different atoms have a different number of electrons, which can sometimes move between atoms.

Atoms that lose or gain electrons are called ***ions*** (Figure 2.2.2). Ions are very important in maintaining various processes within our body. For example, electrical signalling within some cells in our body is driven by a gradient in concentration of two different ions, sodium (Na^+) and potassium (K^+).

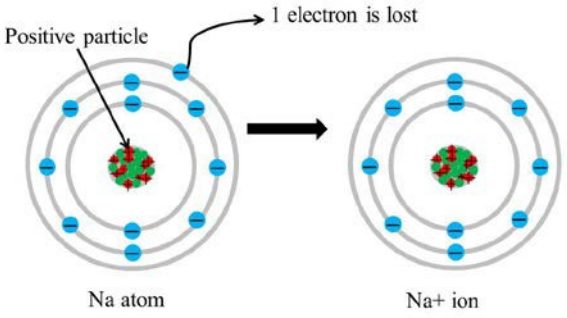

Figure 2.2.2 A sodium (Na) atom can lose an electron to form an ion (Na^+) (Copyright, QUT)

2.2.4 Molecules

A combination of different atoms makes up a ***molecule*** which is held together by chemical bonds e.g. each water molecule (H_2O) is made of two hydrogen (H) atoms and one oxygen (O) atom (Figure 2.2.3).

Our body is made up of two main groups of molecules - organic and inorganic. Inorganic molecules are typically small structures and contain little or no carbon (C). The two most important inorganic compounds in our body are water and salts e.g. NaCl (common salt). Organic molecules are larger and more complex and contain carbon. These molecules have important structural and functional properties. The major classes of organic molecules found in the human body are lipids (fats), carbohydrates (sugars), proteins and nucleic acids. The nucleic acids, better known as DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) carry all our genetic material in the form of genes.

Figure 2.2.3 A water molecule is made up of two hydrogen (H) atoms and one oxygen (O) atom (Copyright, QUT)

2.2.5 DNA to protein

Our genetic material in the form of DNA is the master blueprint for production of protein in our body – this determines our uniqueness and directs all growth and development of the body. In order to make a protein molecule from our DNA, the processes of ***transcription*** and ***translation*** occur (Figure 2.2.4).

2.2.5.1 Transcription

If we want to make a particular protein, a copy of a section of the DNA molecule in the cell nucleus (i.e. the genes which codes for this protein) is made in the form of messenger RNA (mRNA) which carries a "message" of the DNA information or code to form this protein.

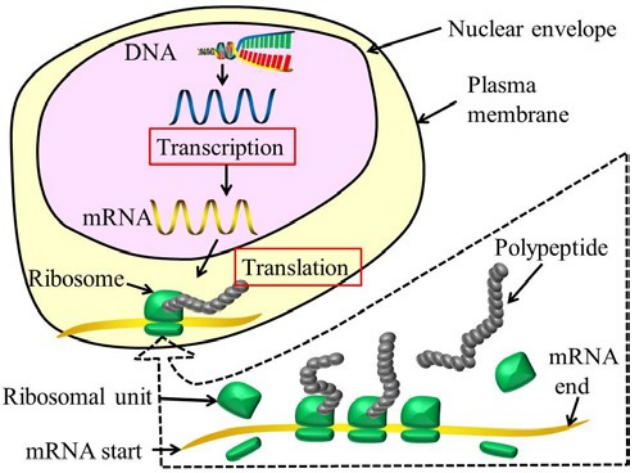

Figure 2.2.4 The process of transcription and translation result in the production of proteins according to the code on our DNA (Copyright, QUT)

2.2.5.2 Translation

mRNA delivers the message to the outside of the nucleus, where it binds to ribosomes. Ribosomes are structures involved in protein synthesis. Here the message is decoded, as the ribosomes move along the mRNA molecule and individual amino acids become attached via another type of RNA molecule, tRNA. Amino acids are the building blocks of proteins; amino acids join together by peptide (chemical) bonds, creating a polypeptide molecule or protein.

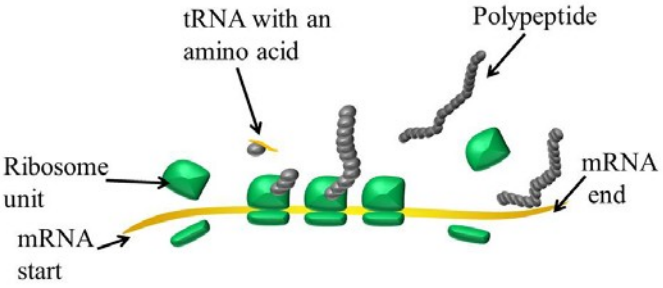

Figure 2.2.5 A more detailed view of translation (Copyright, QUT)

2.2.6 Enzymes

Cells produce a huge variety of proteins. Proteins have many different roles, some are structural (make structures e.g. hair) while others are functional (make things happen). ***Enzymes*** are a type of functional protein involved in metabolic processes which catalyse or speed up the breakdown (catabolism) and the building of molecules (anabolism) in our body, without being changed or used in the process (Figure 2.2.6). Without enzymes, reactions in our body would not occur fast enough for us to function effectively. (Refer also to sections 2.4.5 and 2.5.1).

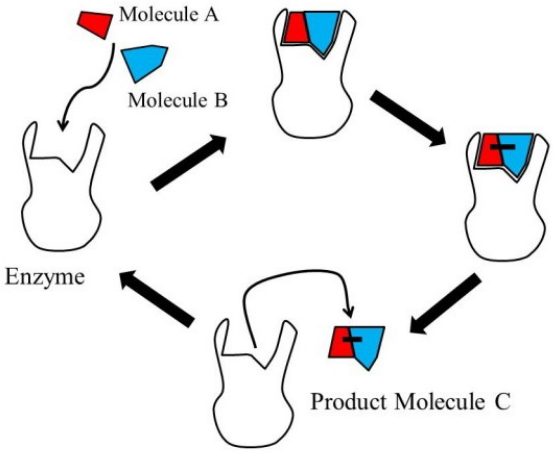

Figure 2.2.6 Enzymes help speed up the production of molecule C from molecules A and B (Copyright, QUT)

2.2.7 Energy storage

The energy released in the chemical bonds between atoms or molecules of lipids, carbohydrates and proteins can be used as cellular fuel to provide energy for all the reactions that happen in our body. This energy is stored in high energy bonds in the primary energy storage molecule in the body, ***ATP*** (adenosine triphosphate) (Figure 2.2.7).

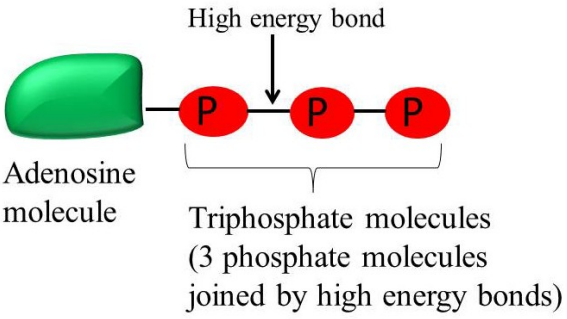

Figure 2.2.7 A diagrammatic representation of ATP (Copyright, QUT)

2.2.8 Cells

Cells are the smallest living component of the human body and we need a microscope to view them. The cells which make up our body have 3 main characteristics as shown in Figure 2.2.8.

- They are bound by a ***plasma membrane*** which keeps the contents of the cell separated from the rest of the body's fluid. This characteristic allows the cell to maintain its own unique environment (e.g. concentrations of ions).
- They contain ***cytoplasm***. This is the fluid within the cell which contains all of the organelles, and is contained by the plasma membrane.
- They usually have a ***nucleus***.

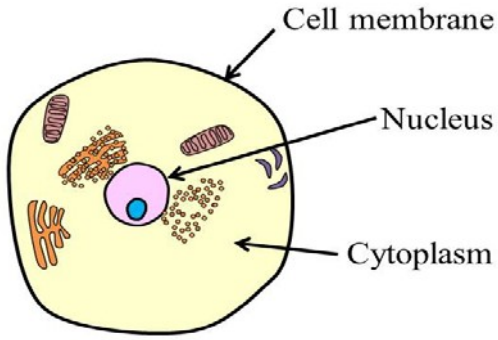

Figure 2.2.8 A typical human cell (Copyright, QUT)

2.2.9 Cell types

Our body is made up of over 200 different cell types with specialised functions. Here are a few examples shown in Figure 2.2.9.

- ***Epithelial cells*** line and cover surfaces e.g. the skin.
- ***Skeletal muscle cells*** help move our body.
- ***Nerve cells*** (neurons) which may be up to 1 m long, transmit information.

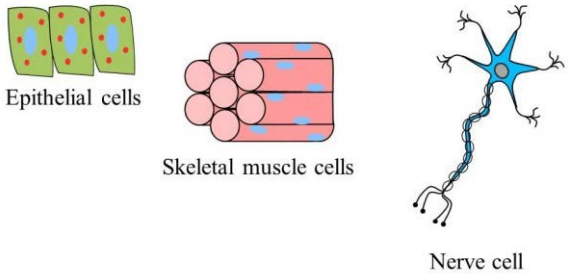

Figure 2.2.9 Three types of specialised human cells (Copyright, QUT)

2.2.10 Organelles

Organelles are the basic components of the cells, each performing a specialised role. Because different cells perform different functions they contain different organelles, however, some organelles are common to most cells. The following organelles are shown in Figure 2.2.10.

- The ***nucleus*** is the control centre of the cell. It stores our genetic material in form of DNA.
- ***Nucleoli*** (1 nucleolus) have the primary function in building of ribosomes to read the RNA sequence.

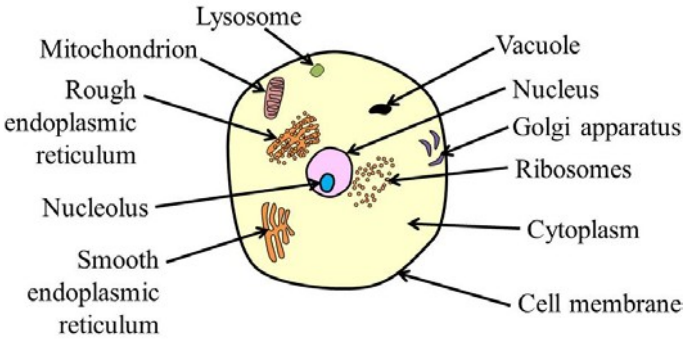

Figure 2.2.10 A typical human cell showing the common organelles (Copyright, QUT)

- Continuous with the nuclear membrane surrounding the nucleus is ***smooth*** and ***rough endoplasmic reticulum***. These are networks of interconnected membranes involved in synthesis of lipids and protein, respectively.
- ***Golgi apparatus*** modifies and prepares substances for use within the cell or for export to the outside of the cell.
- A typical cell performs many functions for which it needs energy. The ***mitochondria*** (1 mitochondrion) are the "power plants" that produce energy from organic molecules to form ATP for use by cells.

2.2.11Tissues

Groups of structurally similar cells that perform a common or related function arrange themselves to form ***tissue***. Different tissue types make up our entire body. Tissues are discussed in the next e-chapter.

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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2.3 Tissues to Organism

Sally Schaffer and Ana Pavasovic, School of Biomedical Sciences, Queensland University of Technology

2.3.1 Introduction

This resource aims to build on the first series of topics covered in "Cells to Tissues" and it continues our journey in understanding the structural complexity of our body. Here we will focus on different tissue types and their contribution to creation of organs, organ systems and the end product, the organism.

2.3.2 Tissues

To sustain our body, we depend on the individual actions of the cells as well as the collective action of many cells. A tissue is created when many structurally similar cells perform a common or related function. Different tissue types make up our entire body.

Tissues are characterised by the type of cells that form the tissue and the type of extracellular matrix (material outside of the cell) which those cells produce. Our body is made up of 4 primary types of tissues as follows (Figure 2.3.1):

- ***Epithelial tissue*** is a very versatile tissue type which performs many functions. It protects structures by creating layers of covering and secretes, absorbs and filters substances.
- ***Connective tissue*** is the most abundant tissue type which supports, protects and binds structures within our body.
- ***Nervous tissue*** is responsible for communication within our body, via rapid electrical signals.
- ***Muscle tissue*** **allows** us to move; it moves our blood via the pumping action of the heart and it moves substances in some of our organs.

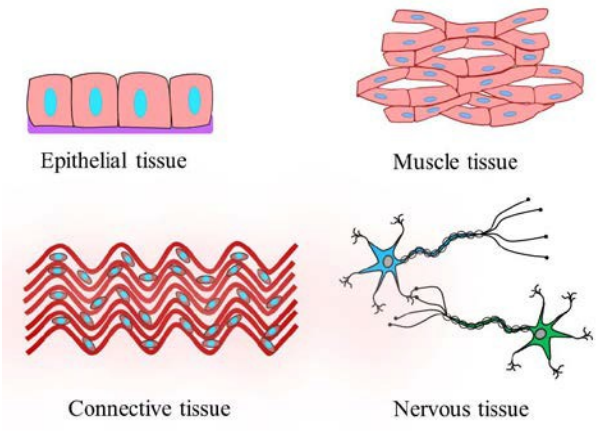


Figure 2.3.1 The 4 primary tissue types (Copyright, QUT)

2.3.2.1 Epithelial tissue

Epithelial tissue generally performs two functions. It covers and lines structures as well as forms glandular structures. Because epithelial tissue is so diverse we use specific terminology to identify different types of epithelia (Figures 2.3.2 and 2.3.3).

simple = one layer
stratified = multilayered
squamous = flattened
cuboidal = cube-like
columnar = tall
pseudostratified = false layers

- ***Simple squamous epithelium*** has a single layer of flattened cells, forming a delicate barrier usually associated with diffusion or filtration of materials e.g. lining of alveoli in lungs where it facilitates diffusion of gases.
- ***Simple cuboidal epithelium*** consists of a single layer of cube-like cells. This epithelium is typically associated with secretion and absorption of substances e.g. kidney tubules which function to reabsorb substances from urinary filtrate.
- ***Simple columnar epithelium*** is made up of a single layer of tall cells. This type of epithelium absorbs substances and may also secrete mucus e.g. it lines lower sections of the digestive tract where a lot of absorption of nutrients takes place.
- ***Pseudostratified columnar epithelium*** consists of a single layer of cells of varying heights (the nuclei also appear at different levels). Cells of this epithelium may have cilia (small hair-like projections at the free edge of the cells, which help propel substances). This epithelium is often associated with secretion and movement of substances, such as mucus e.g. upper respiratory tract where cilia can trap dust particles and where mucus is secreted.
- ***Stratified squamous epithelium*** has many layers of flattened cells. This type of tissue provides protection against abrasion e.g. inside lining of our mouth and our skin.
- ***Transitional epithelium*** is a very unique epithelium as the cells change shape allowing for the epithelium to stretch e.g. urinary bladder where transitional epithelium stretches to accommodate increase in urine content.

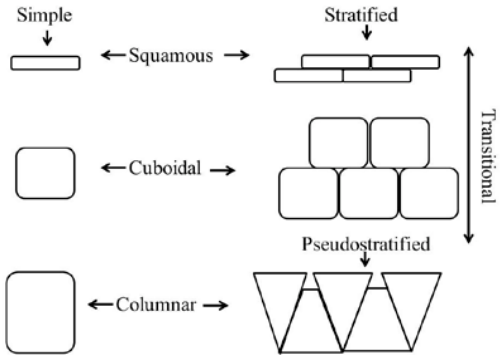


Figure 2.3.2 Some of the terms used to describe epithelial cell types (Copyright, QUT)

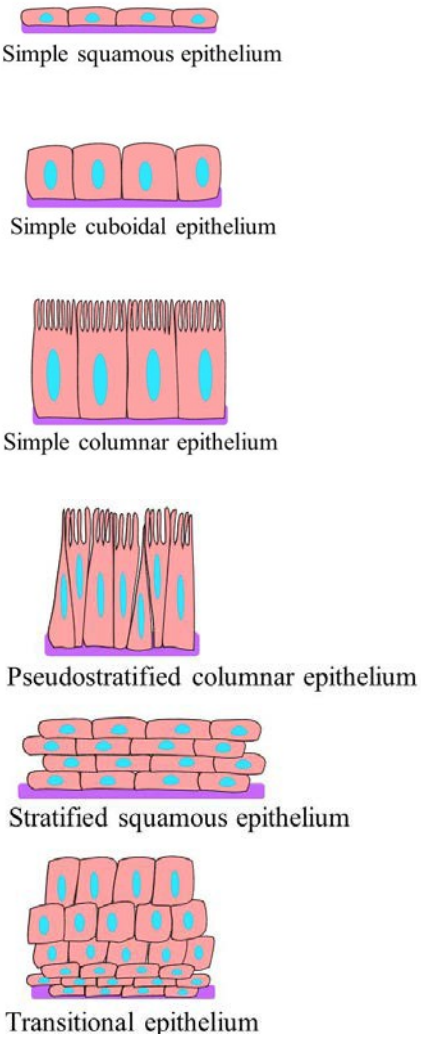


Figure 2.3.3 Different types of epithelia (Copyright, QUT)

2.3.2.2 Connective tissue

Connective tissue has a unique feature where the tissue is primarily made up of the extracellular matrix, rather than densely packed cells. The 4 main groups of connective tissue are ***connective tissue proper***, ***cartilage***, ***bone*** *and* ***blood***. Some specific examples are presented here (Figure 2.3.4).

- ***Dense regular tissue*** is a type of connective tissue proper. The extracellular matrix contains collagen fibres secreted by fibroblasts (the main cell type in this tissue). Parallel arrangement of these fibres gives this tissue great tensile strength, e.g. tendons and ligaments. ***Adipose tissue*** (fat) is also a type of connective tissue proper. It consists of unique cells called adipocytes which are filled with lipid. Adipose tissue is essential in insulation against heat loss and as storage of fuel for cellular processes.
- ***Osseous tissue (bone)*** is a hard, calcified matrix made up of calcium salts. The primary cell type is an osteocyte. The primary function of bone is to support and protect body structures.

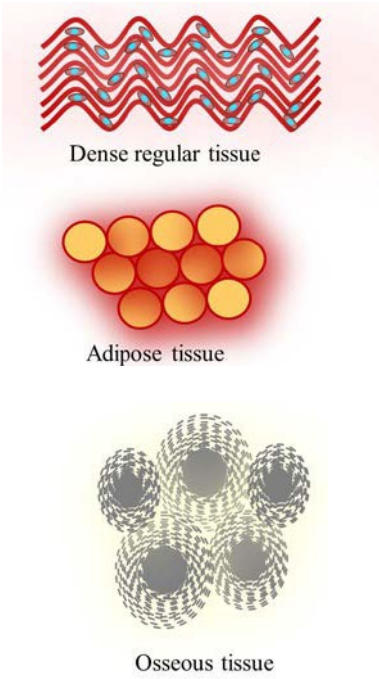


Figure 2.3.4 Some examples of different types of connective tissue (Copyright, QUT)

2.3.2.3 Nervous tissue

Nervous tissue makes up the brain, spinal cord and nerves. It is made up of two types of cells. Nerve cells or ***neurons*** relay information through electrical signalling and support cells (glial cells) protect and nourish the neurons.

Neurons are made up of a cell body and a long process called an axon (Figure 2.3.5). The cell body houses the nucleus and other organelles, and it is also where the electrical impulses are initiated. Axons are long structures (up to 1m long) which carry the electrical signal to the target cell. Dendrites receive the signal from communicating neurons (see section 3.1.1).

The best known glial cells are Schwann cells. They wrap around axons and act as electrical insulators (like insulation tape around an electric wire). Schwann cells are effective insulators because of the fatty material they produce, called myelin.

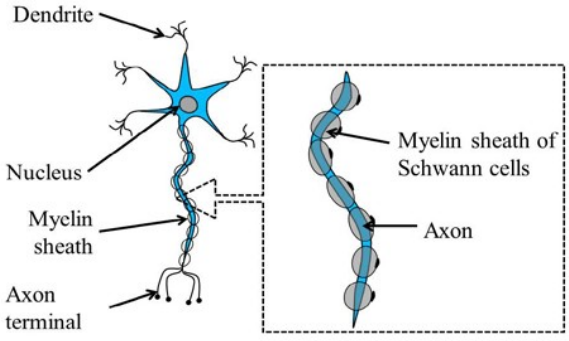


Figure 2.3.5 A typical neuron showing the axon and myelin sheath (Copyright, QUT)

2.3.2.4 Muscle tissue

There are 3 kind of muscle tissue - ***skeletal, cardiac*** and ***smooth muscle*** (Figure 2.3.6). Each of these muscle groups has unique properties relating to its cells or muscle fibres.

- ***Skeletal muscle*** is made up of muscle fibres which are long, cylindrical, and multinucleate (more than one nucleus). Skeletal muscle fibres are characterised by the presence of striations, or vertical bands along the length of the fibre, due to the arrangement of sub-cellular structures which facilitate movement. This type of muscle is generally found attached to our bones.
- ***Cardiac muscle*** also displays striations, however, muscle fibres of this type have only one nucleus and are more branched in appearance. Another important feature is presence of intercalated discs, which strengthens the attachment of cells to each other and helps them to contract in unison. This is an important feature as this muscle type makes up our heart.
- ***Smooth muscle*** is made up of spindle-shaped fibres, which do not have striations but instead form sheets. This type of muscle lines the walls of hollow organs found in our body e.g. digestive tract where it propels food.

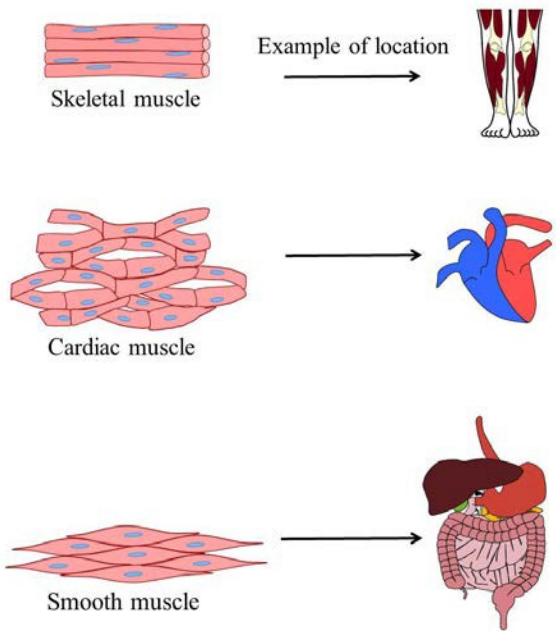


Figure 2.3.6 The 3 kinds of muscle tissue (Copyright, QUT)

2.3.3 Organs

An ***organ*** is made up of two or more tissue types that perform a specific function. For example the heart is an organ made up of multiple tissue types including muscle tissue (cardiac muscle contracts the heart), connective tissue (fat attached to the surface of the heart) and epithelial tissue (lining the inner surface of the heart and blood vessels) (Figure 2.3.7).

Organs are discrete functioning units and are structurally different to each other e.g. heart is structurally and functionally different to kidney, brain or lungs.

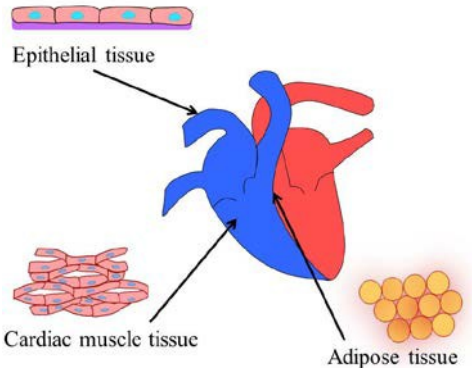


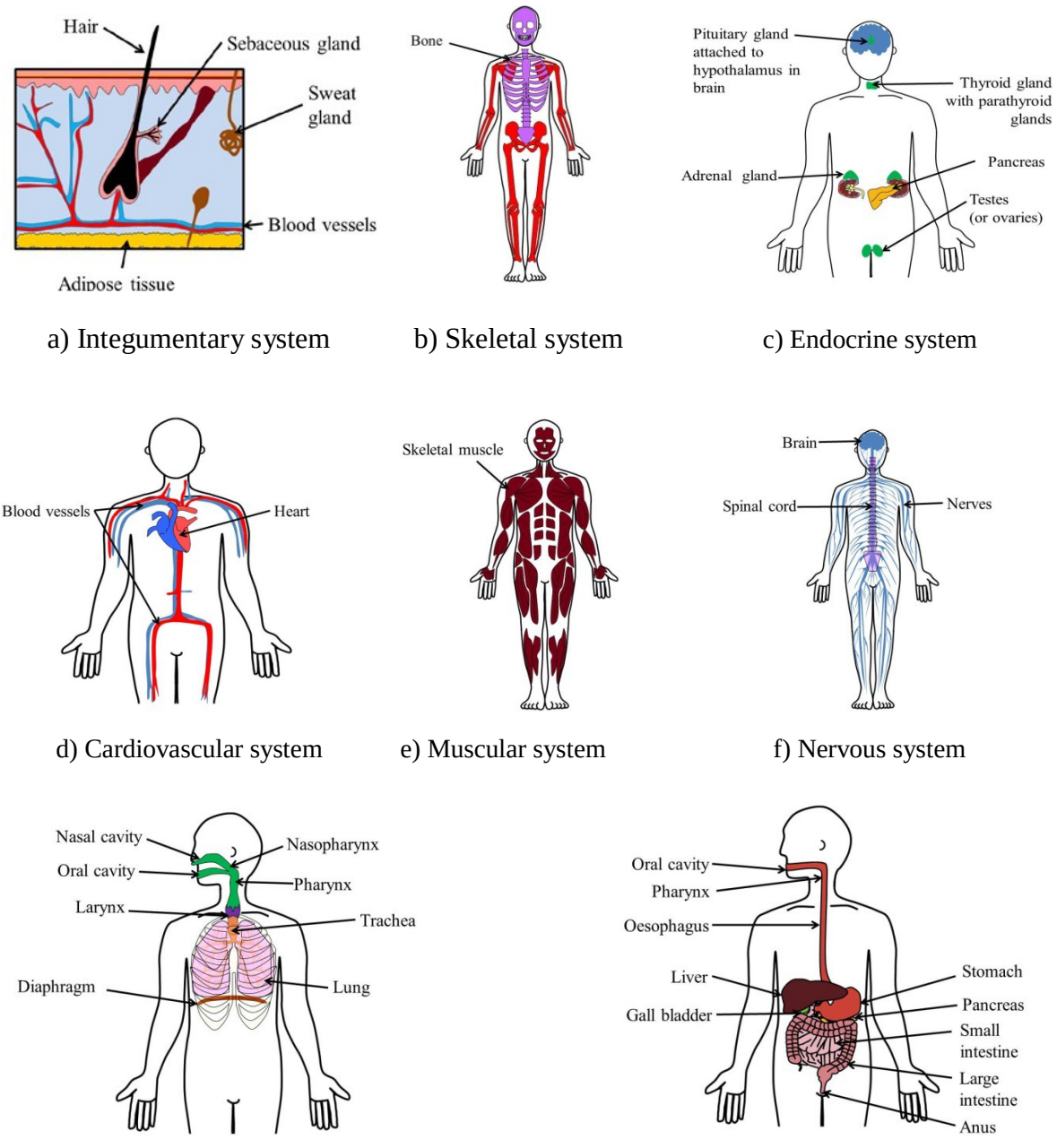
Figure 2.3.7 The heart is an organ composed of different tissue types (Copyright, QUT)

2.3.4 Organ systems

Organ systems consist of different organs working closely together to achieve a common function e.g. the cardiovascular system is made up of the heart and blood vessels.

Here we will introduce you to some of the body's organ systems.

- ***Integumentary system*** consists of the skin and accessory structures such as hairs and glands. Skin is our largest organ and is the one that keeps us protected from pathogens by forming an external body covering.
- ***Skeletal system*** provides a framework for our body. It supports and protects our organs.
- ***Endocrine system*** is responsible for the production of hormones. This system consists of various glands, some of which include the thyroid gland, adrenal gland and the pancreas.
- ***Cardiovascular system*** is an extensive network of blood vessels and the heart which are responsible for delivery of nutrients and removal of cellular wastes throughout the body.
- ***Muscular system*** consists primarily of skeletal muscle which attaches to the bony framework and allows for movement. It is also important in the production of heat.
- ***Nervous system*** is the control system which sends electrical signals throughout the body. Three main parts of the nervous system include the brain, spinal cord and the nerves.
- ***Respiratory system*** is responsible for the continuous supply of oxygen needed for cellular function and expelling of carbon dioxide. It is the principal site for exchange of gases.
- ***Digestive system*** provides a site for chemical and mechanical digestion of food, absorption of nutrients and elimination of wastes.



a) Integumentary system b) Skeletal system c) Endocrine system

d) Cardiovascular system e) Muscular system f) Nervous system

g) Respiratory system h) Digestive system

Figure 2.3.8 Some of the major organ systems of the body (Copyright, QUT)

2.3.5 Organism

An organism represents the highest level of structural and functional organisation – the human being.

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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2.4 Homeostasis

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2.4.1 Introduction

Homeostasis (Figure 2.4.1) is a balancing act!

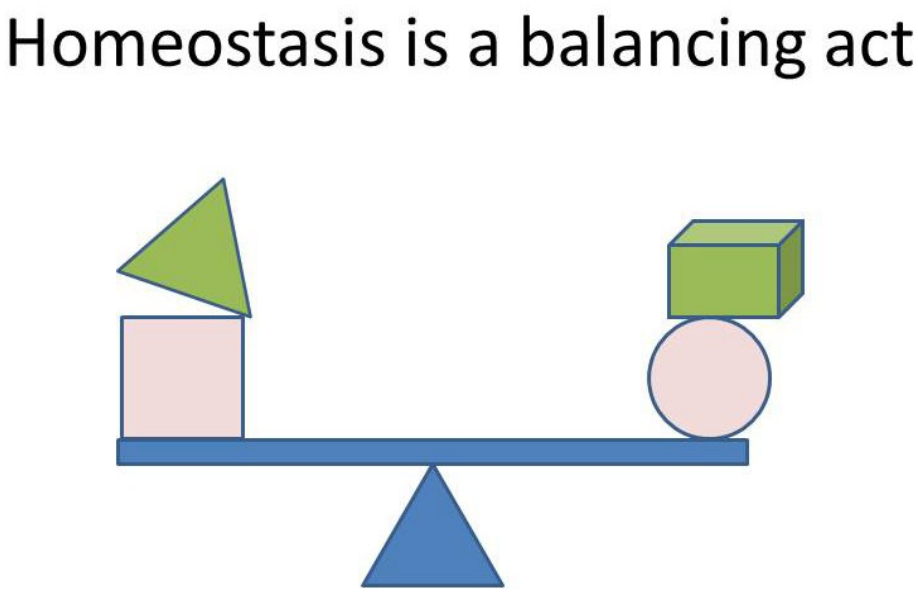

Figure 2.4.1 Homeostasis is a balancing act (Copyright Sheila Doggrell, QUT)

Many years ago it was identified that we have an internal environment in our bodies, and that we need to preserve this to maintain life. This preservation of the internal environment is known as **homeostasis** (from the Greek words *homis*, meaning 'like', and *stasis*, meaning 'standing still').

For homeostasis, many variables within the body have to be kept relatively constant. No matter what the changes are outside the body, the internal environment is maintained. If not, we die.

These variables (another name for them is *parameters*) are things such as temperature, pH (acid-base balance), amount of energy, etc.. These variables are all important in the functions of our bodies. For example, for cells to survive they need to have specific environmental conditions. For cells to survive they need a pH around 7.35-7.45. Similarly, for all the other variables there is a small range of normal values that are needed to maintain life.

2.4.2 Homeostasis and the cell

The cells in the body can be very close together as in an epithelium (cells that line the cavities or body), or further apart as in connective tissue. All cells regulate their inside environment. The figure below (2.4.2) illustrates the fact that cells have an intracellular environment and an extracellular environment.

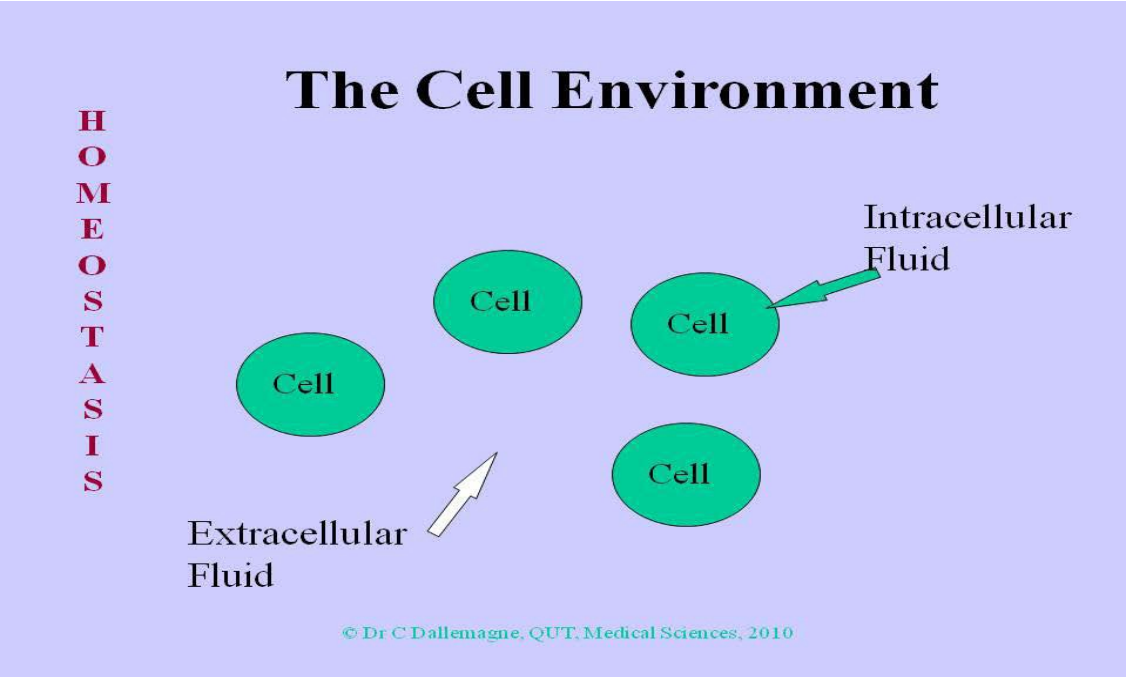

Figure 2.4.2 Intracellular and extracellular fluids

Water constitutes 55-70% of our body weights, so mostly we have fluids: intracellular (inside cells) and extracellular (outside cells).

However, the composition of intracellular and extracellular fluid is quite different. For example if we look at the concentration of sodium, we find that it is much higher in the extracellular fluid than in the intracellular fluid. We need to ask ourselves: how is this maintained?
How does it come about?
To explain the differences between intra- and extracellular fluid we need to consider the cell and its bounding membrane (the cell membrane, or plasma membrane) (Figure 2.4.3).

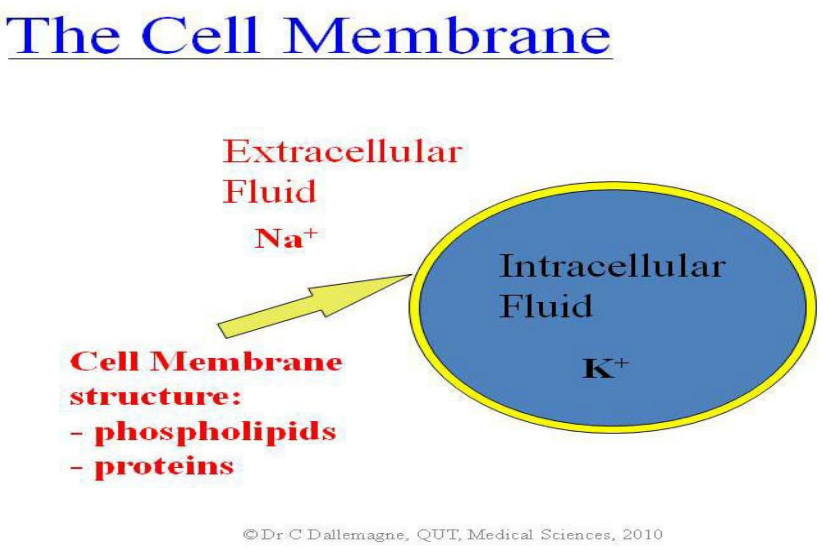

Figure 2.4.3 The cell membrane

Within the cell membrane we have proteins that act as transporters. These work to pump sodium out of the cell for example. But the cell membrane still allows some sodium to diffuse back into the cell, by a process called diffusion. Thus, the pump must work continuously to remove sodium from the cell. This requires energy and oxygen.

Potassium concentration is higher inside the cell: again there will be diffusion out of the cell and the need for a pump to pump it back in. Cells actually use the same pump for sodium and potassium: it pumps sodium out while at the same time pumping potassium in.

So homeostasis of the internal environment includes maintenance of fluid composition, e.g. in ions, such as Na^{2+} and K^{+} (ions are also called electrolytes). The cell also interacts with the other variables in the cellular environment such as nutrients and oxygen. Thus nutrients and oxygen must be able to enter the cell and waste products must exit the cell. And of course the various body systems help in the bringing material and removing waste products.

From this discussion, you will have gathered that the cell is not an inert structure: it has a complicated machinery that you looked at earlier, in the chapters 2.2. and 2.3.

Cells are sensitive to chemicals (stimuli). Many chemicals are found in the body, and are known as endogenous chemicals. To respond to those chemical-stimuli the cell has receptors on its surface or in its interior. The endogenous chemical can bind to these receptors. In fact, the whole body is controlled by two main mechanisms: chemical and nervous (nerves works by releasing chemicals too).

2.4.3 Homeostasis regulation and the body

There are two main mechanisms of homeostasis within the body: **autoregulation** and **extrinsic regulation**.
In autoregulation, the activities of a cell, tissue or organ change automatically when faced with environmental variation. For example, when cells in a certain tissue need more O_2, this is sensed, and cells release chemicals, including adenosine, which resulting in the dilatation (opening) of nearby blood vessels. The result of this is that the cells receive more O_2 (Figure 2.4.4). This is of course only localized.

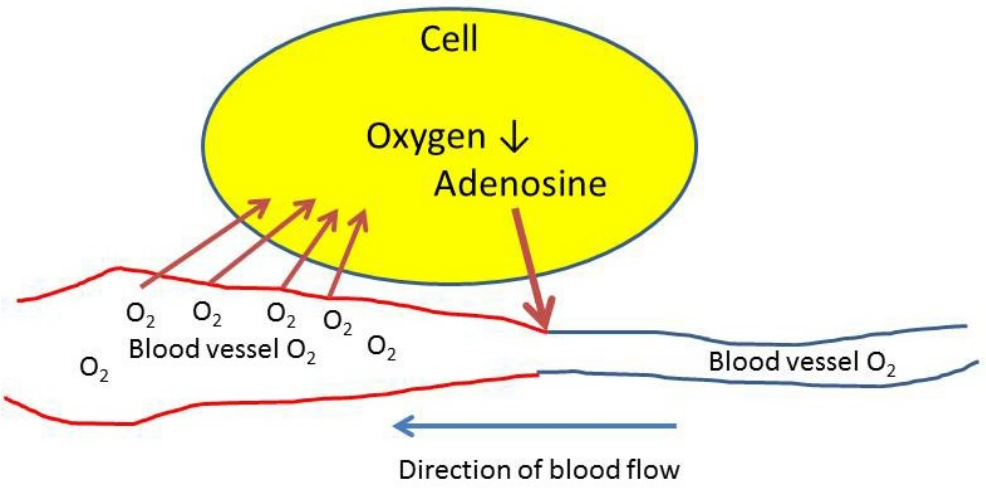

Figure 2.4.4 Local autoregulation (Copyright Sheila Doggrell, QUT

In contrast, extrinsic regulation involves activities of several systems, such as the nervous and endocrine, working together to adjust or change the internal conditions. All body systems contribute to homeostasis.

An example of nervous system contribution to homeostasis is when we touch something dangerous, such as a stove (Figure 2.4.5). The sensory nerves send a message to the central nervous system – a message of burning/pain. The central nervous system sends a motor nerve message to the muscles in the arm, which make the muscles in the arms contract and moves the hand away from the stove, so that we are not burnt.

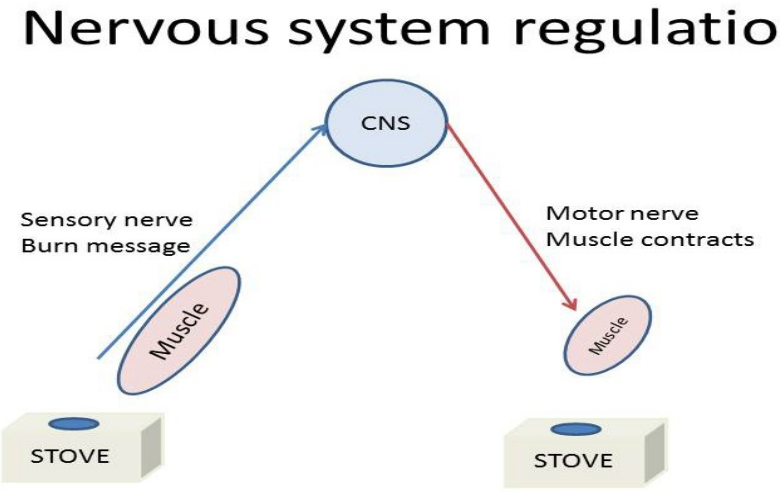

Figure 2.4.5 Nervous system regulation (Copyright Sheila Doggrell, QUT)

An example of endocrine system control of homeostasis is the release chemical messengers (hormones) that affect cells in other systems. For example when you are frightened or go for a run, the chemical adrenaline is released into the circulation and acts on the heart to increase heart rate and force (Figure 2.4.6). Adrenaline also acts on the blood vessels in the muscles in the legs to cause vasodilation to increase blood flow and oxygen delivery to muscles. Finally, adrenaline also acts on the lungs to cause bronchodilation and the supply of oxygen to the body.

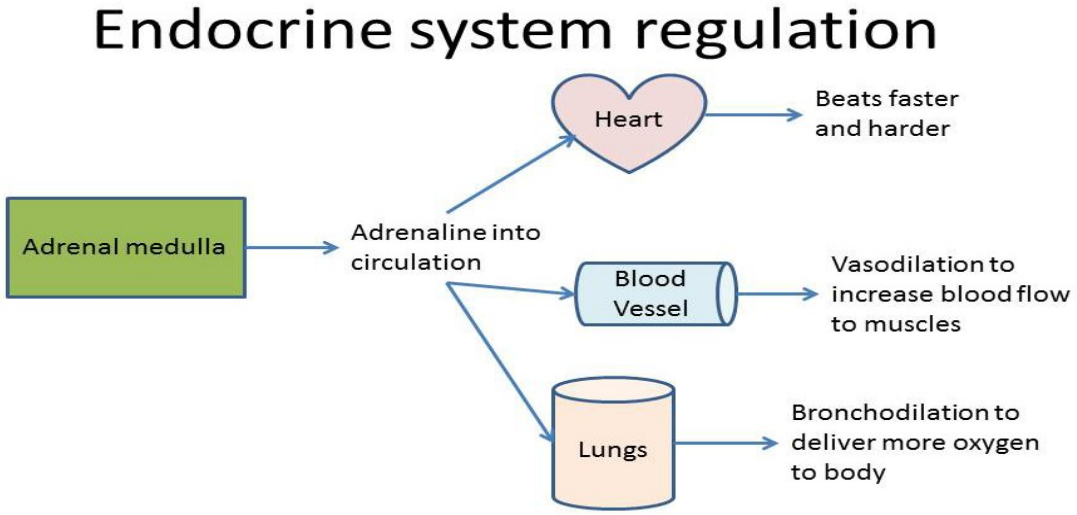

Figure 2.4.6 Endocrine system regulation (Copyright Sheila Doggrell, QUT)

2.4.4 Examples of variables that are controlled by homeostasis

Acidity of fluids is tightly regulated. Acidity is measured by what is called pH, which is related to the concentration of the hydrogen ion (H^+). The pH of blood is maintained between 7.35 and 7.45. This is needed; for example for the activity of enzymes. The kidneys are very important for the excretion of excess acid, resulting from our food intake.

Your blood pressure and heart rate are also regulated: the standard normal values are 120/80 for blood pressure and about 60-80 beats/minute for heart rate. Again this will vary depending on conditions: if you do exercise, your heart rate increases.

2.4.5 Metabolism also contributes to homeostasis

Metabolism has two components: anabolism and catabolism (Figure 2.4.7). Cells produce molecules for their – or other cells' – needs. They also break down molecules. The process of building molecules is called anabolism: making fats, muscle, bones for example. You have probably heard of anabolic drugs: what do they do? They build up muscle tissue. It all starts by constructing molecules.

The process of breaking down molecules is called catabolism. When molecules are fully broken down (for example; food such as glucose is 'burnt' using oxygen) we end up with carbon dioxide and water. The respiratory system then gets rid of the carbon dioxide. Heat is also produced by catabolism, which helps us maintain our body temperature.

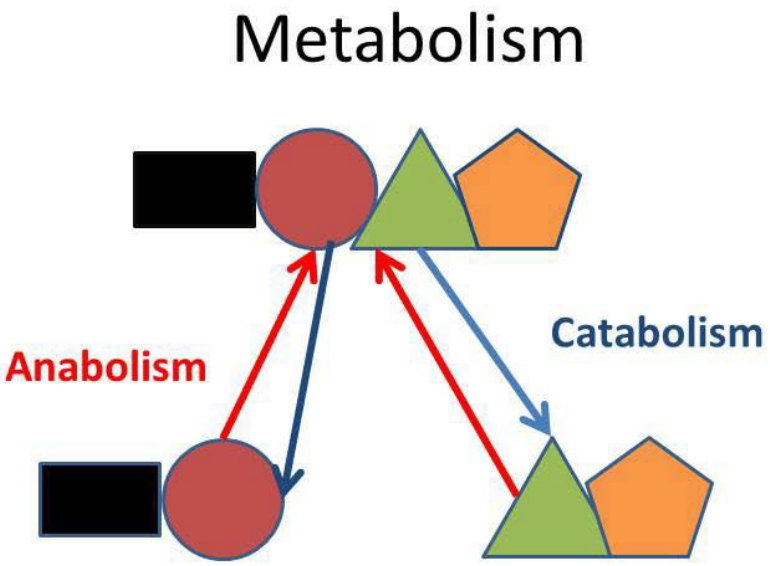

Figure 2.4.7 Anabolism and catabolism (Copyright Sheila Doggrell, QUT)

2.5 Physiological Feedback/Control Mechanisms

Sheila A Doggrell & Catherine Dallemagne, School of Biomedical Sciences, Faculty of Health, Queensland University of Technology

The body often uses feedback mechanisms to regulate its internal environment. In this eChapter we will discuss examples of feedback/control mechanisms for body temperature control, insulin release, glucocorticoid release, and lactation.

2.5.1 Body Temperature

Firstly, we will consider the feedback mechanisms to control body temperature. If there is a sudden cold change in the weather, you may not be prepared for it, and your body temperature will decrease. This will be detected by the temperature receptors in the skin, which will feed this information, via the sensory nerve fibres to the central nervous system (Figure 2.5.1). The hypothalamus is the region of the central nervous system that controls temperature. When you are cold, the hypothalamus sends out a message via the somatic nervous system to the skeletal muscle, and this starts them shaking, a process commonly called shivering (Figure 2.5.1). Shivering generates heat, which will cause the body temperature to increase (Figure 2.5.1), and help to restore body temperature to normal levels.

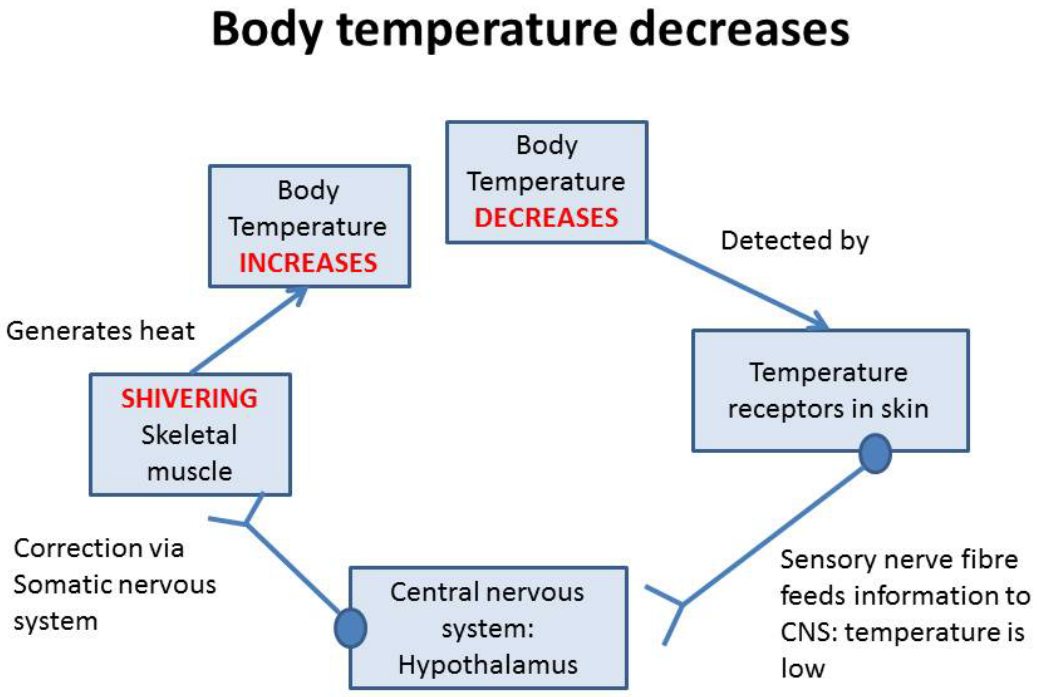

Figure 2.5.1 Body temperature decreases (Copyright Sheila Doggrell, QUT)

When you go out into the hot sun, your temperature will increase, and this time the feedback mechanism will work to decrease your temperature. The temperature will still be monitored by the temperature receptors in the skin, but this time, the message that will be fed to the central nervous system is that temperature is high (Figure 2.5.2). This time, the correction message will be sent by the autonomic nervous system, which will cause sweating, and vasodilation of the blood vessels in the skin (Figure 2.5.2). Both of these process lead to heat removal, and this will decrease body temperature.

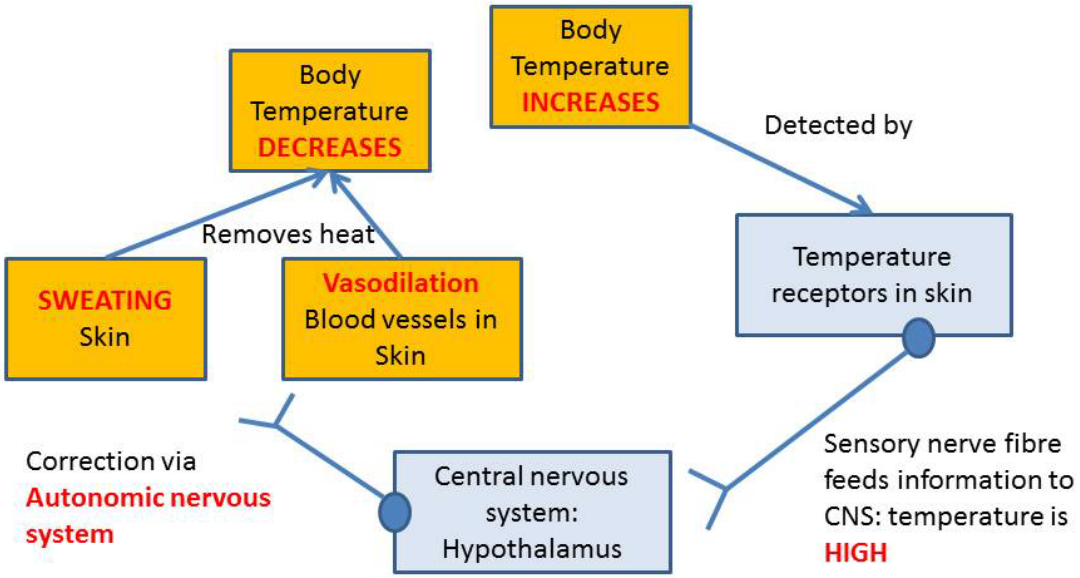

Figure 2.5.2 Body temperature increases (Copyright Sheila Doggrell, QUT)

2.5.2 Endocrine system feedback/systems

Secondly, we will consider a couple of important feedback/systems systems in the endocrine system. Firstly, we will consider the link between plasma glucose levels and insulin secretion. Plasma glucose levels have to be kept in a small range. If the levels of glucose are too low hypoglycaemia develops, which is characterised by sweating, hunger, palpitations, tremor, anxiety, convulsions, and coma.

When we have a meal, the food is broken down, and the levels of plasma glucose rise. Glucose is transported into the pancreatic β-cells and this stimulates the release of insulin from these cells (Figure 2.5.3). Insulin then stimulates the conversion of glucose to glycogen in the liver, the conversion of glucose to triglycerides in adipose tissue, and the conversion of amino acids to protein in muscle. These biochemical changes lead to a decrease in the plasma glucose, which removes the stimulus for insulin secretion (Figure 2.5.3). This feedback prevents excessive insulin secretion, which would lead to hypoglycaemia.

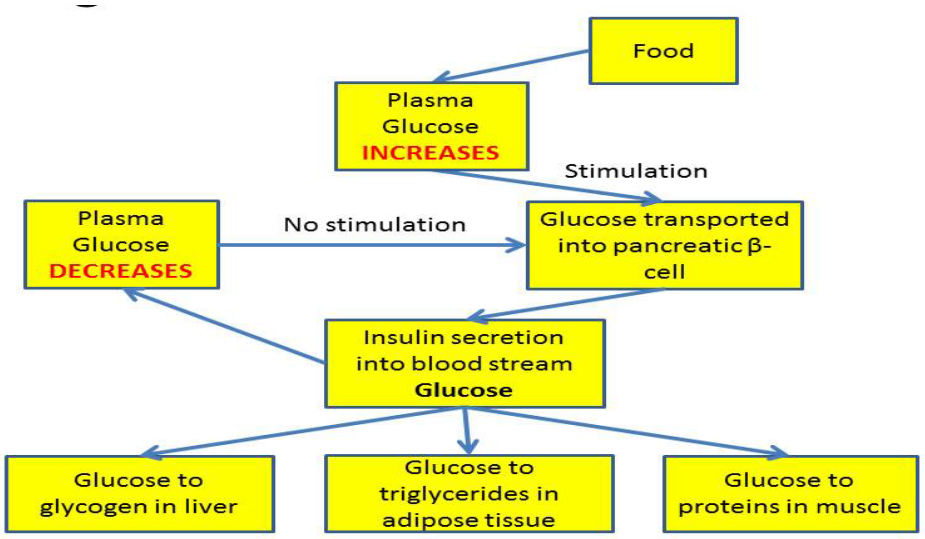

Figure 2.5.3 Plasma glucose and control of insulin release (Copyright Sheila Doggrell, QUT)

The second example of endocrine control is the negative feedback of circulating corticosteroids on the release of corticotrophin releasing factor and adrenocorticotrophic hormone, and subsequently on the corticosteroids themselves (Figure 2.5.4). In times of stress, the hypothalamus releases corticotrophin releasing factor, which in turn stimulates the anterior pituitary to release adrenocorticotrophic hormone (ACTH, corticotrophin hormone), and the adrenal cortex to release the corticosteroids. The corticosteroids have major roles in metabolism, and less prominent effects as anti-inflammatory and immunosuppressants. Once the corticosteroids are released they feedback on the hypothalamus to inhibit the release of corticotrophin releasing factor, and on the anterior pituitary to inhibit the release of ACTH (Figure 2.5.4).

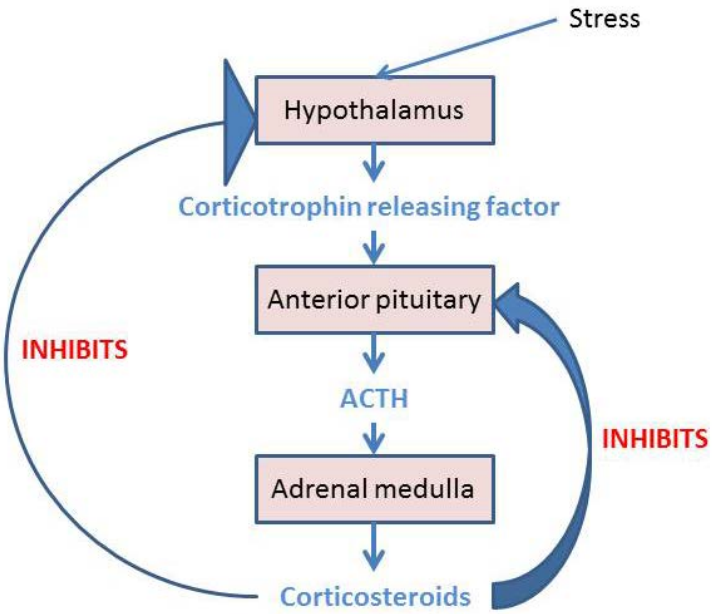

Figure 2.5.4 Feedback inhibition of corticosteroid release (Copyright Sheila Doggrell, QUT)

In pharmacology, the properties of the corticosteroids have been manipulated to produce synthetic drugs that are potent as anti-inflammatory agents and as immunosuppressants (e.g. for use after heart transplants). Unfortunately, if these agents are used long term they cause long term suppression of the axis in Figure 2.5.4 by mimicking the physiological feedback, and the axis can take a long time to recover. Thus, if synthetic corticosteroids are abruptly withdrawn after a long period of use, the natural axis can be slow to recover, leaving the body unable to cope with stress, infection, and immune challenges.

2.5.3 Positive feedback

Good examples of positive feedback are with oxytocin, a hormone released from the posterior pituitary. In the process of child birth, oxytocin is release from the posterior pituitary of both the mother and foetus. The oxytocin stimulates its receptors on the uterus to cause contraction (Figure 2.5.5). Oxytocin also stimulates its receptors on the placenta to stimulate the production of prostaglandins. Prostaglandins also stimulate receptors on the uterus to cause contraction. Thus, when both oxytocin and prostaglandins are produced, vigorous contractions of the uterus occur, leading to childbirth (Figure 2.5.5).

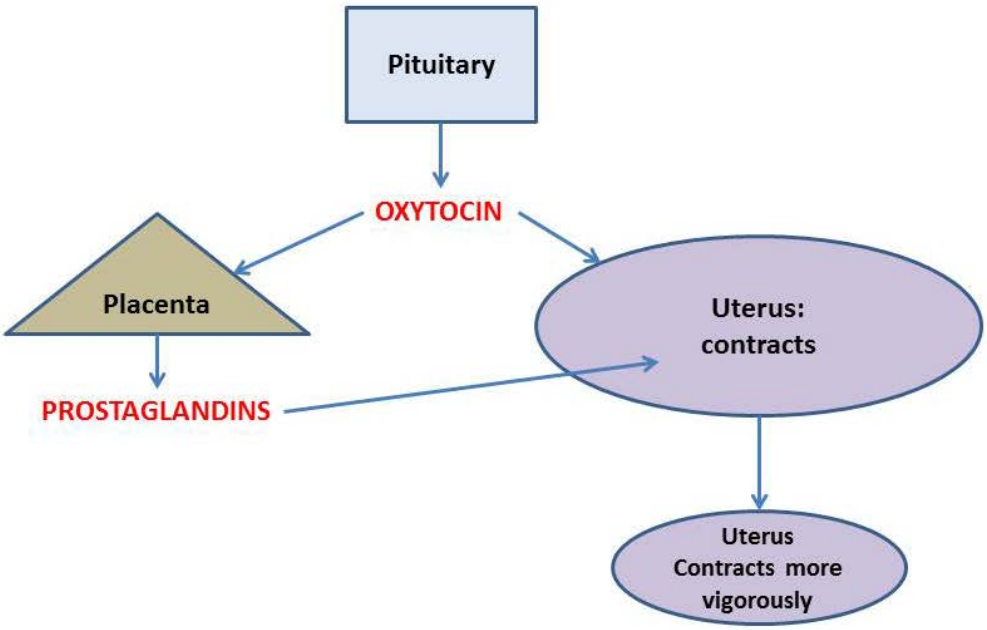

Figure 2.5.5 Oxytocin and uterine contraction (Copyright Sheila Doggrell, QUT)

Oxytocin also controls the positive feedback whereby suckling by a baby leads to milk release. Thus, suckling leads to a sensory nerve input to the hypothalamus, and the release of oxytocin from the posterior pituitary (Figure 2.5.6). Oxytocin has a positive feedback on the breast leading to stimulation of milk release for the baby to drink (Figure 2.5.6).

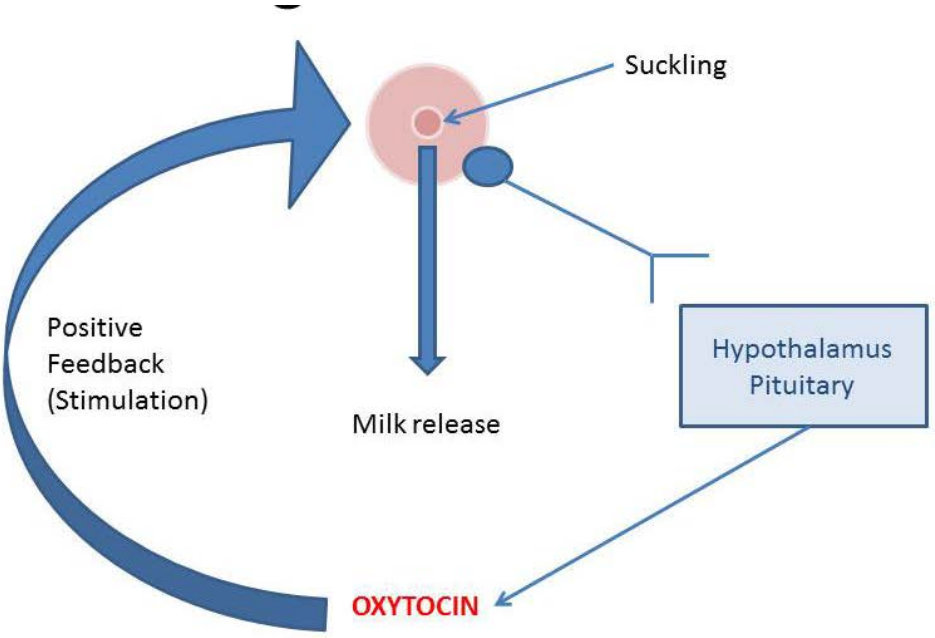

Figure 2.5.6 Oxytocin and milk release (Copyright Sheila Doggrell, QUT)

2.6.1 Binding sites – the Keys to Pharmacology

This part of the introduction is of binding sites and how they act as locks, which can be unlocked by drugs/medicines: making them the key to pharmacology.

Pharmacodynamics is **'What the drug does to the body'**. When we administer a drug to a person, we hope that the drug will have a beneficial effect (Figure 2.6.1). In order to do so, the drug will have to cause an alteration in a physiological, biochemical or pathological process. This alteration is called the mechanism of action or pharmacodynamics of the drug. It is the molecular mechanism of action of the drug, and the actions of the drug in the human body that follow from this mechanism of action.

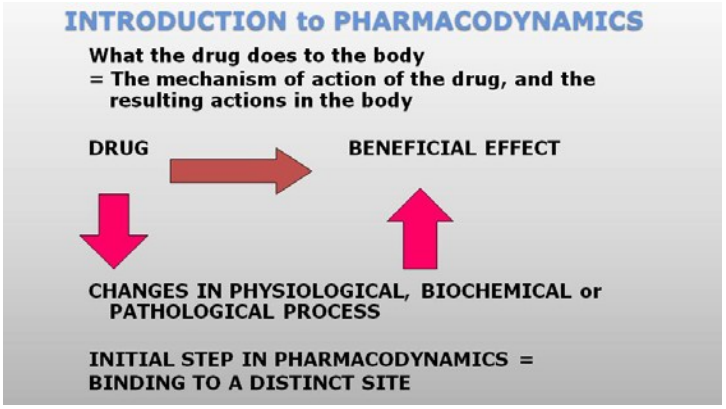

Figure 2.6.1. Introduction to Pharmacodynamics

The initial step in pharmacodynamics is the **binding to distinct sites**. Although the body does not have any binding sites that were specifically designed for medicines to bind to, it has lots of binding sites for endogenous compounds, and drugs can use these binding sites. These include enzymes, ion channels, carriers, and receptors.

Enzymes are proteins that catalyze (i.e. increase the rates) of chemical reactions. In enzymatic reactions, the molecules at the beginning of the process are called substrates, and the enzyme converts them into different molecules that are called products. Enzymes have **binding sites** that are usually intended for substrates of that enzyme (Figure 2.6.2). The substrate binds to the enzyme, the enzymatic reaction takes place, and a product is produced.

Drugs can also bind to these sites to have an effect. Mostly drugs bind to enzymes to **inhibit** their actions (Figure 2.6.2). Thus, the substrate cannot be turned into the product. This may give a change in a biochemical process for a beneficial effect.

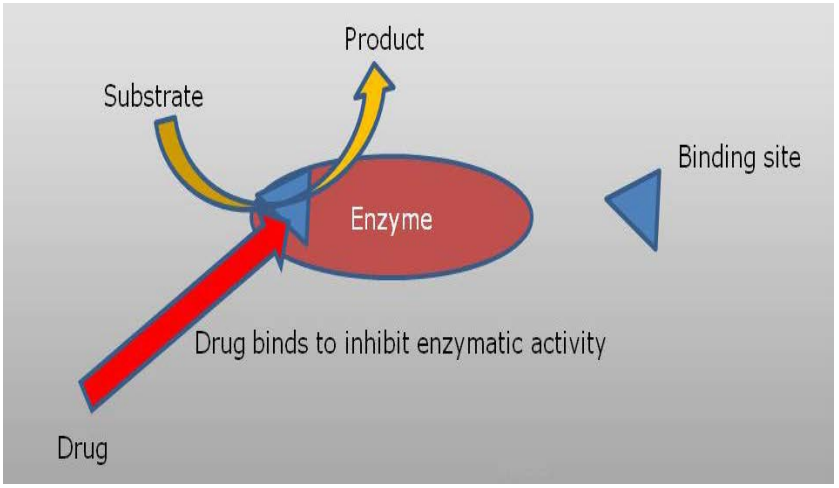

Figure 2.6.2. Drug inhibits enzyme activity and no product is produced

(Copyright QUT, Sheila Doggrell)

The enzyme **cyclooxygenase** turns the substrate **arachidonic acid** into prostaglandins (Figure 2.6.3). Prostaglandins cause pain. The commonly used medicine **paracetamol** binds to the binding site on cyclooxygenase enzyme to inhibit the action of the enzyme. This leads to a decrease in the production of the prostaglandins. As the prostaglandins cause pain, there is a decrease in the pain.

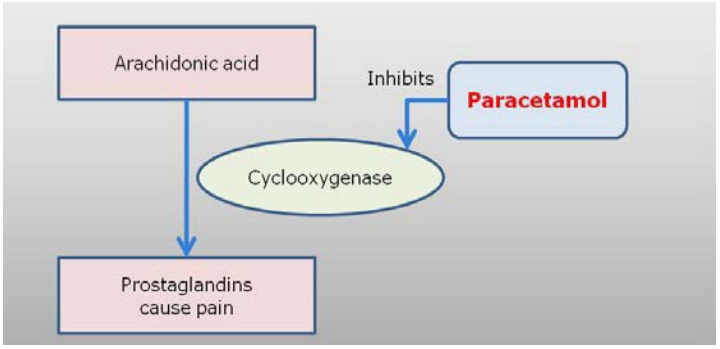

Figure 2.6.3.

Paracetamol inhibits cyclooxygenase to decrease the levels of pain causing prostaglandins
(Copyright QUT, Sheila Doggrell)

Drugs can also bind to ion channels. **Ion channels** are pores in membrane that open and close to control the movement of ions, such as Na^+, Ca^{2+}, and K^+, in and out of cells (Figure 2.6.4). The movement of ions in and out of cells controls many physiological processes, and is regulated by binding sites.

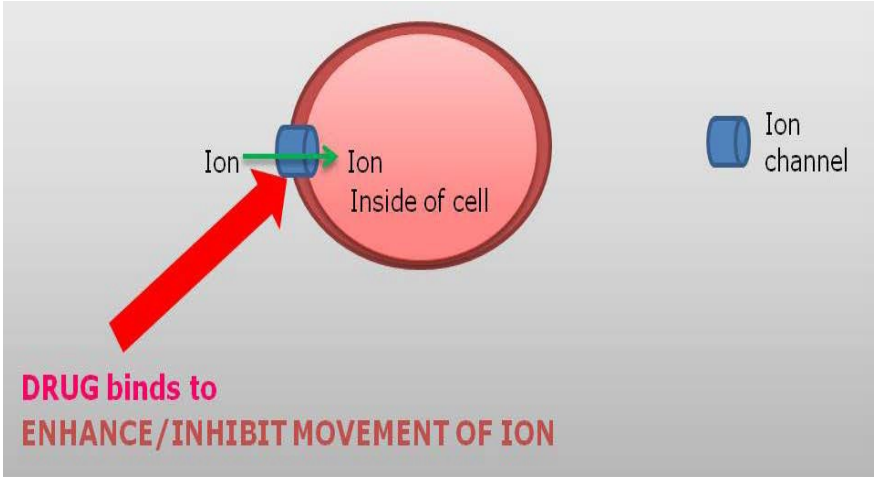

Figure 2.6.4. Ion channel

Drugs can bind to these sites to enhance or inhibit the ionic movements. Many of the drugs that have important effects on the cardiovascular system, and are used in the treatment of cardiovascular disease have actions at binding sites for ion channels, and examples of this will be discussed in the Unit.

A good example of how inhibiting a channel can change function is the blockage of sodium channels with local anaesthetics e.g. lignocaine. When you have tissue damage, the afferent nerves are activated and a message is sent along the afferent (sensory) nerves to the brain, which originates the feeling of pain (Figure 2.6.5).

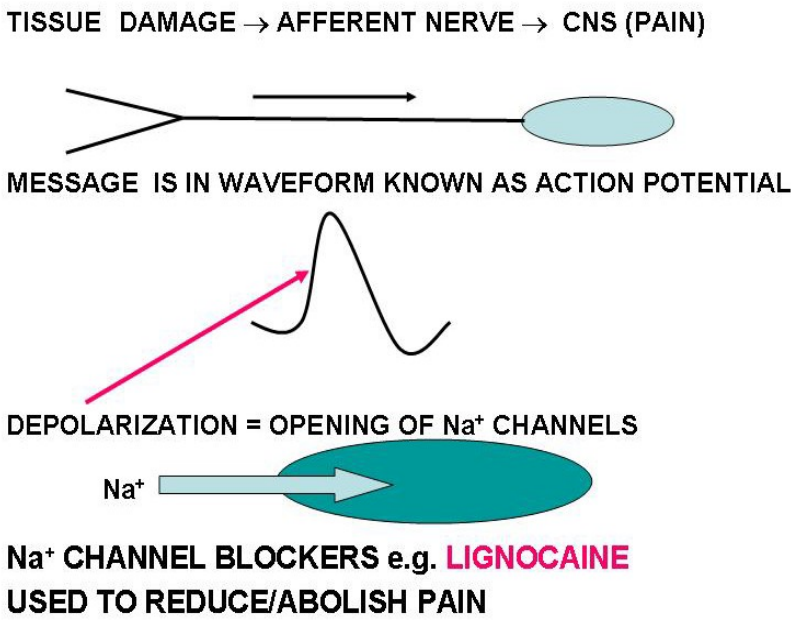

Figure 2.6.5 Na^+ channels and lignocaine

The pain message is carried along the nerve as part of the wave form known as the **action potential**. The upstroke or **depolarization** phase of the action potential is due to sodium

entering the nerve cell. Na^+ channel blockers, like **lignocaine**, block the Na^+ channels, so there are no longer action potentials, and without this messenger there is no pain.

Another site that drugs can bind to is carriers. **Carriers** can be divided into **transporters** and **pumps**. Both of these carry endogenous substances (substances that occur naturally in the body) across membranes. Carriers have binding sites for their particular endogenous substance. The endogenous substance binds to the transporter and is carried across the membrane. The transporter moves across the membrane, and then releases the endogenous substance.

Carriers can be involved in both the **distribution of drug** and the mechanism of action of the drug (Figure 2.6.6). Drugs that have a similar structure to the endogenous substance intended for the transporter can also bind to the transporter and be transported across the membrane. This is one of the ways in which drugs can be distributed around the body.

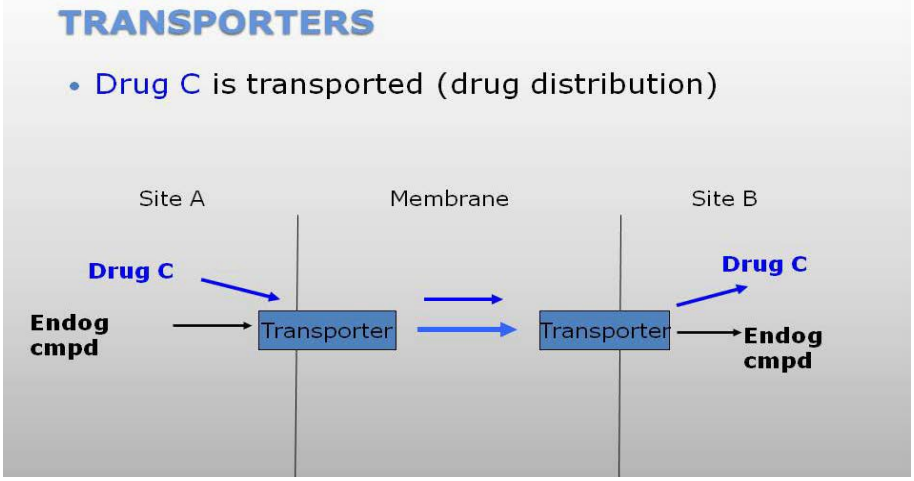

Figure 2.6.6.

Drug distribution using a transporter

Drugs can also bind to the binding sites on transporters to initiate their mechanism of action (Figure 2.6.7). Thus, drugs may bind to a site, typically to inhibit the transporters. Most of the drugs used in the treatment of depression bind to transporter to have their antidepressant effect, and examples of these will be discussed in the Unit.

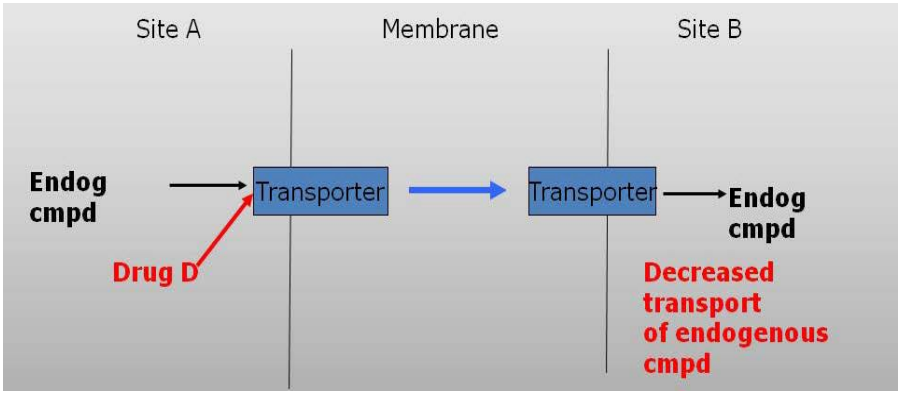

Figure 2.6.7.

Drug D inhibits a transporter to decrease the levels of the endogenous compound at Site B

An important group of drugs that inhibit transporters are the antidepressants. The biochemical cause of depression may be abnormal function of the neurotransmitters in the brain. One of the main neurotransmitters implicated in depression is **5-hydroxytryptamine** (5-HT), which is also known as **serotonin**. One thing we do know about depression is that there is long-term effectiveness in depression of drugs that increase the levels of 5-HT in the brain. Inhibitors of the 5-HT transporter increase the levels of 5-HT in the synapses of the brain.

To understand how this works, we first need to review the physiological process. On activation of the nerve terminal, 5-HT is released, and then stimulates 5-HT receptors to have an effect (Figure 2.6.8).

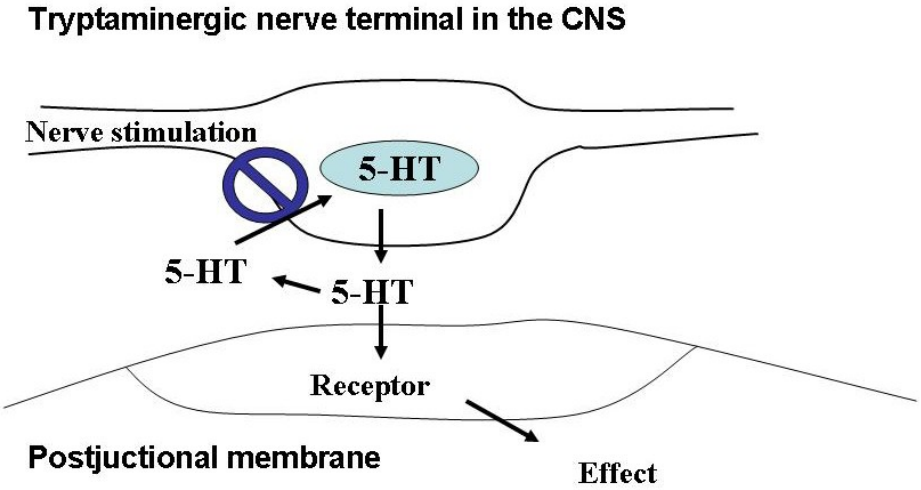

Figure 2.6.8 SERT transporter

The action of 5-HT is short lived, as it is rapidly inactivated. The 5-hydroxytryptamine (5-HT) is inactivated by transport back into the neurone, on a transporter that is selective for 5-HT, the SERT (the SERotonin Transporter). When it is stored in nerve endings, with no access to its receptors, the 5-HT is inactive. SERT is inhibited by **Prozac (Fluoxetine)**. This

inhibits inactivation of 5-HT, and increases the levels of 5-HT in the synapse, with increased stimulation of receptor, and an increased effect. It takes a bit of time, but eventually raising the levels of 5-HT in the brain synapses has an antidepressant effect.

A very important site that drugs bind to is **receptors.** Naturally occurring substances, such as neurotransmitters and hormone bind to **specific receptive substances**, which limits their effects to specific sites. Over the years, specific receptive substance has been shortened to **receptor**.

Drugs can bind to receptors to have an action (Figure 2.6.9). The binding can be considered to analogous to a key and lock. If the drug mimics the effect of the naturally occurring substance at the receptor, the drug is known as an **agonist**. The key fits the lock, and opens the door. If the drug prevents the action of the endogenous substance, the drug is known as an **antagonist**. In this case, the key had fitted into the lock but has not opened the door, but has prevented any other keys getting into the lock.

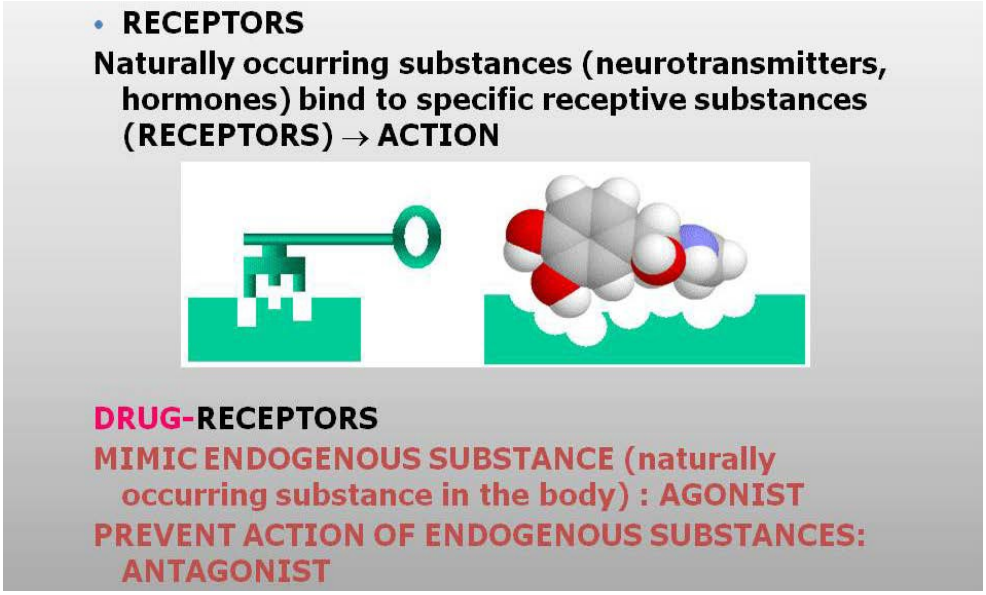

Figure 2.6.9.

Lock and key, drug and receptor

A drug interacting with receptors is the most common mechanism for a drug.

A final site at which a drug may bind is to the **cell signalling.** After a receptor is stimulated by an endogenous substance, some intracellular (inside of the cell) processes occur that lead to the final action (Figure 2.6.10). These intracellular processes are known as **cell signaling**. Drugs can combine with components of the cell signaling to either enhance or inhibit the cell signaling, and hence the final action.

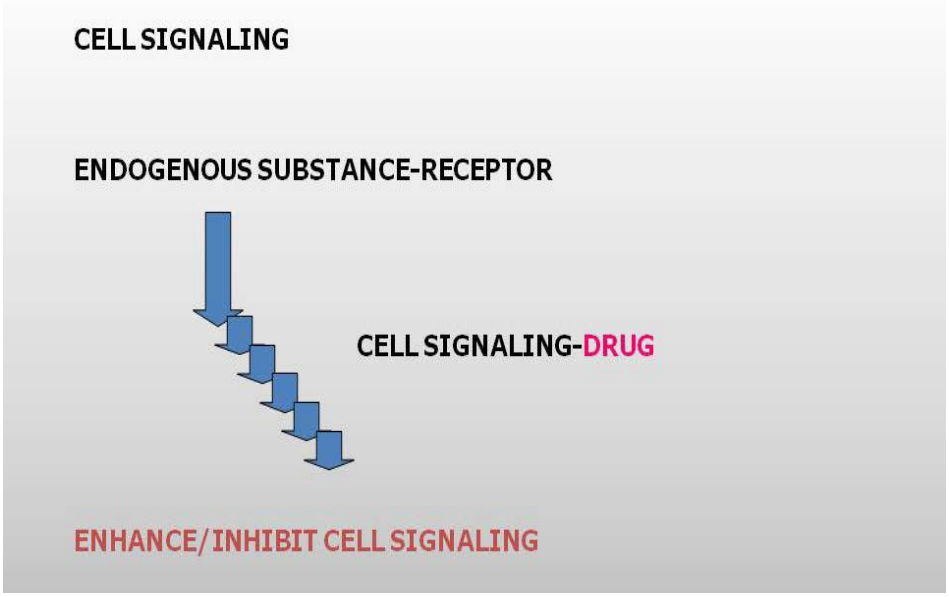

Figure 2.6.10.

Drugs can bind to components of cell signalling

(Copyright QUT, Sheila Doggrell)

2.6.2 Physiological processes – Links to Pharmacokinetics

Welcome to the second chapter of introduction to Pharmacology– physiological processes and their links to pharmacokinetics

Our bodies were not designed to deal with drugs. Our bodies were designed to nourish us and protect us from bad things. The physiological processes used in nourishing and protecting us, are the same processes responsible for the absorption, distribution, metabolism (break down), and elimination of drugs – pharmacokinetics.

The previous pharmacology chapter dealt with what the drug does to the body. This chapter deals with what the body does to the drug: Pharmacokinetics. What the body does to the drug is absorb it, distribute, break it down (metabolism) and eliminate it.

When we swallow food, the food is broken down into its components in the gastrointestinal tract (gut). For instance, the proteins in meat are broken down by enzymes in the gut to peptides, and then to amino acids (Figure 2.6.11).

When we swallow a drug, if the drug is a protein, it is treated exactly, the same way as the protein in meat. A peptide drug is broken down to amino acids, and is useless. Thus, most peptide drugs have to be given by a different route. There are lots of routes of drug administration, but the one people prefer is oral (by mouth). This chapter only talks about drugs that are administered orally. Most drugs are not peptides, and therefore can be administered orally, and not broken down (Figure 2.6.11).

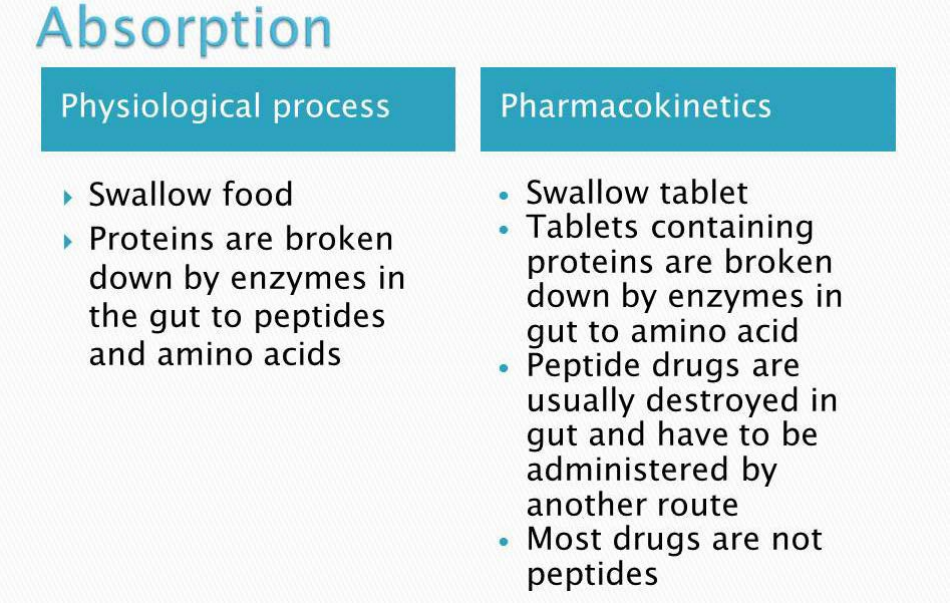

Figure 2.6.11. Comparing swallowing food to ingestion of drug

Food is broken down, in the gut, to nutrients such as amino acids and sugars. Some drugs are broken down in the gut, and this may mean they cannot be administered by mouth (orally), and have to be taken by another route e.g. injection into the vein (intravenously).

Some of the nutrients are absorbed from the gut into blood vessels by diffusing (moving) through the lipid membranes. To do this the nutrients have to be lipid soluble. Other

nutrients are actively transported from the gut to the blood stream. Thus, nutrients bind to a transporter and are moved across from the gut to the blood vessels.

Some drugs are lipid soluble, which means they dissolve in lipids. Such drugs can diffuse through lipid membranes and move from the gut to the blood stream. Some drugs bind to transporter and are transported from the gut to the blood stream (Figure 2.6.12).

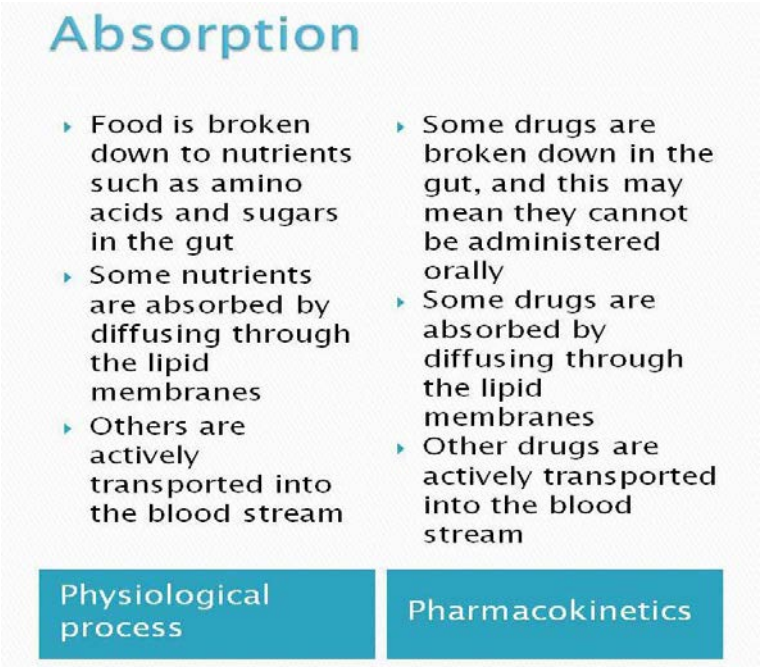

Figure 2.6.12 Absorption of nutrients and drugs

From the intestine, some of the nutrients enter a blood vessel known as the portal vein. This vein takes nutrients to the liver (Figure 2.6.13). The liver has an important role in metabolising nutrients such as carbohydrates, lipids and proteins. This metabolism involves many, many enzymes.

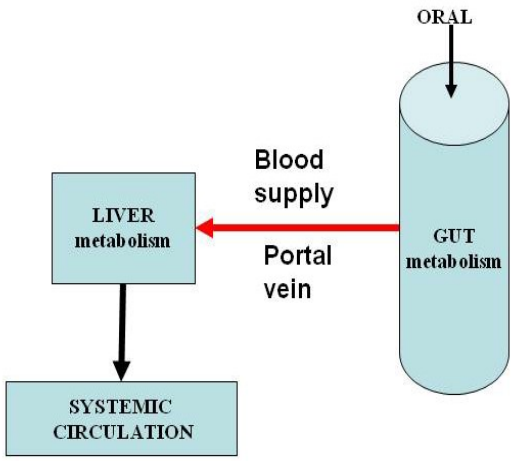

Figure 2.6.13 The route for a drug after oral administration

Drugs are also delivered to the liver by the portal vein. The enzymes that metabolise the nutrients can also metabolise the drugs. If the metabolism of the drug is to a great extent, the drug will be inactivated by the liver, and never reach the circulation to have an effect. Only drugs that survive the attack by the liver enzymes enter the general circulation and have an effect (Figure 2.6.14). Drugs that are extensively metabolise by the liver have to be given by another route to avoid drug metabolism.

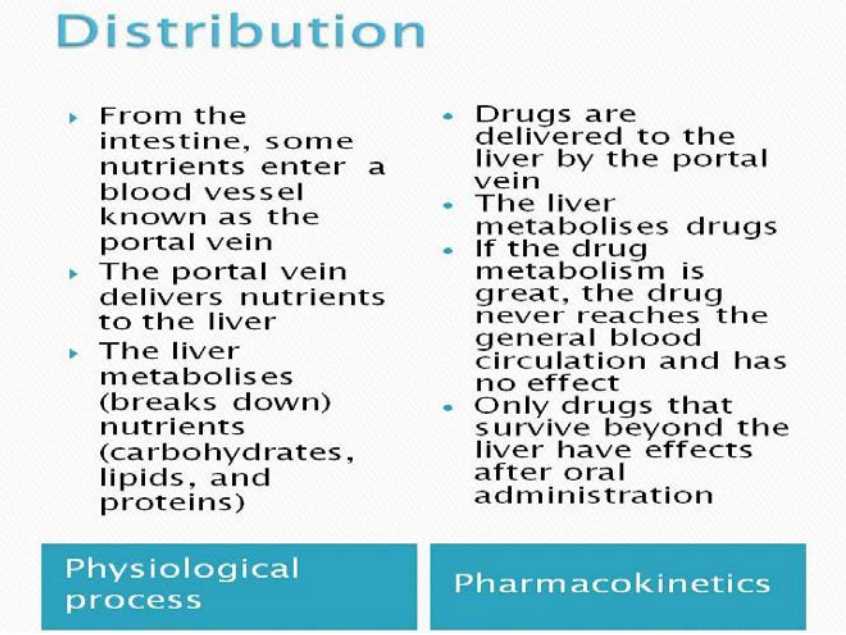

Figure 2.6.14 Distribution of nutrients and drugs to the liver

In the physiological process, the blood flow out of the liver is returned to the main vein, the venae cava. The blood goes from the venae cava to the heart, and the heart pumps the nutrient-containing blood around the body.

Drugs in the blood from the liver also go to the venae cava, the heart, and are distributed throughout the body. The highly perfused (lots of blood) organs initially receive more of the drug. Highly lipid drugs can move out of blood vessels and be distributed and stored in fat (Figure 2.6.15).

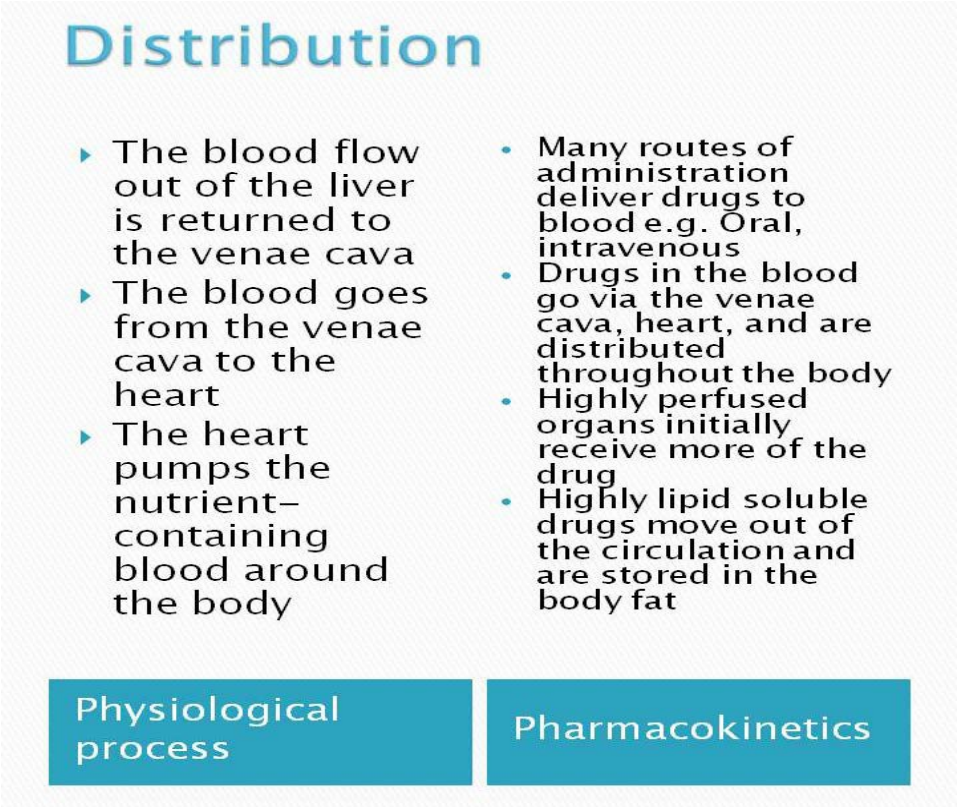

Figure 2.6.15 Distribution of nutrients and drugs

The chemicals from nutrients are used to make the components of the body such as hormones and neurotransmitters. Many of these naturally occurring substances (hormones, neurotransmitters, local hormones) bind to receptors to mediate responses. Drugs often bind to receptors for naturally occurring substances to mediate or inhibit the physiological response (see previous chapter).

In addition to having enzymes to metabolise nutrient, the liver had enzymes to protect the body from foreign dangerous material.

Drugs in the circulation go through the liver on a regular basis. Drugs are metabolised by the enzymes in the liver. This metabolism usually inactivated the drug (Figure 2.6.16).

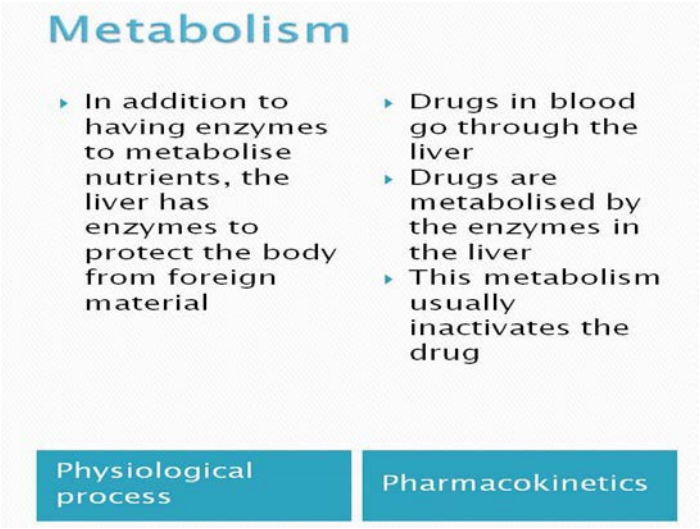

Figure 2.6.16 Metabolism of foreign material and drugs

The organs and tissues take up nutrients from the blood stream and use them, and turn them into waste products. The waste products are delivered back to the blood stream. The waste products are excreted from the kidney.

After metabolism, the inactive drug metabolites are delivered to the blood stream. The blood stream takes the drug metabolites to the kidney. Many drugs are excreted by the kidney (Figure 2.6.17).

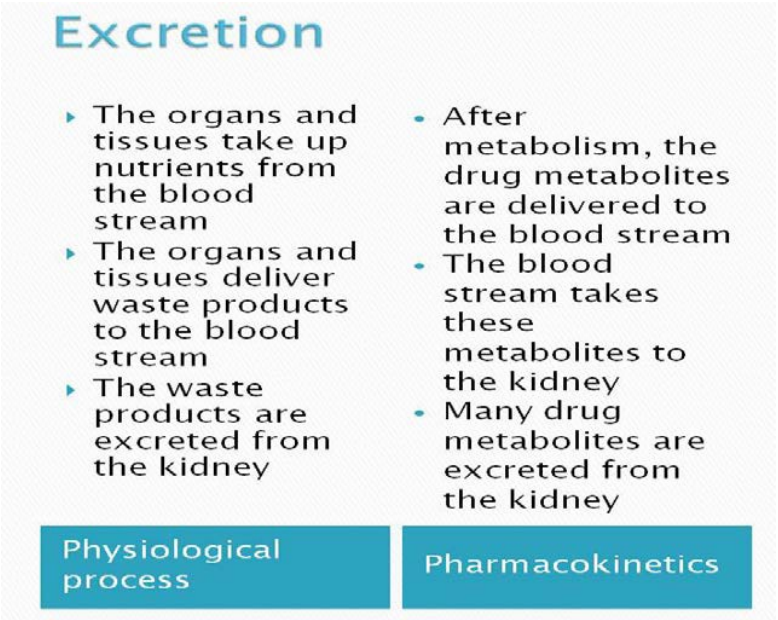

Figure 2.6.17 Excretion of waste products and drug metabolites

3.1.1 Nervous and Endocrine systems

Sally Schaffer & Mark Woolf, School of Biomedical Sciences, Queensland University of Technology

3.1.1.1 Introduction

The human body is very complex and made up of trillions of cells. It is important that activities of cells, tissues and organs are coordinated in order for the body to function normally. Control and communication within the body occurs via the nervous system and the endocrine system. The nervous system acts through nerve impulses and neurotransmitters; the endocrine system produces hormones. The activities of these two systems must be integrated in order to allow for coordinated functioning of the body.

Messages via nerves are conducted very rapidly (in milliseconds) but the duration of the action is very short e.g. the response to a painful prick to a finger is a very rapid withdrawal of the hand. Hormones generally act more slowly and it can take hours or days before a response occurs, but this response can be sustained for a longer time e.g. the hormones that regulate growth or pregnancy can be effective for years or months.

3.1.1.2 Neural signalling

The nervous system produces nerve signals in the form of electrical impulses (action potentials) that are transmitted along special nerve cells or ***neurons***. Neurotransmitters are chemical messengers released by neurons to allow for communication at the ***synapses*** or junctions between neurons or between neurons and target cells (they respond to the neuron e.g. a skeletal muscle cell may contract when receiving a message from a motor neuron) (Figure 3.1.1.1).

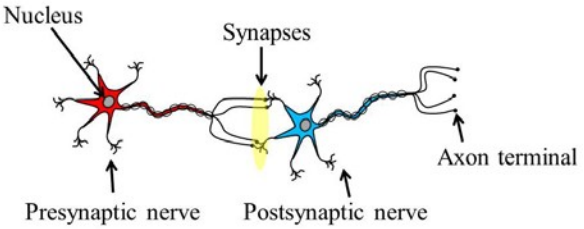

Figure 3.1.1.1 A diagram showing 2 neurons communicating at the synapse (Copyright QUT)

Neurotransmitters are released from the terminals of the axon (single arm-like process) of the presynaptic neuron; they cross the synaptic gap and bind to receptors on adjacent, postsynaptic neurons or target cells (Figure 3.1.1.2). Transmission of nerve impulses along the neuron is in the form of electrical signals, whilst the neurotransmitters are chemical signals.

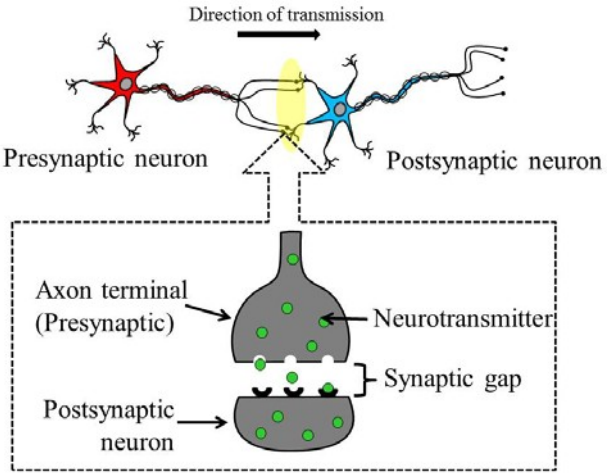

Figure 3.1.1.2 A more detailed view of a synapse (Copyright QUT)

3.1.1.3 Divisions of the nervous system

The nervous system is divided into the central nervous system (CNS), comprising the brain and spinal cord, and the peripheral nervous system (PNS) of peripheral nerves that link the CNS to all parts of the body. The PNS is made up of sensory or afferent nerves that transmit information towards the CNS and motor (efferent) nerves that conduct information away from the CNS to muscles and glands. The motor division of the PNS is further divided into the somatic or voluntary nervous system that allows conscious control of skeletal muscle and the autonomic or involuntary division that regulates the activity of smooth and cardiac muscle and glands; we have no conscious control of these nerves. The autonomic nervous system is further divided into the sympathetic division that mobilises the body during activity and the parasympathetic division that promotes housekeeping functions during rest.

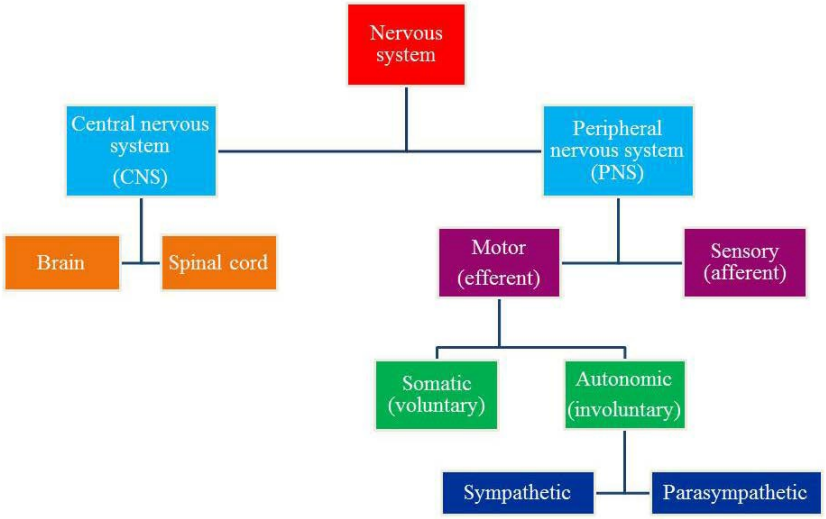

Figure 3.1.1.3 Divisions of the nervous system

3.1.1.4 The Endocrine system

The endocrine system consists of collections of glands and tissues that secrete hormones into the blood. Hormones travel in the blood or lymph to act on distant target cells.

3.1.1.5 Location of some important endocrine glands

The hypothalamus and pituitary gland are found in the brain. The parathyroid glands are found on the posterior of the thyroid gland which is located in the anterior neck region. There are 2 adrenal glands sitting superior to the kidneys. The male testes and female ovaries are also important hormone producing organs (Figure 3.1.1.4). See section 3.1.4.7 for information about the endocrine functions of the pancreas.

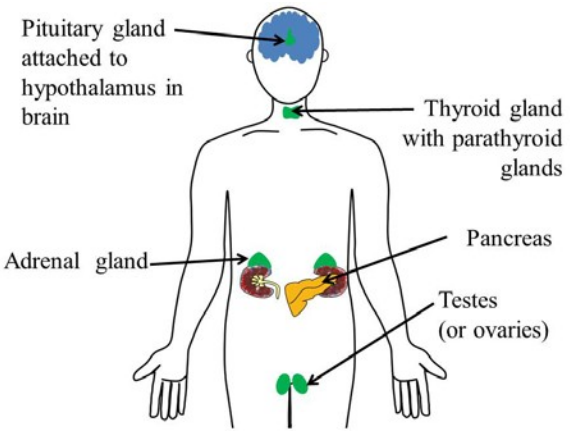

Figure 3.1.1.4 The location of some important endocrine glands (Copyright QUT)

3.1.1.6 Endocrine signalling

Hormones bind to receptors on the cell membrane or inside target cells (if they can pass through the cell membrane), resulting in a change in the structure or function of the target tissue e.g. hormones can cause a change in growth or metabolism of cells. Refer also to section 2.5.1.

Only the correctly sized/shaped hormone (key) will bind to the specific receptor site (lock) to bring about a response or action. A hormone will not activate a cell if it cannot bind to the receptors outside or inside the cell.

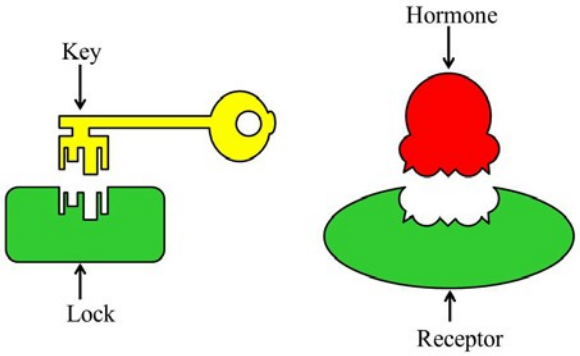

Figure 3.1.1.5 Hormones bind to specific receptors like a key fits into a lock (Copyright QUT)

Acknowledgements

We thank Kaileen Lynch for the preparation of the figures.

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3.1.2 Cardiovascular system

Sally Schaffer & Mark Woolf, School of Biomedical Sciences, Queensland University of Technology.

3.1.2.1 Introduction

The cardiovascular system is important to transport blood, nutrients, blood gases and wastes around the body. It is made up of the heart and blood vessels. The heart pumps the blood to the lungs in the pulmonary circuit for gas exchange to occur between the capillaries and the lung tissue – oxygen is taken up by the blood and carbon dioxide is released into the lungs. The heart distributes the oxygenated blood to all the body tissues and organs via the systemic circuit (Figure 3.1.2.1).

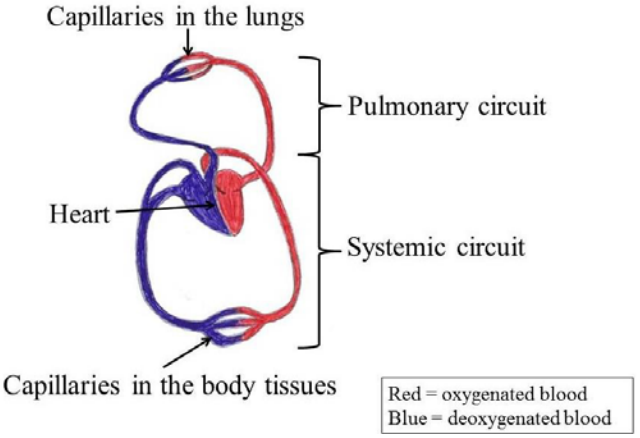

Figure 3.1.2.1 The pulmonary and systemic circulations (Copyright, QUT)

3.1.2.2 Anatomy of the heart

The heart is divided into 4 chambers – the right atrium and right ventricle and the left atrium and left ventricle.

The blood enters the right atrium from the body tissues via the major veins, the superior and inferior venae cavae; blood then empties into the right ventricle which pumps it into the pulmonary arteries for gas exchange to occur in the lungs. The oxygenated blood is returned to the left atrium via the pulmonary veins; it then passes into the left ventricle where it is pumped into the major artery, the aorta and distributed to the tissues of the body (Figure 3.1.2.2).

The cardiac or heart muscle has its own blood supply known as the coronary circulation. Coronary arteries arise from the aorta and supply the heart with oxygenated blood. The coronary veins remove the deoxygenated blood and return it to the right atrium.

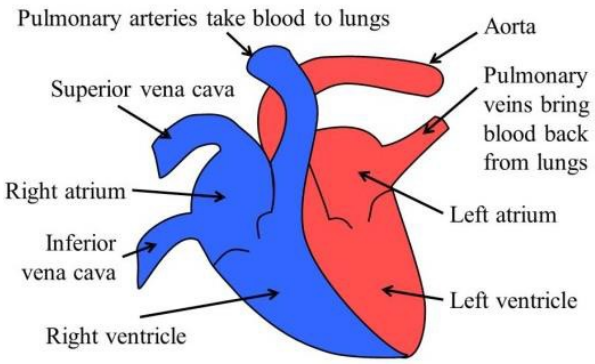

Figure 3.1.2.2 The anatomy of the heart (Copyright, QUT)

3.1.2.3 Intrinsic conducting system

The heart can beat of its own accord without a nerve supply, due to the spontaneous electrical activity of specialised cells in the heart – known as the intrinsic conducting system (Figure 3.1.2.3). The distribution of impulses allows the heart to contract in a coordinated way.

The pacemaker or sinoatrial (SA) node determines the heart rate as it produces electrical impulses at the fastest rate. The electrical impulses generated by the pacemaker spread to the atria causing them to contract. From the SA node, electrical activity spreads to the atrioventricular (AV) node which distributes the impulses to the AV bundle which connects the atria and ventricles. The bundle fibres and Purkinje fibres distribute impulses to the ventricles allowing the ventricles to contract.

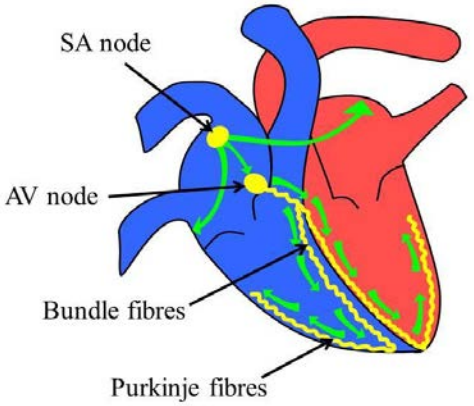

Figure 3.1.2.3 The intrinsic conducting system of the heart (Copyright, QUT)

3.1.2.4 The cardiac cycle

When the heart contracts, it pumps blood out of the chambers; it then relaxes in between contractions to allow the chambers to fill with blood (Figure 3.1.2.4).

Diastole refers to the relaxation period when the heart is filling with blood. Systole refers to the period of heart contraction when blood is pumped out of the heart.

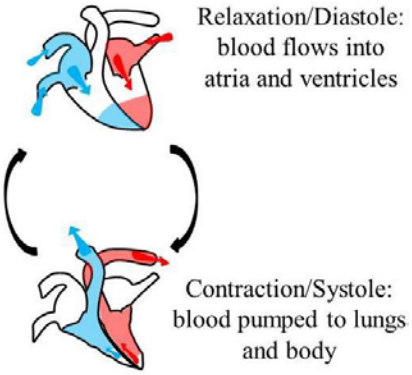

Figure 3.1.2.4 The cardiac cycle showing the periods of diastole and systole (Copyright, QUT)

3.1.2.5 Heart rate, stroke volume and cardiac output

We can measure the ***cardiac output (CO)*** or the amount of blood that is pumped out of each ventricle in one minute using the following equation:

CO (ml/min) = HR (beats/min) x SV (ml).

It is important that adequate cardiac output is maintained so that the body tissues receive the blood supply they need.
Although the heart can beat of its own accord, heart rate can be changed by the autonomic or involuntary nervous system which is made up of the sympathetic and parasympathetic divisions. Sympathetic nerve activity speeds up heart rate. Parasympathetic nerve activity dominates when the body is resting and slows down the heart rate (it is therefore slower than the pacemaker rate). Refer also to section 3.1.1.3.

HR = Heart rate which refers to the number of times the heart beats each minute.

SV = Stroke volume which is the amount of blood that is pumped out of a ventricle with each contraction or beat.

3.1.2.6 Blood pressure

Our normal arterial ***blood pressure*** (BP) is expressed as 120/80. When the left ventricle contracts and forces blood into the aorta, this peak pressure called systolic pressure is about 120mm Hg in healthy adults. During diastole the heart relaxes as it fills with blood and the pressure in the aorta drops to its lowest level of 80mm Hg, called diastolic pressure.
Blood pressure drops as it reaches the capillaries and veins (Figure 3.1.2.5).

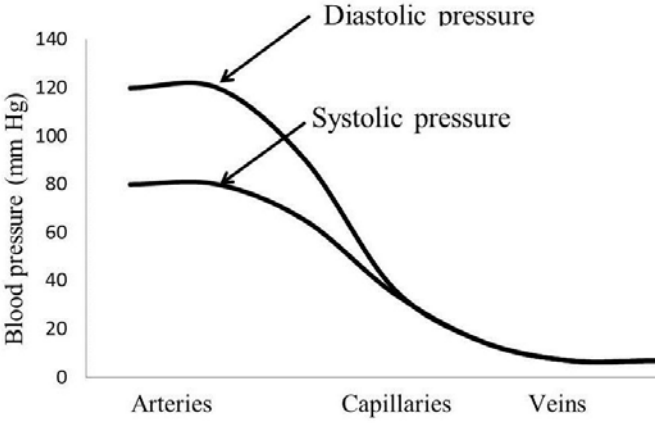

Figure 3.1.2.5 Blood pressure in the various blood vessels (Copyright, QUT)

4.1.2.7 Blood vessels

The 3 main types of blood vessels are ***arteries, veins*** and ***capillaries*** (Figure 3.1.2.6). Arteries carry blood away from the heart at high pressure so they have elastic fibres in their walls; they also contain lots of smooth muscle in their walls which allows them to alter blood flow to tissues by constriction or dilation of the blood vessels (vasoconstriction or vasodilation). Veins carry blood back to the heart at low pressure and have valves to prevent backflow of blood. Capillaries are involved in exchange of nutrients, gases and wastes between tissues and the blood.

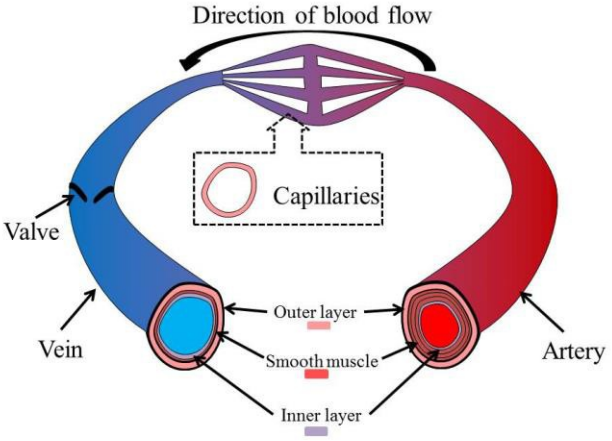

Figure 3.1.2.6 The generalised structure of different blood vessels (Copyright, QUT)

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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3.1.3 Respiratory system

Sally Schaffer & Mark Woolf, School of Biomedical Sciences, Queensland University of Technology

3.1.3.1 Introduction

The respiratory system is made up of the lungs and respiratory passages (nasal and oral cavities, nasopharynx, pharynx, larynx, trachea etc) (Figure 3.1.3.1). Its main function is to provide the body with oxygen and to get rid of waste carbon dioxide. Oxygen is needed for the production of energy, in the form of ATP, to enable the body to carry out important functions.

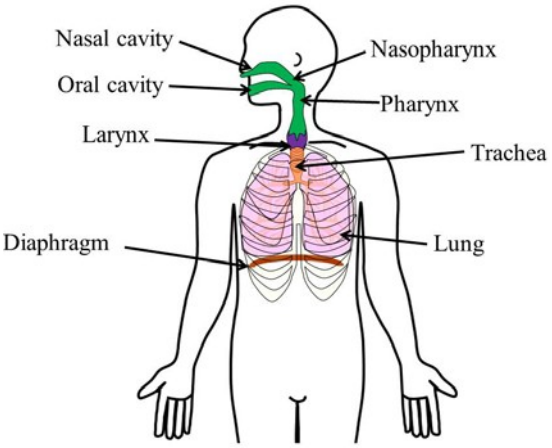

Figure 3.1.3.1 Some of the major structures that make up the respiratory system (Copyright, QUT)

3.1.3.2 Anatomy of the Respiratory system

The respiratory system is divided into 2 regions – the conductive region and the respiratory region (Figure 3.1.3.2). The passageways of the conductive region transport air to and from the lungs. Incoming air is also cleaned, moistened and warmed. The respiratory region in the lungs is involved in exchange of gases (oxygen and carbon dioxide) between the blood and the air in the lungs. Carbon dioxide in the blood forms a weak acid (carbonic acid) that releases H^+ ions into the blood and can make the blood more acidic if it is not removed (low pH). The lungs help regulate the pH of the blood by removing excess carbon dioxide from the body. Figure 3.1.3.2 shows some of the major structures that make up the respiratory system.

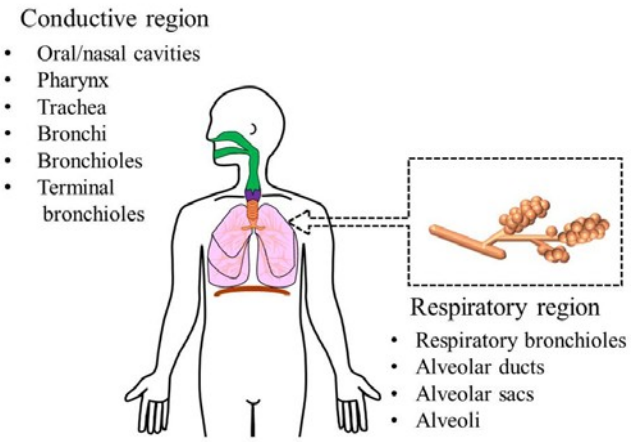

Figure 3.1.3.2 The generalised conductive and respiratory regions (Copyright, QUT)

3.1.3.2.1 Conductive region

Air passes from the oral or nasal cavities into the pharynx or throat; it then passes into the larynx and trachea which branches into left and right bronchi. These bronchi branch continuously into smaller passages like a tree until the air reaches the smallest branches called bronchioles. These passages form the conductive region (Figure 3.1.3.3).

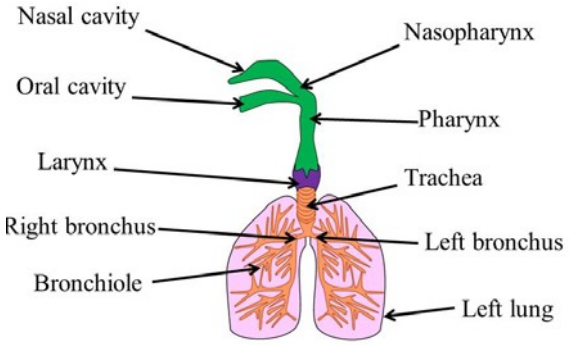

Figure 3.1.3.3 Some of the structures of the conductive region (Copyright, QUT)

3.1.3.2.2 Respiratory region

The air passes eventually via smaller air passages such as respiratory bronchioles into air sacs or alveoli that are arranged into alveolar sacs like bunches of grapes. The alveoli have very thin walls and exchange of gases can occur easily across these walls. This is the respiratory region (Figure 3.1.3.4).

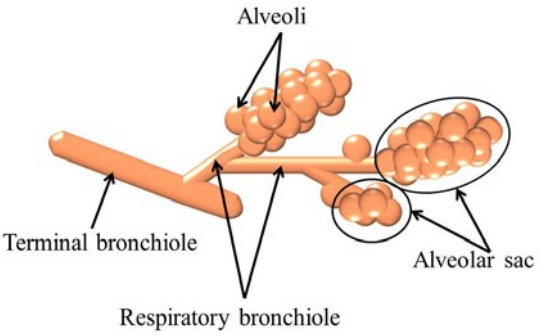

Figure 3.1.3.4 Some of the structures of the respiratory region (Copyright, QUT)

3.1.3.3 Mechanics of breathing

During inspiration or breathing in, the major respiratory muscle, the diaphragm contracts and flattens, the rib cage moves upwards and outwards and air moves into the lungs. During expiration the diaphragm relaxes, the rib cage moves back to its normal state and air is forced out of the lungs or breathed out (Figure 3.1.3.5).

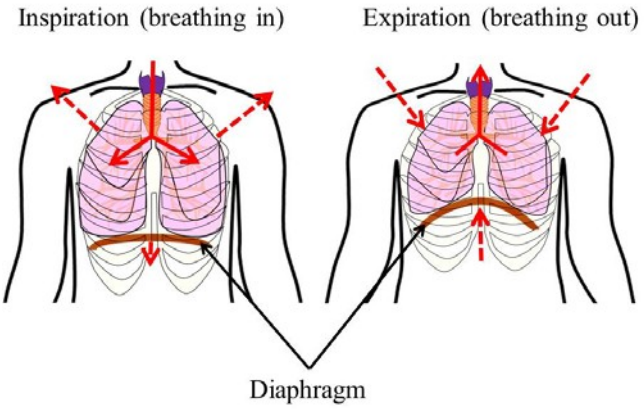

Figure 3.1.3.5 The process of breathing (Copyright, QUT)

3.1.3.4 Exchange of gases

In the lungs oxygen diffuses from the alveoli across the thin respiratory membrane and into the blood in the capillaries. This occurs as there is a higher concentration of oxygen in the alveoli than in the blood. Carbon dioxide also moves by diffusion from a higher concentration in the blood into the alveoli where the concentration is lower (Figure 3.3.3.6).
At the tissues oxygen diffuses from the blood in the capillaries into the tissue and carbon dioxide diffuses from the tissues into the blood.
The cardiovascular system which transports the blood around the body plays an important role in supplying oxygenated blood to the tissues and receiving carbon dioxide from the tissues and delivering it to the lungs for excretion.

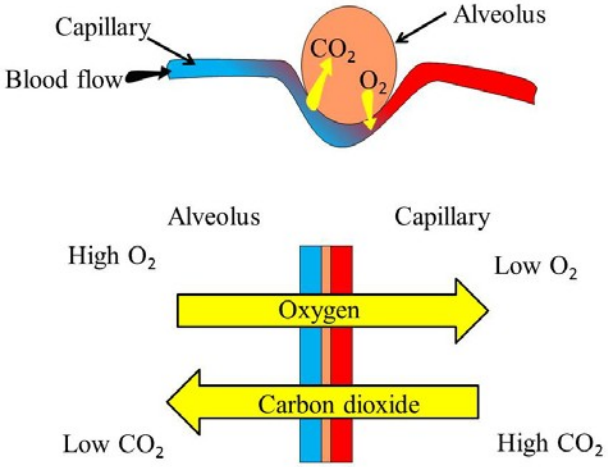

Figure 3.1.3.6 The process of gas exchange (Copyright, QUT)

3.1.3.5 Transport of oxygen

A small amount of oxygen dissolves in the blood but most is carried by haemoglobin (Figure 3.3.1.7). Each haemoglobin molecule has 4 iron-containing haem groups to bind and carry an oxygen molecule which can be carried to the tissues where it is released to allow for energy production in cellular mitochondria.

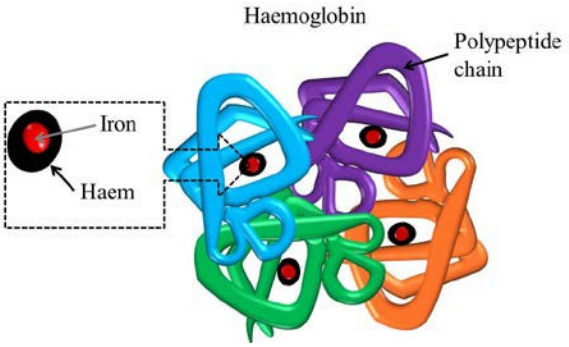

Figure 3.1.3.7 The structure of haemoglobin (Copyright, QUT)

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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3.1.4 Digestive system

Sally Schaffer & Mark Woolf, School of Biomedical Sciences, Queensland University of Technology

3.1.4.1 Introduction

The body needs a regular intake of food in the form of organic and inorganic molecules. The digestive system converts food into raw materials that can be used to make new molecules and cells and to replace old cells and structures. Food is also needed for cellular metabolism as it can be broken down to release energy for cellular work.

3.1.4.2 Organisation of the digestive system

The digestive system (see Figure 3.1.4.1) is made up of the ***gastrointestinal tract*** or gut which a continuous tube is starting at the mouth (oral cavity) and passing through the body as the pharynx, oesophagus, stomach, small intestine and ending in the anus of the large intestine. There are also accessory digestive organs such as the liver and pancreas.

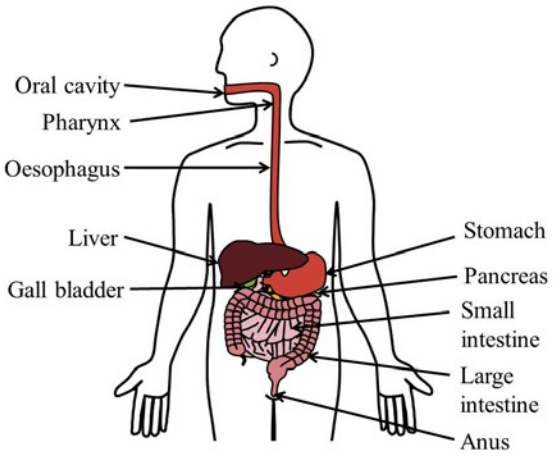

Figure 3.1.4.1 The digestive system showing the major organs (Copyright, QUT)

3.1.4.3 Digestive system functions

The major functions of the digestive system are ***digestion, absorption*** and ***defaecation***. Digestion involves the mechanical breakdown of foods such as chewing by teeth and churning of food in the stomach. Chemical digestion occurs in a series of steps whereby food is broken down by enzymes into small simple molecules that can be absorbed through the lining of the gastrointestinal tract into the body. The following nutrients are absorbed: carbohydrates e.g. glucose; proteins in the form of simple amino acids; lipids or fats e.g. fatty acids; electrolytes or ions e.g. Na^+ and Ca^+ as well as vitamins, nucleic acids and water. Food that cannot be digested is eliminated from the body via the anus.

3.1.4.4 The stomach

Both mechanical and chemical digestion occurs in the ***stomach***. Contractions of the smooth muscle of the stomach result in churning and mixing of the food. Gastric or stomach secretions containing enzymes and HCl (hydrochloric acid) start chemical digestion of proteins. The partially digested contents leave the stomach as chyme (semi-fluid, partly digested food).

3.1.4 5 The small intestine

The ***small intestine*** is the major area of digestion and absorption of all nutrients. It is made up of 3 parts, the duodenum, the jejunum and the ileum. It is 2-4m in length and the length and folding of the inner lining increase the surface area for absorption of nutrients (Figure 3.1.4.2).

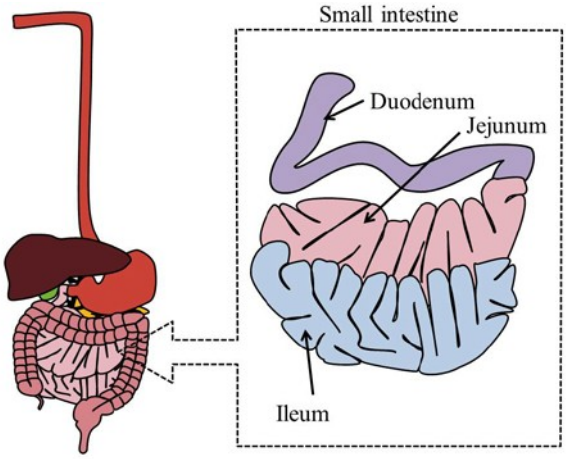

Figure 3.1.4.2 The gastrointestinal tract showing the small intestine (Copyright, QUT)

3.1.4. 6 The liver

The ***liver*** is an accessory digestive organ with many important metabolic and regulatory roles e.g. it stores glucose in the form of glycogen. Its important digestive function is the production of bile which contains a mixture of cholesterol salts and bilirubin, a breakdown product from old red blood cells. Bile is stored in the ***gall bladder*** and released into the duodenum to help with digestion of lipids. (Figure 3.1.4.3).

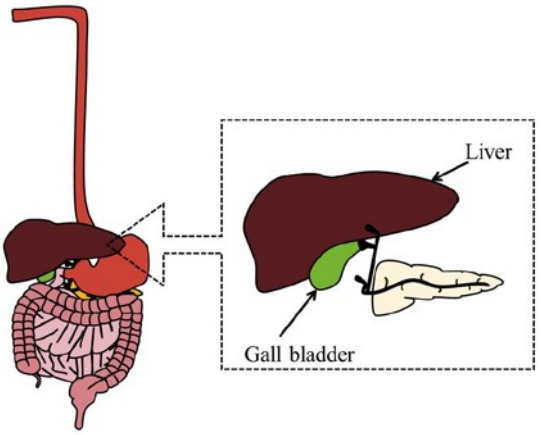

Figure 3.1.4.3 The gastrointestinal tract showing the liver and gall bladder (Copyright, QUT)

3.1.4. 7 The pancreas

The ***pancreas*** is another important accessory organ with both endocrine and exocrine functions (exocrine glands release secretions into the body cavity via ducts). The endocrine function involves the production of hormones insulin and glucagon that help regulate blood glucose. The exocrine function involves the release of digestive juices into the duodenum for digestion (Figure 3.1.4.4). The pancreatic juices contain bicarbonate ions to neutralise the stomach acid and digestive enzymes: the carbohydrases digest carbohydrates, the proteases digest proteins and lipases digest lipids. (The suffix –ase refers to enzymes).

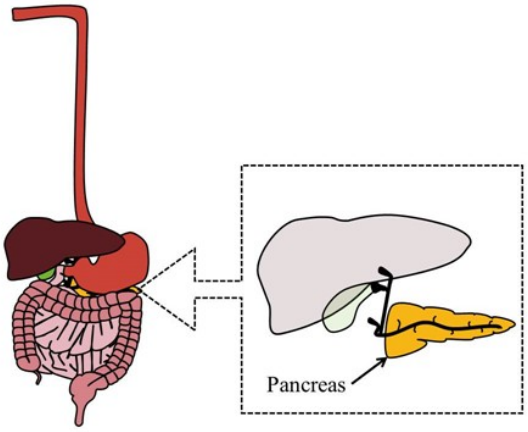

Figure 3.1.4.4 The gastrointestinal tract showing the pancreas (Copyright, QUT)

3.1.4. 8 The large intestine

The ***large intestine*** is made up of 4 main regions, the caecum, colon, rectum and the anal canal (Figure 3.1.4.5). Its major digestive function is to absorb most of the remaining water in the gut and to eliminate the undigested food as faeces.

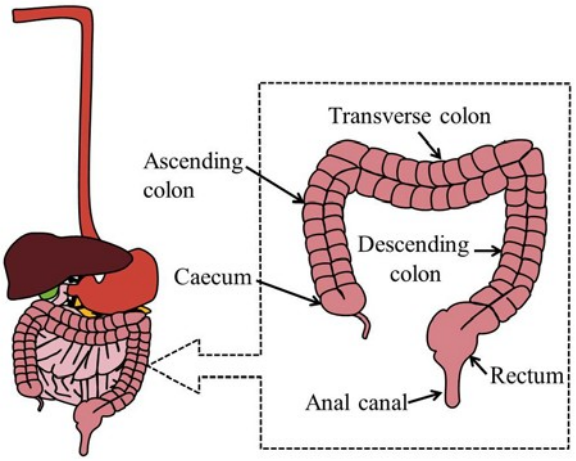

Figure 3.1.4.5 The gastrointestinal tract showing the large intestine (Copyright, QUT)

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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3.1.5 Urinary system

Sally Schaffer & Mark Woolf, School of Biomedical Sciences, Queensland University of Technology

3.1.5.1 Introduction

The urinary system consists of paired ***kidneys*** that produce urine; two ureters that transport urine to the bladder, where it is temporarily stored and a urethra which carries urine out of the body from the bladder (Figure 3.1.5.1).

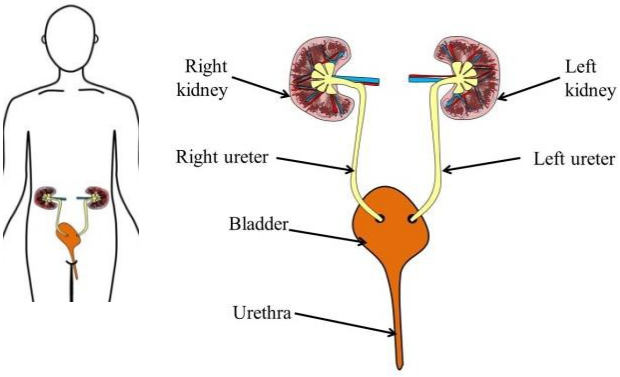

Figure 3.1.5.1 The urinary system (Copyright, QUT)

3.1.5.2 Kidneys

The kidneys have two major functions. They remove wastes such as urea from the breakdown of proteins and potentially harmful substances such as drugs and toxins from the blood and excrete them in the urine. Additionally they are involved in maintaining homeostasis of body fluids. They achieve this by regulation of water volume and sodium content to maintain blood pressure; regulation of potassium ions for neuron, muscle and heart functioning and regulation of the concentration of H+ ions to maintain acid base balance.

Blood enters the kidneys via renal arteries and the blood that has been filtered at the nephrons leaves the kidneys via renal veins. The nephrons produce the urine which is transported to the bladder via the ureters (Figure 3.1.5.2).

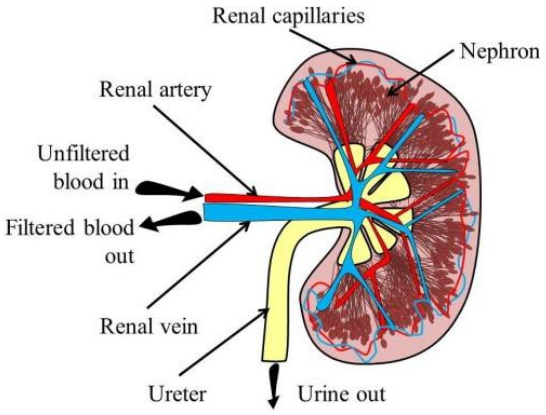

Figure 3.1.5.2 A kidney showing its blood supply (Copyright, QUT)

3.1.5.3 Nephrons

Each kidney comprises about a million ***nephrons*** which produce the urine; each nephron is made up of a glomerulus (the renal capillaries supplying each kidney with blood), a surrounding glomerular capsule for the formation of the urinary filtrate, and a number of tubules and collecting ducts for the modification and concentration of the urine (Figure 3.1.5.3).

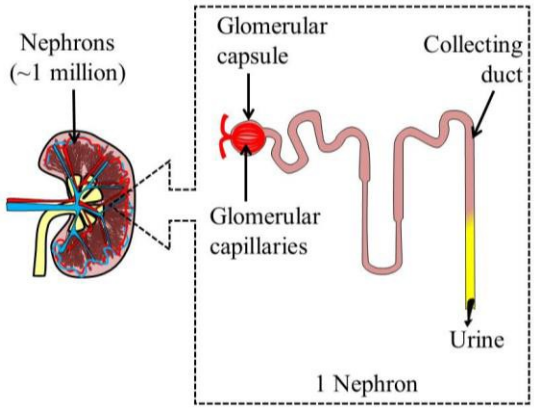

Figure 3.1.5.3 A kidney showing a nephron in more detail (Copyright, QUT)

The first step in urine formation involves ***filtration*** (a process where small molecules from the blood pass through blood capillary wall into the glomerular capsule) of about 180L blood per day from the capillaries into the capsule (Figure 3.1.5.4).

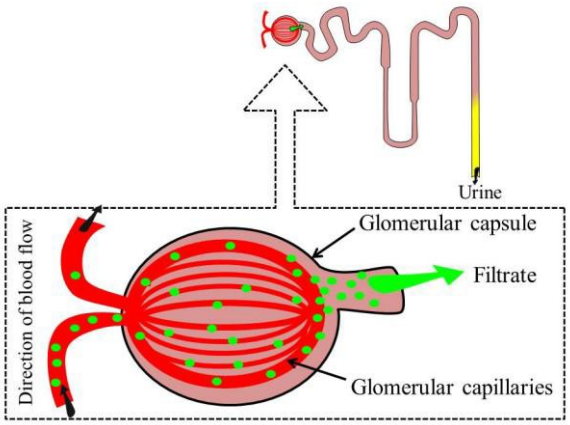

Figure 3.1.5.4 Filtration occurs at the glomerular capsule (Copyright, QUT)

The urinary filtrate is then modified by ***reabsorption*** and ***secretion*** of various substances from the tubules and into the tubules from the blood. Water is reabsorbed from the filtrate so the urine volume is about 1% of the filtrate volume and is quite concentrated by the time it leaves the collecting ducts (Figure 3.1.5.5).

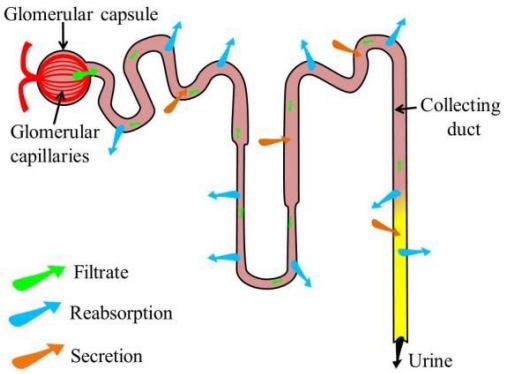

Figure 3.1.5.5 Reabsorption and secretion occurs at the tubules of the nephron (Copyright, QUT)

3.1.5.4 Homeostasis of blood

Antidiuretic hormone (ADH) is released when we are slightly dehydrated, this will concentrate the urine by increasing water reabsorption back into the blood from the tubules. When blood volume or pressure are low, the hormone ***aldosterone*** promotes sodium reabsorption from the filtrate, water follows sodium by osmosis and blood volume and pressure is raised (Figure 3.1.5.6). The release of aldosterone is dependent on the renin-angiotensin-aldosterone mechanism, a hormonally regulated system to increase blood pressure in the body.

Aldosterone also regulates potassium secretion when levels become too high. When blood pH comes too low (too acidic) the renal tubules secrete extra H^+ ions into the filtrate to maintain homeostatic blood pH. If blood pH is too high, it becomes alkaline and the renal tubules secrete excess bicarbonate ions (HCO_3^-) into the filtrate to maintain homeostatic blood pH.

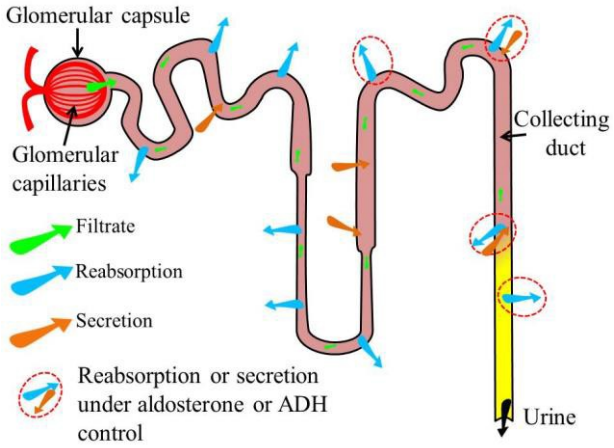

Figure 3.1.5.6 Reabsorption and secretion is promoted by hormones to maintain homeostasis of the blood (Copyright, QUT)

Acknowledgements
We thank Kaileen Lynch for the preparation of the figures.

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3.2 A Spotlight on Medical Microbiology

Sally Schaffer & Adam Polkinghorne, School of Biomedical Sciences, Queensland University of Technology

3.2.1 What are microorganisms and why do we care about them in health-care settings?

Microorganisms or microbes are usually too small to be seen with the naked eye. They range from prions (abnormal forms of normal cellular proteins) and viruses which are non-living microbes (they can only grow inside a living cell), to bacteria, protozoa, algae and fungi (Figure 3.2.1). Some of them cause infectious disease and make us ill; they are known as pathogens or infectious agents. Some helminths (worms) and arthropods (such as ticks and lice) are also considered as part of this group though they can be seen by the naked eye. Additionally there are lots of microbes that live on our bodies (we are the host) and may be beneficial to us – they form our normal flora; however they may become opportunistic and cause infection e.g. if the host's immune defences are lowered.

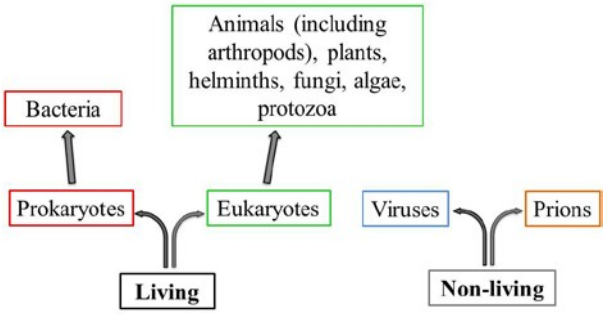

Figure 3.2.1 Classification of living organisms and non-living structures that may cause infectious disease (Copyright QUT)

3.2.2 Naming of microorganisms

Living microbes can be named according to a universal naming system for all organisms. A group of organisms can be placed into a genus; within the genera (plural) there are different species e.g. the bacterium *Staphylococcus* (genus) *aureus* (species) or *Staphylococcus* (genus) *epidermidis* (species). A species can be further divided into strains or serotypes e.g. *Chlamydia trachomatis* serotype A that causes trachoma (eye infection).

An example of how we name organisms:

Staphylococcus (genus) ***aureus*** (species)
Staphylococcus (genus) ***epidermidis*** (species)

3.2.3 Differences between eukaryote cells and prokaryote cells

Living organisms can be classified based on the differences in their cell structures. Bacteria are prokaryote cells and all other living things are called eukaryotes. Some of the differences between eukaryote and prokaryote cells are given in the following table (Table 3.2.1).

Eukaryote cells	Prokaryote cells
Structurally complex	Structurally simple
Nuclear membrane	Nuclear region
Membrane-bound organelles	No membrane-bound organelles
Cell wall absent or simple	Most have a complex cell wall
Large (5 – 100 μm)	Small (0.4 – 2.0 μm)

Table 3.2.1 Some key differences between prokaryote and eukaryote cells.

3.2.4 Microorganisms and other infectious agents

3.2.4.1 Bacteria

They are prokaryote cells with DNA necessary for determining the structure and function of the cell; they also contain ribosomes for synthesis of proteins. Some bacteria have flagella that help them to move or fimbrae that help them to attach to a host cell. Some bacteria are surrounded by a capsule or slime layer that protects them from ingestion by our immune cells and helps them attach to a host cell (Figure 3.2.2).

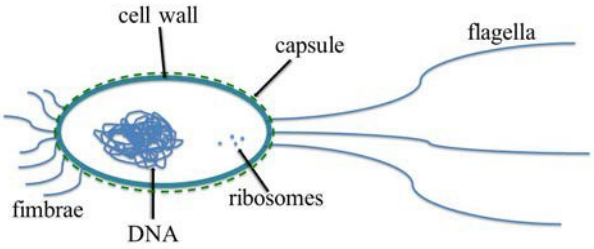

Figure 3.2.2 A diagram of a typical bacterial cell (Copyright QUT)

The characteristic structure of most bacteria is the cell wall. The cell wall gives support and protection to the bacteria and is largely composed of peptidoglycan (a carbohydrate-protein complex). Most bacteria can be categorised as Gram-positive or Gram-negative following use of a laboratory staining techniques known as the Gram stain. The staining depends on the composition of the cell wall and this helps in the identification of the pathogen causing a particular disease. Gram positive bacteria have a thick layer of peptidoglycan layer whilst Gram negative bacteria have a thin peptidoglycan wall (Figure 3.2.3).

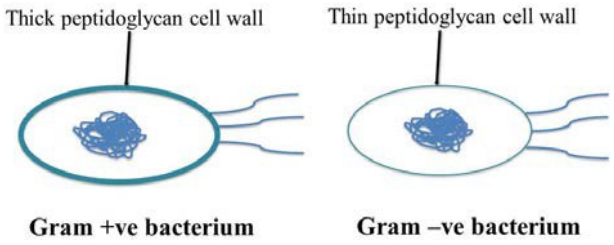

Figure 3.2.3 A comparison between Gram positive and Gram negative bacteria (Copyright QUT)

Bacteria are the largest group of microbes that are of medical importance. Examples of bacteria are: *Staphylococcus aureus* which is part of the normal flora of our skin but can cause wound infections in hospitals or *Escherichia coli* which is part of the normal flora of the gut but can cause urinary tract infections in some people.

3.2.4.2 Viruses

Viruses are non-living and can only reproduce and grow inside a living host cell. They contain DNA or RNA surrounded by a protein coat or capsid that helps the virus to attach and enter a host cell. Some viruses are surrounded by an envelope, derived from the cell membrane of the host cell, with some viral protein or glycoprotein spikes for attachment (Figure 3.4.2). Replication of the virus within a human cell can be complex and depends on whether the DNA or RNA is double or single stranded; single stranded RNA viruses e.g. HIV that can cause AIDS, are known as retroviruses and replicate by first producing a strand of DNA.
Examples of viruses are: Influenza type A which causes flu and Varicella zoster that causes chicken pox and shingles.

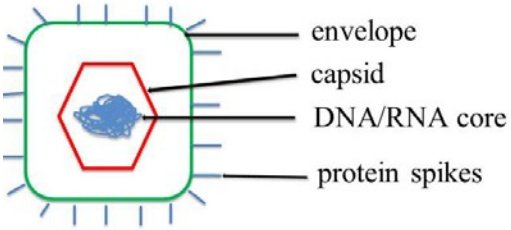

Figure 3.2.4 A schematic diagram of a virus (Copyright QUT)

3.2.4.3 Protozoa

Protozoa are single-celled organisms sometimes found as parasites (they derive food from their host) in animals and humans. They have different life stages and can survive in harsh environments as cysts by producing a resistant layer around themselves. Protozoa are surrounded by a cell membrane (not a cell wall) and contain a number of organelles (Figure 3.2.5). Parasites such as *Giardia intestinalis* cause diarrhoea.

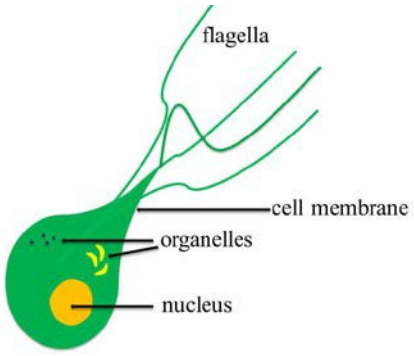

Figure 3.2.5 A diagram of a typical protozoan (Copyright QUT)

3.2.4.4 Fungi

Fungi may be single-celled, such as the yeast *Candida albicans* that can cause thrush, or multicellular moulds. The moulds consist of long filaments or hyphae that form a dense mat called a mycelium; they reproduce by means of spores produced in sacs arising from the hyphae (Figure 3.2.6). Moulds include *Penicillium* species that produces penillicin with antibiotic properties and *Microsporum* species that cause ringworm or tinea.

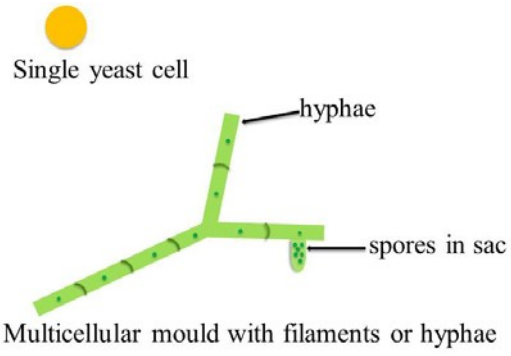

Figure 3.2.6 A diagram showing different types of fungi (Copyright QUT)

3.2.4.5 Helminths

The helminths or worms have a complex life cycle, involving eggs, larval and adult stages that may require more than one host (Figure 3.2.7). Humans are not always needed for the life cycle but eggs or larvae such as from the tapeworm *Taenia* may be accidently ingested via contaminated food e.g. beef or pork.

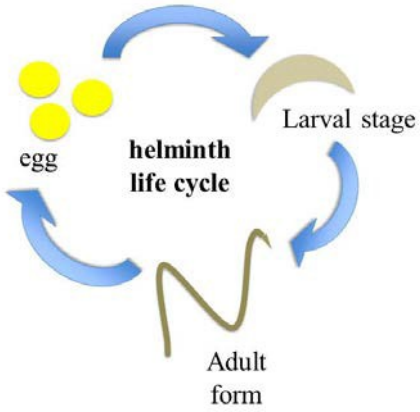

Figure 3.2.7 The life cycle of a worm showing different life stages (Copyright QUT)

3.2.4.6 Arthropods

There are a number of insects and spiders e.g. lice, ticks and mites that can live on the outside of our body (known as ectoparasites) and cause diseases such as scabies, caused by the mite *Sarcoptes scabei*.

3.2.5 Transmission of infectious diseases

For disease to spread, the pathogen must be transmitted to a susceptible host. The spread of these infectious microbes can occur via direct contact or indirect contact, via common vehicles such as food, water or air or by vectors such as insects. Vertical transmission from a mother to the foetus can occur across the placenta.

Direct contact involves close communication between an infected individual and a susceptible host; this includes skin contact via touching with hands and exchange of bodily secretions through kissing and sexual activity. Indirect contact involves transmission via fomites or inanimate objects such as clothing, medical equipment, eating utensils, phones, door knobs, keys etc. Direct contact transmission can occur via contaminated hands and indirect contact transmission can occur via contaminated drinking utensils (Figure 3.2.8).

One of the most common insect vectors is the mosquito that can carry the protozoan *Plasmodium* species causing malaria or the virus that causes Ross River fever.

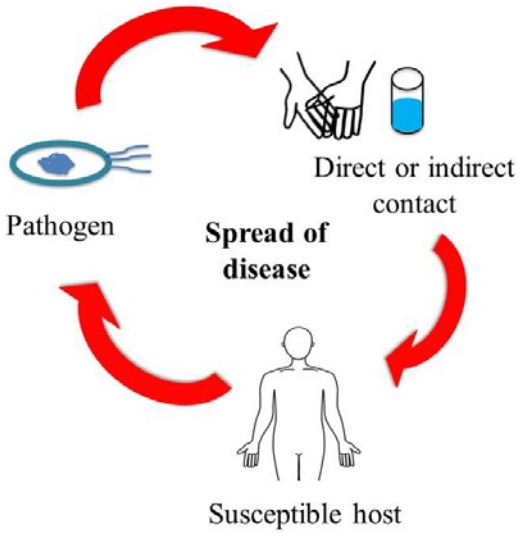

Figure 3.2.8 The cycle of transmission of pathogens between one host (ourselves) and another (Copyright QUT)

3.2.6 How are infectious diseases diagnosed?

Once a specimen has been collected from a patient e.g. urine, sputum or blood sample, the following procedures can be carried out to identify the cause of an infection (Figure 3.2.9).

- The pathogen may be identified with the naked eye e.g. fungi.
- A specimen can be examined under a microscope to look for any microbes; the Gram stain may help with identification if there are bacteria present.
- A nutrient-rich culture can be used to grow the microbe at a particular incubation temperature and pH in the presence or absence of oxygen. This method is best used to grow bacteria and fungi.
- The microbial DNA may be identified using a DNA multiplication method (polymerase chain reaction or PCR)
- Antibodies (proteins) produced specifically to a microbe's antigens (proteins on the surface of the microbe) by the patient's immune system, may be identified.

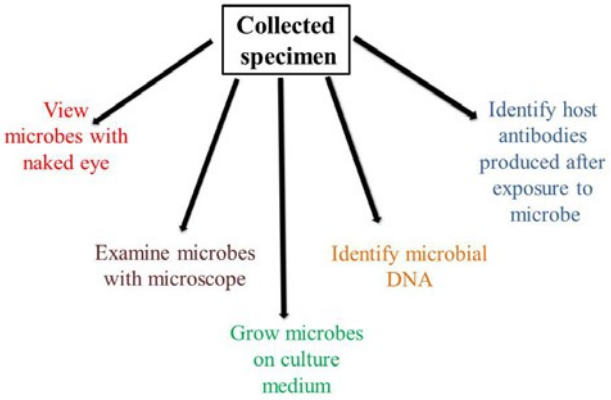

Figure 3.2.9 Procedures that can be used to diagnose the pathogen causing an infection (Copyright QUT)

3.2.7 How do we defend ourselves from disease?

The body has lots of ways to defend us from becoming infected. Our innate or non-specific immune defence includes intact skin and mucous membranes, certain immune cells and antimicrobial proteins and chemicals and the presence of the normal flora that can supress the growth of pathogens. We also have a second-line defence mechanism, the acquired immune system that is activated in response to specific invading pathogens (the antigens on the surface of the pathogen are detected); this response involves mainly the production of antibodies and lymphocytes (specialised white blood cells) (Figure 3.2.10).

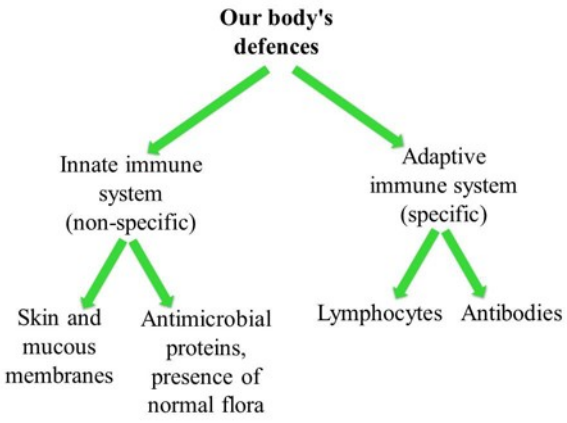

Figure 3.2.10 A summary of the body's defence mechanisms (Copyright QUT)

Prevention of disease involves prevention of transmission of infectious microbes via careful handwashing, sterilisation and disinfection and other hospital and public health infection control procedures. Antimicrobials such as antibiotics are used in treatment of disease, however, overuse has resulted in drug resistance and the appearance of "superbugs" in hospitals e.g. methicillin resistant *Staphylococcus aureus* (MRSA) commonly known as "golden staph".

Acknowledgements
We thank Michelle Maugham for the preparation of the figures.

References
Lee, G. & Bishop, P. (2010). Microbiology and infection control for health professionals. 4th Edition. Pearson Australia.

Active Learning Checklist

(*adapted from Gardner, J. N. & Jewler, A. J. (2005) Your College Experience: Strategies for Success, Wadsworth/Thomson Learning.)*

I am an active learner because……	Yes/No/Sometimes (Y/N/S)	I plan to….
I am usually comfortable about asking questions in class.		
I am usually comfortable to provide an example of something the lecturer is talking about.		
If I have a question about the learning materials or the assessment, I will make an appointment to see the lecturer or be sure to attend workshops/tutorials.		
I try to summarise the material in my notes or in the text to make sure I have grasped the key points.		
When I read and take notes, I write comments on the material and questions in my own words.		
I look up words in the text or lecture I do not understand.		
When I read, I pause frequently to check to make sure I am grasping the main points.		
If I am confused by a point in a text or lecture, I look it up in another source to see if I can get an explanation I can understand.		
I have generated a weekly study plan for the semester.		
I show up on time for my classes and appointments.		
I check Blackboard regularly for updates to the unit or learning materials.		
If a video is shown in class, I take notes about the main points, locate the source and review the video again later.		
If I don't get to a lecture/tutorial/lab, I will follow up online by listening to the lecture and completing exercises to cover the learning I missed.		
I recognise that I need to study in groups to develop my team skills for the workplace.		
I have back up plans for things that might go wrong and impact on my study, such as babysitters, transportation, computer/printer issues, etc.		
I space my study over several days rather than cramming the night before a test.		
When I study, I make sure my environment is free from distractions, e.g. put phone away, turn off the TV, find a quiet place, good lighting, chair posture etc.		
I check the library learning support materials e.g. Studywell before planning my assessment.		
When I have a big, complex essay question, I use the criteria marking sheet to make a rough plan to organise my thoughts before beginning to write.		
I save my 'skip days' for real emergencies.		
I make an effort to meet my peers outside class to discuss the unit/study materials.		