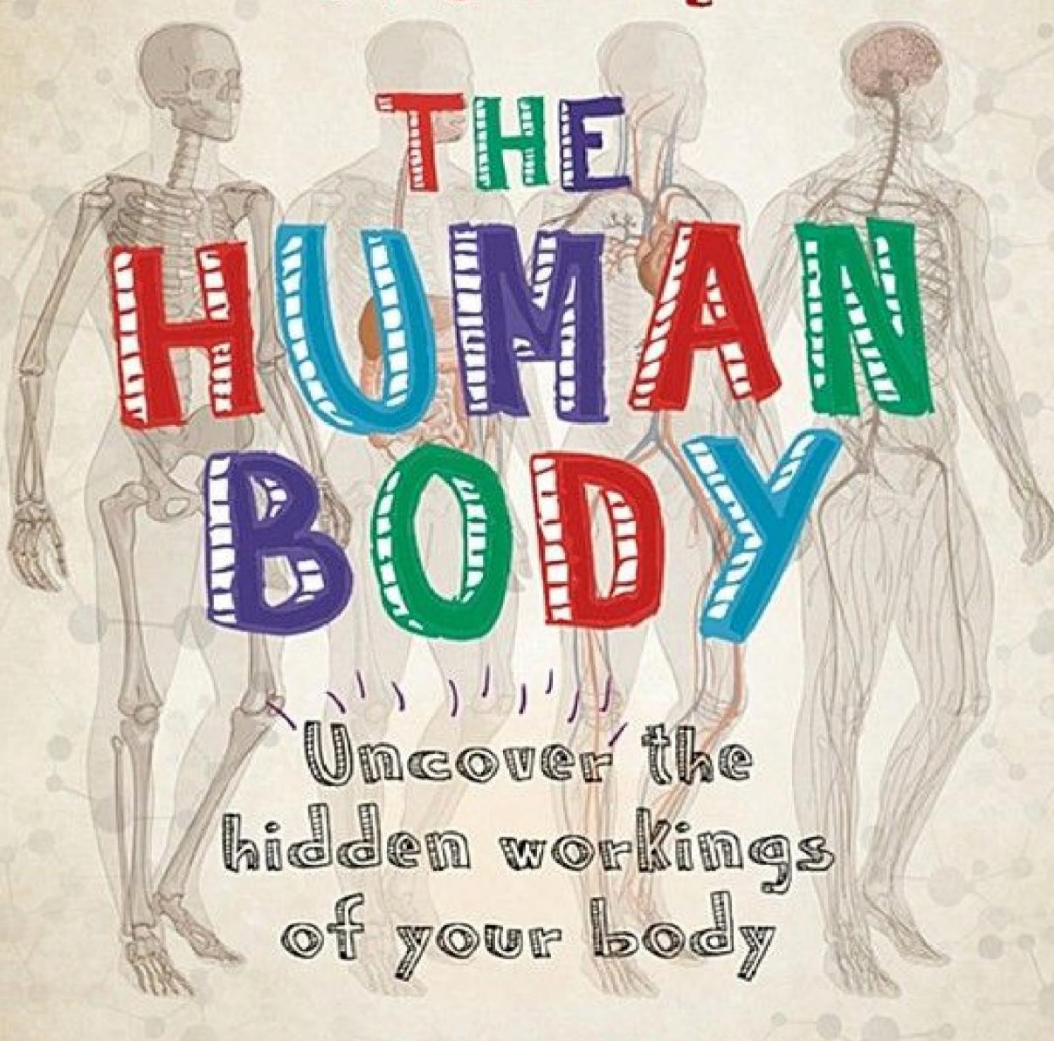
The Secret Life of THE HUMAN BODY



Uncover the hidden workings of your body

JOHN CLANCY

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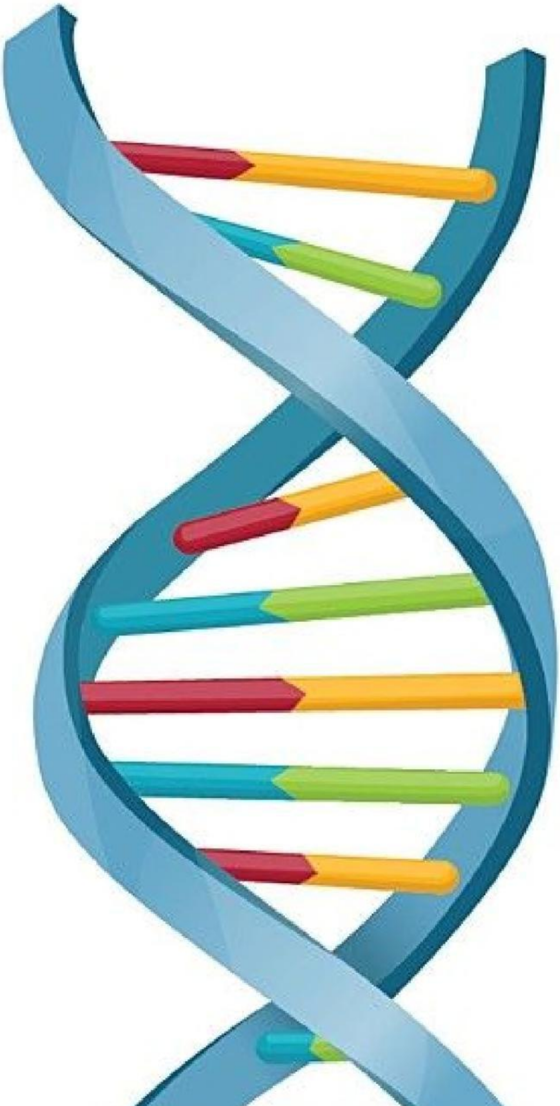
Introduction

You are about to begin the fascinating, dynamic study of the human body. For thousands of years, people have been observing and investigating the human body, trying to comprehend how it works when it is healthy and what goes wrong during ill health.

Discovering the Body

Before the end of the 16th century, medics had to rely on studying the human body armed only with the naked eye, and they often relied on "gut instinct" to treat disease and illness. Thankfully, since then, we have made great strides forward in our knowledge base of the human body. Inventions that have made this possible include the light and electron microscopes in the 20th century. The invention of the electron microscope was responsible for a major breakthrough in our knowledge in 1953, when Watson and Crick made public that they had found "the secret of life" and announced the structure of deoxyribonucleic acid (DNA). The current use of medical imaging techniques, including X-rays, ultrasound, three-dimensional Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) scans, have progressed our knowledge base of the human body.

Arguably, the greatest innovation recorded to date was in 2003, with publication of the Human Genome Project. This identified the exact position of each of the 25,000 genes within our 46 chromosomes. As such, it led to the first individual having their entire DNA sequence uploaded onto the Internet in 2007. It is predicted that in the near future our medical records will include our own genome, so treatments can be personalized to you.



The complex double-helix shape of a DNA molecule was identified as the genetic blueprint from which a human being is made and is responsible for identifying differences between individuals.

What's Next, You Might Ask?

Well, currently, the research regarding the human genome is ongoing, and almost every week, a gene sequence has been associated with either a healthy or diseased trait. The natural evolution of genomic knowledge is to identify the products of gene activity, so a group of scientists became involved in the Human Proteomics Project. This involves studying the gene products, that is enzymes, their structure and their functional activity. These studies will provide more information as to what is happening in the cell. This has applications for drug design, tailoring them to the individual. There is also a group of researchers investigating how environmental factors affect gene-enzyme activity in health and disease. This could reveal how risk factors such as smoking, stress, microbes and other environmental hazards can affect the human body. All in all, we are experiencing a very exciting time in the study of the human body, which will no doubt provide a longer and healthier life span for us humans.

Armed with this advanced technology, we can now explore the microscopic world inside the human body. By studying this book you will discover an amazing collection of secrets about your body, such as how the it is made up of trillions of microscopic structural and functional units called cells. Each cell can be regarded as the "basic unit of life", since it is the smallest part of the body capable of performing all the basic needs necessary for your survival. Cells can digest food, generate energy, move, respond to stimuli, grow, excrete and reproduce. To support these basic needs, cells contain organelles or "little organs" that carry out specific activities. You will see from chapter 1 and chapter 11 that the genes we inherit from our parents are the controllers of the secret chemistry associated with our cells' activities and hence the health of the human body. They are also involved when disease strikes.

The study of the human body involves several branches of science: human biology, chemistry, physics, mathematics, psychology and sociology. Each contributes an understanding of how the body functions in health, during times of exercise, illness, pain, distress, trauma and surgery. However, it must be stressed that human beings are biological organisms. The two interwoven branches of science covered in this book that will help you understand the human body are anatomy, that is how your body is organized structurally, and physiology, that is how it functions. Identifiable within these is a concept referred to as homeostasis.

Homeostasis: "A Happy Healthy Body"

Homeostasis refers to the automatic actions within the body, which are necessary to maintain the "healthy" consistent state of the body's environment, despite changes in the environment outside the body. Collectively, anatomical structure, physiological function (or activities) and the maintenance of homeostasis enable the cells to function and perform the basic needs of life necessary for a "happy healthy body".

If homeostasis provides a secret basis for health in the human body, then illness occurs when there is a failure of the automatic actions within the body, which are necessary to maintain the "normal" healthy status quo. This book highlights some of the more common illnesses of the human body. However, it cannot be overstated that illness may be classed according to the primary disorder, such as a stomach or lung problem, a tumour of a particular tissue, such as the breast, or as being due to an infection, such as pneumonia. Nonetheless, all will have consequences elsewhere in the body, other than those involved in the primary disturbance, and so the healthcare we receive when we are "ill" may be directed at symptoms apparently far removed from the primary problem. For example, these may include relieving constipation in a patient who has a colorectal tumour.

We Are All Different

We only have to look at other people around us to recognize that genetic variation dictates not only the colour of our hair, eyes and skin, but also how individuals respond to stress, the diseases to which we are susceptible and even how we react to different medicines. However, despite this variation, we are all built to the same basic template, with the same body systems, and our cells working the same basic way. It is with this in mind that this book takes a systems approach, since it allows greater understanding of how the body works as a whole. The human body is made up of a number of different systems, each with their own separate function. These systems are linked together through the circulatory and lymphatic systems and communicate with each other through the nervous and endocrine systems. Together, all the systems allow the body to move, explore and interact with the environment, and to carry out activities which are vital to health and our survival. A deterioration in one system, however, leads to other systems being affected, and ultimately, when the systems cannot operate anymore, this can or this will lead to our death.

With more than seven billion people on the planet, the amount of genetic variation is truly staggering. Even so, we humans all follow the same body blueprint allowing medics to simplify treatment for a whole host of diseases.

Chapter 1

CELLS, TISSUES AND BODY STRUCTURE

The Cell

Cells make up all living things (including you!), and that's why we refer to them as the "building blocks of the body".

Cells are also called the "basic units of life" because they are the smallest parts of the body that are capable of performing the basic functions needed for life. Their roles include digesting food, generating energy, moving, responding to stimuli, growing, excreting and reproducing. Just as the body has organs to perform specialized functions, cells have small component parts called organelles, or "little organs", that perform specific roles within the cell.

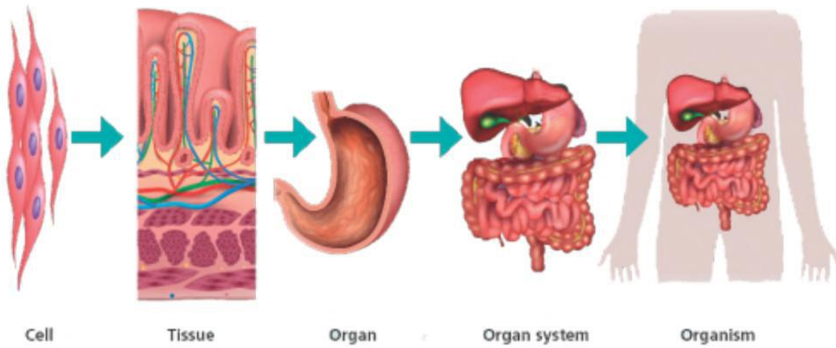
Control Substances

The production of enzymes is the cell's main job. This is because enzymes produce all the components that the cells need, such as proteins, complex carbohydrates and complex lipids. Enzymes also break down things that the cell doesn't need so that you can maintain a happy, healthy body (homoeostasis). They are also responsible for cell division in growth, and the repair and regeneration of cells when they are damaged and need to be replaced.

Organizing the Body

How do you get from a cell to a working human body? It's a process of organization. Cells within the body differentiate and specialize to form tissues that carry out a particular function. These tissues work together to form organs, such as the stomach,

which is an organ made up of different tissues. Organs that work together form organ systems, such as the digestive system, which work with other organ systems to make an entire organism, the human body.



The Cell Factory

The different parts and activities of the cell can be compared to a factory. Many different and important tasks are completed within a factory building, just like the varied parts of a cell.

The nucleus is the main office of the factory, where all the cell's activity is controlled. It contains genes (made of DNA) that give the instructions for making proteins, called enzymes. The nucleus is surrounded by a nuclear membrane, which controls what goes in and out of it.

Cell Membrane

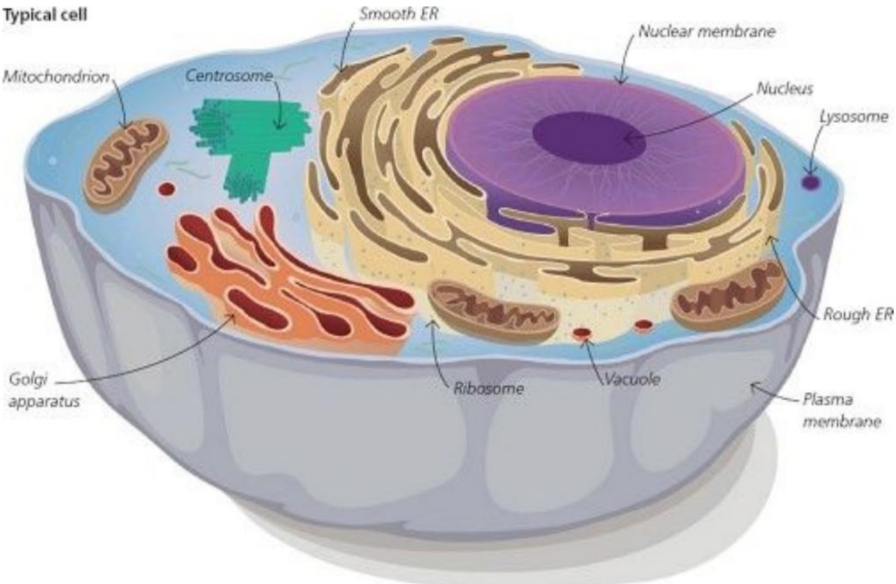
Similar to the fence around a factory, the cell membrane regulates the entry and exit of things into and out of the cell and provides protection against invasion. It also contains specific proteins, called cell markers, which give the cell its identity. For example, the cell markers of heart cells and kidney cells differ from one another and they also differ in individuals, since they are determined by an individual's genetics. It is these markers that are important in matching up donors and recipients so that successful organ transplants can take place.

Cytoplasm

The main building of the factory, the cytoplasm contains everything within the cell, except components of the nucleus.

Nucleoplasm

Equivalent to the main office of the factory, the nucleoplasm houses components, such as the chromosomes of the cell's nucleus.



Mitochondria

These are like the power generator of the factory, supplying the electrical energy for the factory's machinery to work. In the cell, the mitochondria break down food (mainly sugars) with oxygen in a process called aerobic respiration. This provides energy in the form of adenosine triphosphate (ATP), which drives chemical reactions. It also releases heat that maintains body temperature and provides the best conditions for enzyme activity. This is why the mitochondria are often called the "powerhouse" of the cell. The other end products of aerobic respiration – carbon dioxide and water – are important as they maintain the pH (acidity or alkalinity) of the cell, which also optimizes conditions of enzyme activity.

Endoplasmic Reticulum (ER)

The endoplasmic reticulum (ER) is a network of membranes found throughout the cell and connected to the nucleus. It is equivalent to pipelines in a factory through which supplies are moved. The rough endoplasmic reticulum has ribosomes attached to its outer surface. Ribosomes are similar to the machines on the assembly line that put the parts together to make the protein products (enzymes) of the factory. The smooth endoplasmic reticulum lacks ribosomes and is involved in the storage and synthesis of lipids (fatty acid compounds).

Golgi Bodies

Golgi bodies are similar to the packaging department, where products (carbohydrates, proteins and lipids) are packed together with enzymes, either to be used in the cell or exported.

Lysosomes

These are similar to the cleaning crew of the factory. The lysosomes break down (with enzymes): lipids; proteins; carbohydrates; foreign bodies that have entered the cell; worn out parts of the cell and even the cell itself, when it is no longer functioning at its best. That is why the lysosome is sometimes called the “suicide bag“ of the cell.

The cell membrane acts like security, controlling what goes into and out of the cell.

Centrosome

The centrosome is like the financial controller of the factory, deciding whether to enlarge the factory or to reduce its size depending upon its financial position. In a similar way, centrosomes are important in mitosis – chromosomal duplication required for cell multiplication – and in meiosis – chromosomal reduction in sperm and egg formation. Centrosomes develop microtubules (similar to little muscles), which pull apart duplicating chromosomes in mitosis to ensure daughter cells have identical numbers of chromosomes to the parent cell. In meiosis, centrosomes split chromosomes in two, before the sex cells are produced. This makes sure that the daughter cells have half the chromosomes of the parent cell (*see* Making Sex Cells).

Vacuoles

Like a factory's storage, vacuoles in the cell store water, salts, proteins, lipids and carbohydrates.

The factory is open 24/7 (even when you're sleeping) and its work is never done!

Genes: "the Secret Code of Life"

Genes are the controllers of all the cell's chemical reactions (collectively called metabolism) and indirectly affect enzyme production. Enzymes are biological catalysts and are therefore of fundamental importance in the human body. This is because enzymes speed up chemical reactions in our cells, which are crucial for a "healthy, happy body".

Genes help produce all the products of the cell that give you your observable traits, such as hair, eye and skin colour. They also control activities of the body, such as digestive enzymes, tears, blood clotting proteins, antibodies, hormones and even new cells. Genes are commonly referred to as the "code of life" and enzymes as the "key chemicals of life", because making and maintaining bodies would not be possible without them.

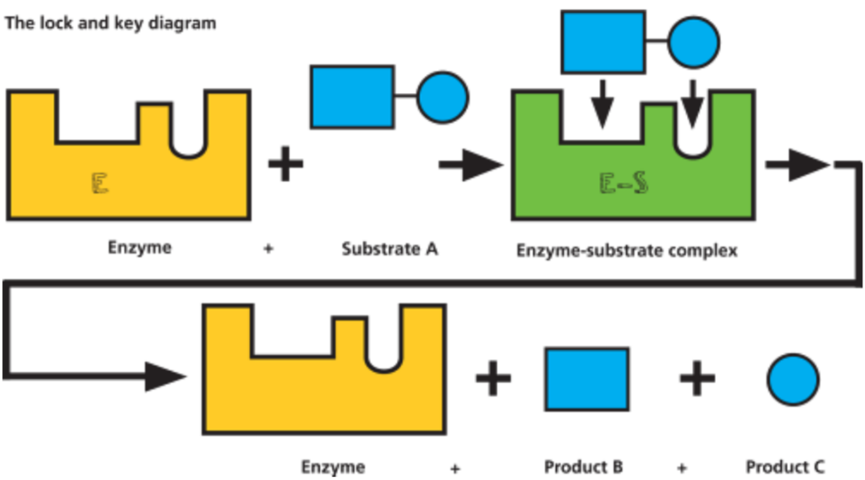
Under Lock and Key

An enzyme only accepts a molecule (the substrate) with the correct shape, just like a key will only fit into a certain lock. This "lock and key" principle applies to various chemical interactions

within the body, such as in the combination of an antibody (blood protein) with an antigen (foreign substance) during an immune response. A lack of a particular enzyme will prevent a certain reaction from occurring, while an excess of the enzyme could cause the reaction to proceed too quickly. Controlling the level of enzyme synthesis is therefore essential in sustaining homeostasis or the balance of chemicals within the human body.

Enzymes produced by a cell are normally for the cell's own use – which is like giving a present to itself! In addition to enzymes that are common to processes in all cells, there are also specific enzymes that relate to the role of a particular cell type. Enzymes may become detectable in blood if the cells are damaged and those that are specific to the cell type may then be isolated and used to diagnose certain conditions. For example, the appearance in blood of the enzyme lactic dehydrogenase (LDH) is an indicator of heart or liver cell damage, which then allows doctors to diagnose conditions like angina, myocardial infarction (heart attack) and liver disease.

The lock and key diagram



Types of Cell

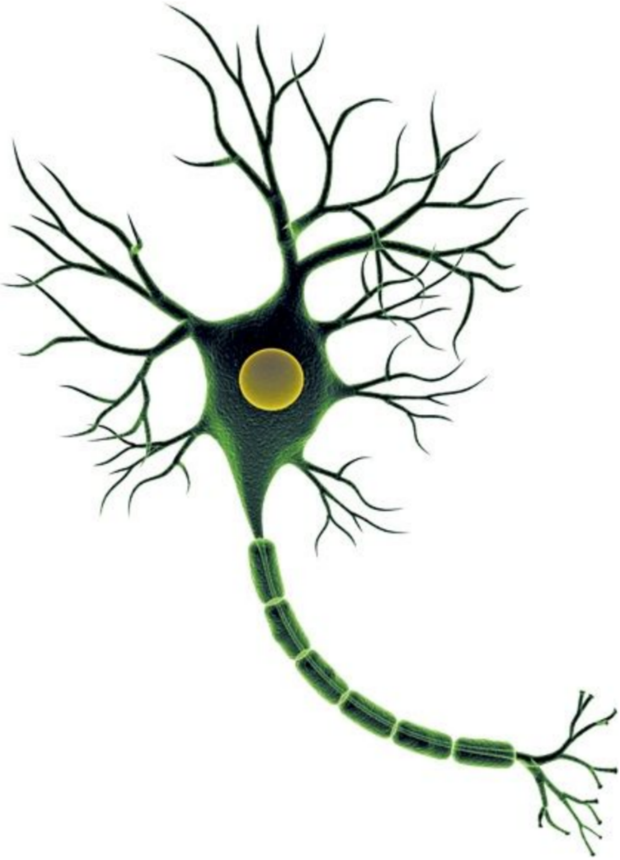
The body contains many distinct kinds of cells, each with a unique structure that is specialized to perform particular functions.

Different types of cell perform specific functions in the body. For example, specialized white blood cells in your body have an abundance of ribosomes because they need to produce lots of protective proteins called antibodies. Skeletal muscle cells have an abundance of mitochondria because they require much more energy than other cells for the contraction of muscles in maintaining posture and movement. Digestive cells and endocrine (glandular) cells have lots of ribosomes to produce digestive enzymes and hormones respectively. They also have plenty of golgi bodies that package these digestive enzymes and hormones so they can be released or secreted into the body. (Digestive and endocrine cells are “secretory” cells, which means they release chemicals into the body.)

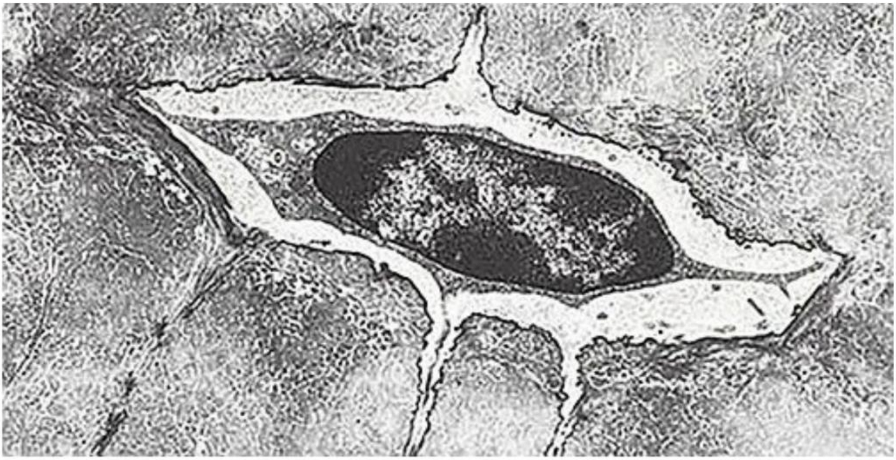
Monitoring Movement

To maintain their specialized functions, cells need to monitor the chemical environment inside and outside the cells of the body. Receptors within the cell or on its outer membrane detect any changes. These receptors inform genes, which produce (start) or inhibit (stop) certain actions.

White blood cells protect the body from infectious diseases and foreign substances.



Nerve cells transmit electrochemical impulses and are the basic units of the body's nervous system.



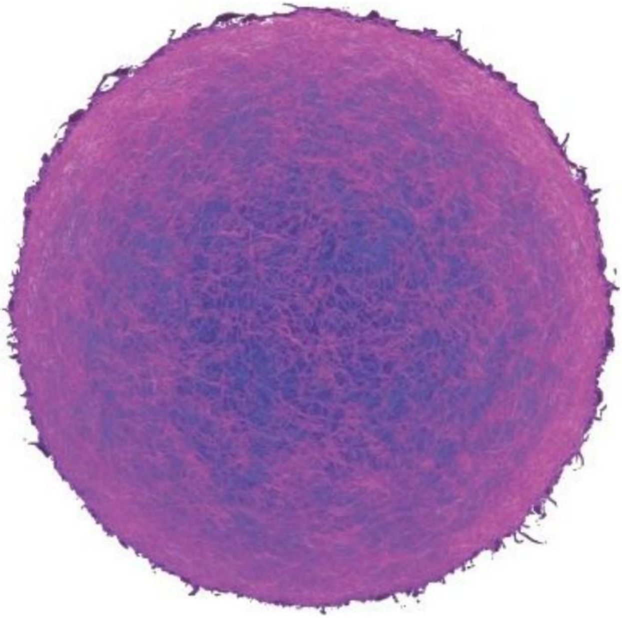
Bone cells (osteocytes, left) are found in fully formed bone tissue. They are long-lived and can transmit signals to other osteocytes if any part of the bone becomes deformed through muscular activity. Premature cell death or dysfunction of osteocytes can lead to diseases such as osteoporosis.

Body and Cell Secrets

- **The body is composed of trillions of microscopic cells, with an average diameter of 0.02 mm (1/2500 in).**
- **The largest cell in the body is the female egg, which is approximately 0.5 mm (1/50 in) diameter and just visible to the naked eye.**
- **The longest cells are the nerve cells supplying your toes, measuring as much as 1.2 m (3.9 ft) in length, but even these are microscopically thin, meaning we need a microscope to see them!**
- **Five million of your body cells die every second, but most are renewed.**
- **White blood cells are used in the fight against infection and may survive for only a few hours.**
- **Your gut lining cells live for approximately three days.**

- Red blood cells live for an average 120 days.
- Bone cells live for about 20 years.
- Your brain cells cannot regenerate, meaning they must last a lifetime, as once they have died, they are gone forever.

Red blood cells absorb and transport oxygen, and deliver it to the body's tissues.



Female eggs (ova) are reproductive cells that grow in the ovaries.

Cell Division

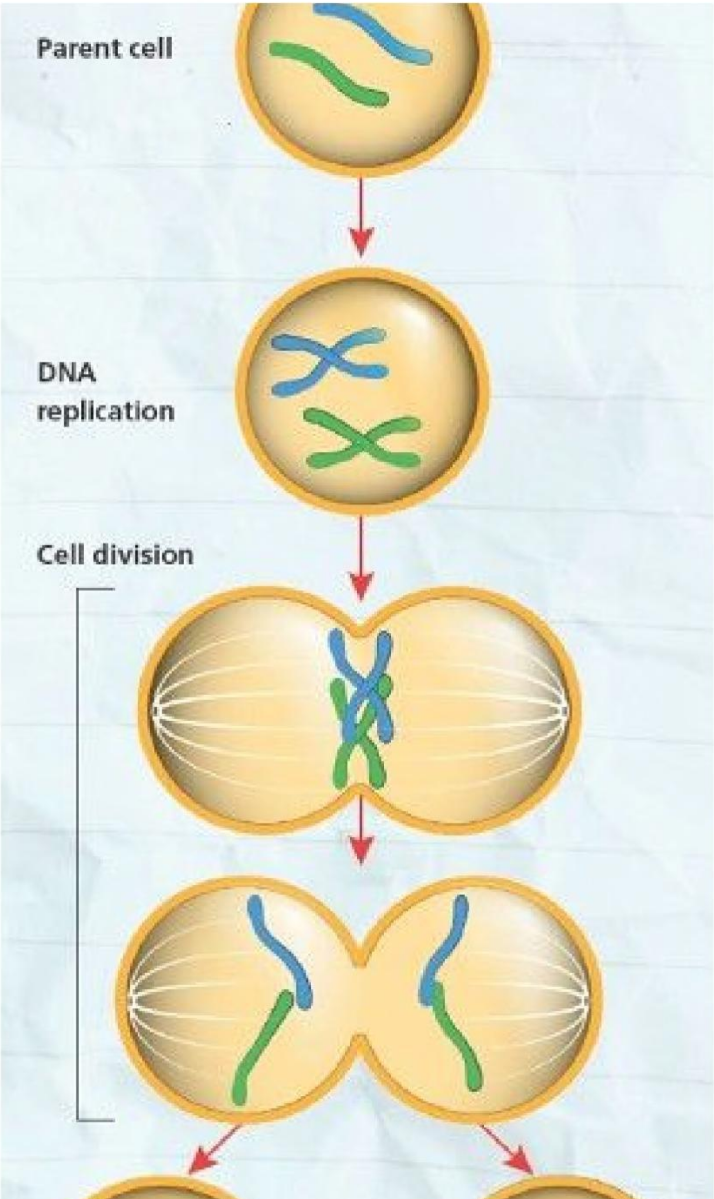
Cell division is an important "basic need of life" as it enables our bodies to survive, grow and repair, and ensures that genetic material is passed on to the next generation.

Cell division makes sure that the body's genetic material is transmitted from one cell to another, and from one generation to another. It also enables cell growth and specialization, and growth in specific stages of human development, such as from baby to infant and infant to young child. In addition, it ensures that dying, diseased, worn-out and damaged cells are replaced to maintain the structural and functional integrity of the human body.

There are two types of cell division – body cell division called mitosis and reproductive cell division called meiosis. In each case, the dividing parent cells produce daughter cells. (Sorry, boys, it's nothing personal!)

Keeping Up the Chromosomes

Mitosis, or duplication division, ensures that the daughter cells have the same number of chromosomes – and therefore the same number of genes and DNA, as chromosomes are made up of genes, which in turn are made up of DNA – as the parent cell. For this to happen, the 23 pairs of chromosomes of the parent cell must first be duplicated so that one copy (23 pairs) can be passed into each daughter cell.

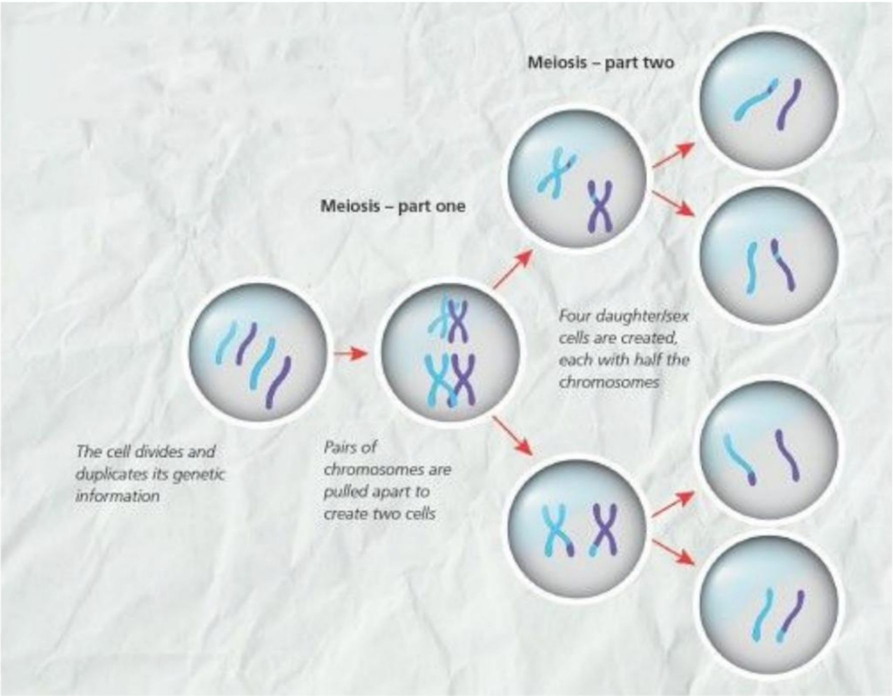

Parent cell
DNA replication
Cell division

During mitosis, the DNA of the parent cell duplicate and form X-shaped chromosomes. After this, the cell divides and the two daughter cells finally separate, each of them an identical copy of the parent cell, with exactly the same genetic information.

Making Sex Cells

Reproductive cell division, called meiosis, reduces the genetic material of two cells to produce male and female sex cells.

Meiosis ("reduction division") occurs in the male and female sex organs (gonads) during the production of the male and female sex cells (spermatozoa and ova, respectively). Meiosis ensures that the daughter cells have half the number of chromosomes of a normal cell (23 chromosomes, half of the 46 chromosomes of the parent cell). This reduction division is necessary so that the normal chromosomal number is restored when two sex cells fuse during fertilization. The new cell (zygote) then divides by mitosis (*see* previous page) and ultimately produces trillions of specialized cells that make up the specific tissues and organ systems of the human body. The joining together of parental genetic information at fertilization is the reason why we can see similarities in looks and behaviour to both our parents.



During meiosis, the cell divides in such a way that all the sex cells (whether sperm or egg) have half the genetic information.

Cell Specialization

During the development of an unborn child, every cell starts to differentiate into specialized cells so they can perform different functions within the body. For example, the movement of the body's skeleton is supplied by the specialized skeletal muscle cells. Similarly, the generation of electrochemical impulses is provided by special nerve cells, the fighting of infection is carried out by white blood cells, and the transportation of oxygen is performed by red blood cells.

The process that transforms the original unspecialized cells into specialized ones is called cell differentiation and specialization, a process determined by the switching "on" or "off" of certain genes within the cell. There are over 200 different types of cell within the body. However, it's not fully understood how and why the chemical signals control the different cells and programme them for specific functions in a particular location of the body.

The switching on or off of certain genes dictates the form and function of the cell as it matures.

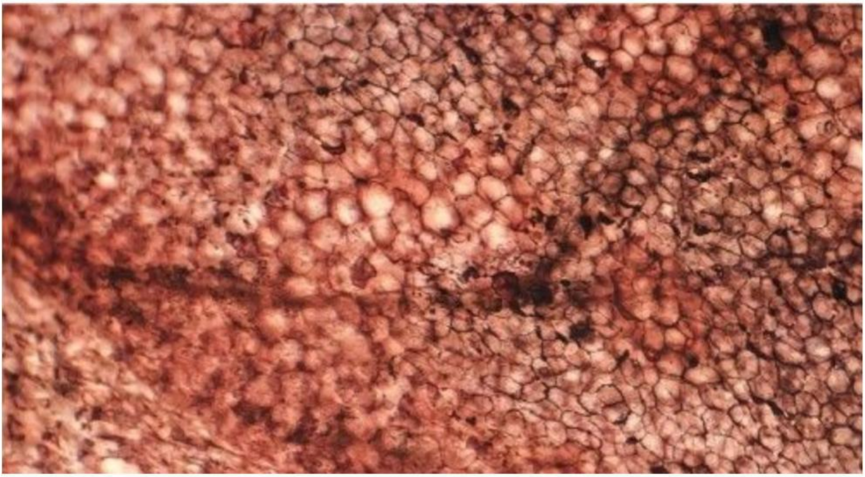
Tissues

The tissues in the body perform a variety of functions, from cushioning delicate organs and lining body surfaces, to expanding and contracting to produce movement in the body.

As cells divide by mitosis and move to new locations in the body, their surrounding chemistry changes. These differing chemicals may be responsible for the switching on and off of specific genes, causing cell differentiation and specialization, and the consequential joining together of these specialized cells with similar properties to form tissues. The 200 different kinds of cells fall into four main categories and make up four types of tissue. Each of these cell types can be further divided into subtypes to perform specialized functions.

Epithelial Tissue

These tissues are found in many areas of the body. They line body surfaces, such as the skin, and cavities, such as the stomach, where they have a protective function. Your epithelia tissues may be simple (one cell thick) or compound (more than one cell thick). Some epithelial tissues, known as glandular epithelia, produce bodily secretions, such as tears to lubricate the eyes and sweat to regulate body temperature. The tissue stops the cavity from drying out and also keeps out substances that could pose a threat, such as pathogens (microorganisms that cause disease) – or even sunlight!



Squamous epithelium is a layer of single cells that is usually found where small molecules need to pass from one place to another, such as alveoli in the lungs and blood capillaries.

Epithelial tissue consists of sheets of cells held together by a basement membrane. The lining of the human bladder is made of compound epithelial tissue. Its wrinkled surface allows the bladder to expand and contract as it fills with and empties out urine.

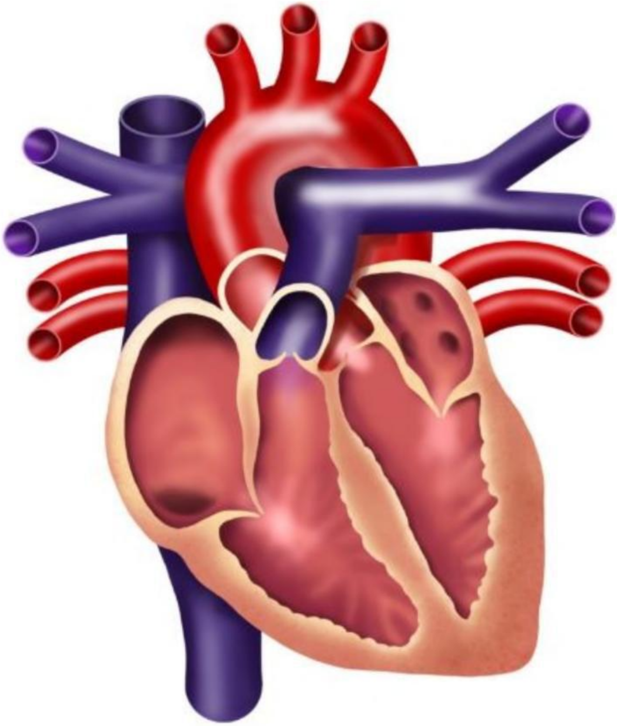
Muscular Tissue

Your muscles are a special type of tissue, which contract to produce movement. There are three different types of muscle tissue in the body:

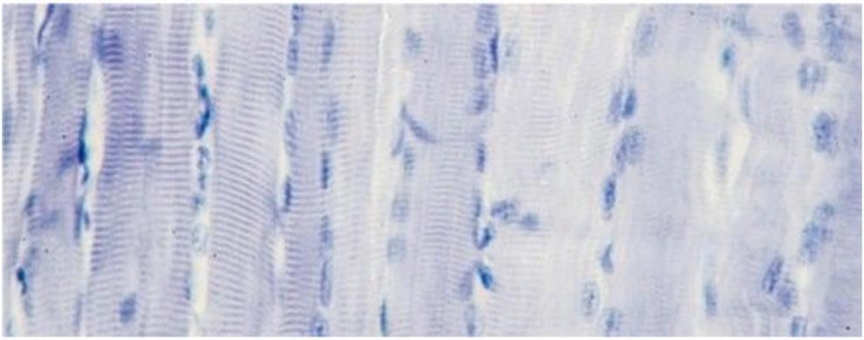
- **voluntary** (also called skeletal or striated muscle)
- **involuntary** (also known as unstriated or smooth muscle)
- **cardiac** (heart muscle).

Muscle cells are often referred to as muscle fibres, because they are long and cylindrical. These elongated cells or fibres can range from several millimetres (⅓ inch) to about 10 centimetres (4 inches) in length.

Muscles contract because they have two types of protein fibres: actin and myosin, which slide over each other to shorten the muscle. Skeletal muscle makes up the flesh of limbs and the body's torso and it moves the skeleton. When stimulated by nerve fibres, these muscles can perform rapid, powerful contractions, but they get tired very quickly and use up their energy supplies faster than non-skeletal muscle. As a result, skeletal muscles have many mitochondria and require a good blood supply to bring oxygen and nutrients to quickly replenish energy supplies.



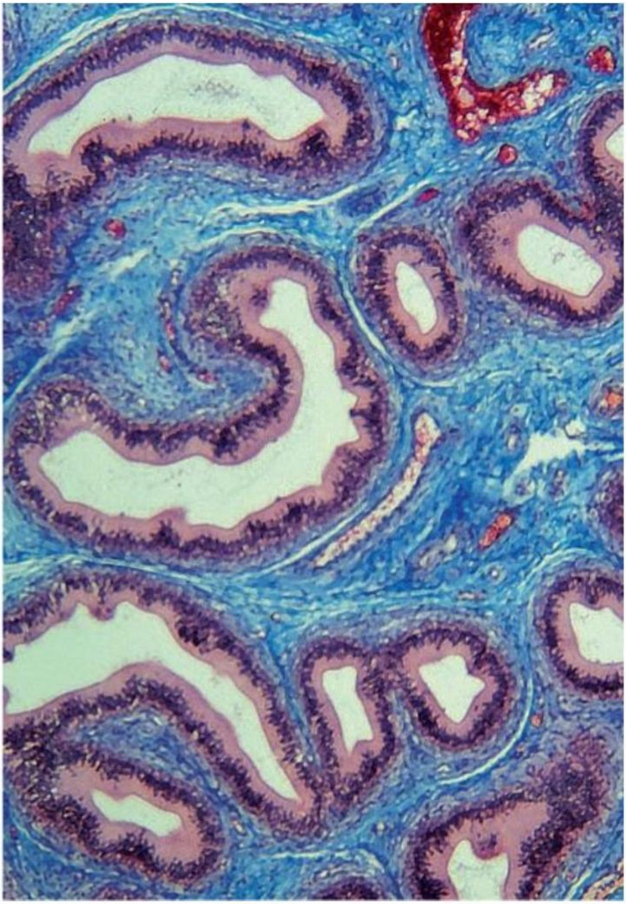
The heart has thick walls of muscle tissue that contract and relax continually throughout a person's lifetime.



The striated or striped appearance of skeletal muscle (which gives this type of muscle its alternative name) is formed by the orientation of the muscle fibres.

Nervous Tissue

Nervous tissue is made up of nerve cells, also known as neurons, which are specialized to generate and conduct electrochemical impulses. There are four main types of neurons: brain cells; sensory neurons, which carry impulses from sensory receptors to the spinal cord and/or the brain; motor neurons, which carry instructions from the brain and/or spinal cord to the tissues of the body; and interneurons, which connect sensory and motor neurons together within the central nervous system (the brain and spinal cord).



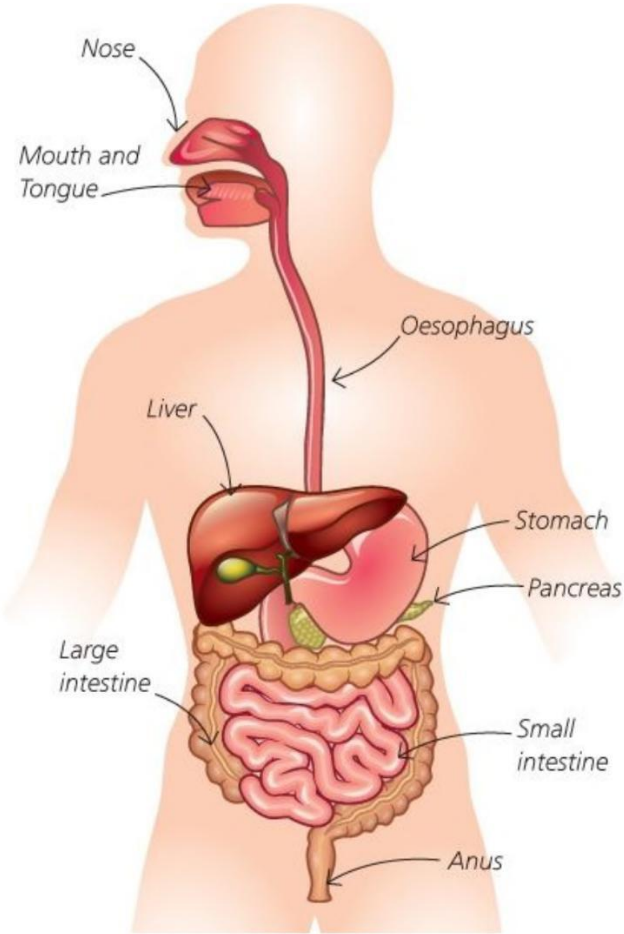
In this cross-section of a windpipe (trachea), the blue highlighted area is a layer of areola connective tissue, which joins together all the layers, including one that contains blood vessels (shown in red).

Organs and Systems

An organ is a group of different tissues working together to perform a specific function. Organs that work together form organ systems.

Each of your organs performs a specific activity that is vital for the survival of the body. Examples of organs are the heart, stomach, liver, brain and skin. Most organs contain all four of the different types of tissues (connective, nervous, muscular and epithelial). In the stomach, for example, the inside epithelial lining secretes gastric juice and absorbs chemicals like alcohol and glucose. The wall of the stomach, however, also contains muscle tissue to aid contraction of the stomach, which helps to break down food, as well as nervous tissue to help regulate the stomach and connective tissue to bind the other tissues together.

Every organ forms a part of a larger system that may contain more than one organ. As an example, the heart is part of the cardiovascular system. An organ system is a group of organs that act together to perform a specific bodily function. The respiratory system maintains the levels of oxygen and carbon dioxide in the blood. These systems work with each other in a coordinated way to maintain the functions of the body. Each level of organization (cell, tissue and organ system) is instrumental in sustaining the basic needs of the human body.



The digestive system breaks down, absorbs and removes food and is made up of several organs.

Body Fluids

Cells in the body are bathed in interstitial (tissue) fluid, which is derived from blood plasma. Tissue fluid supplies the cells with oxygen and nutrients, carries away cell products, such as

hormones, digestive enzymes and tears, and flushes away cell wastes, such as carbon dioxide.

- **The amount of tissue fluid bathing your cells is about 11 litres – that's nearly 20 pints of milk!**
- **The fluid outside your cells (extracellular fluid) is made up of tissue fluid and 3 litres (5 pints) of blood plasma.**
- **The amount of fluid inside your cells (intracellular fluid) totals a massive 28 litres – nearly 50 pints of milk.**

Cytology in Medicine

Cytology includes the branches of biology and medicine concerned with the study of cells. Its findings help medical professionals better understand ill health and how to treat it more effectively.

Understanding the structure, function and the needs of human cells can also help us to understand how tissue and organ abnormalities lead to ill health. As an example, the condition Obstructive Respiratory Disease causes low supplies of oxygen and high carbon dioxide levels in the blood, which can result in cell death (necrosis) in the patient. The body attempts to correct these imbalances after its receptors detect the problem and send information to the respiratory control centre in the brain.

Cytology is concerned with the study of cells and medicine is concerned with the science of the body when it goes wrong and its findings help medical professionals better understand ill health and how to treat it more effectively. Having analyzed the imbalances in the blood, the brain then sends information to the respiratory muscles, which attempt to reverse the problem by increasing the rate and depth of breathing. If this fails to establish equilibrium (homeostasis), then medical intervention may be necessary as the body is unable to resolve the problem by itself.

Diagnosis

Diagnosis and treatment, however, are often more complex. As different parts of the body depend on each other, a disorder that arises at a cellular level and leads to a failure of one functional group of cells can often lead to a deterioration of other groups of cells and

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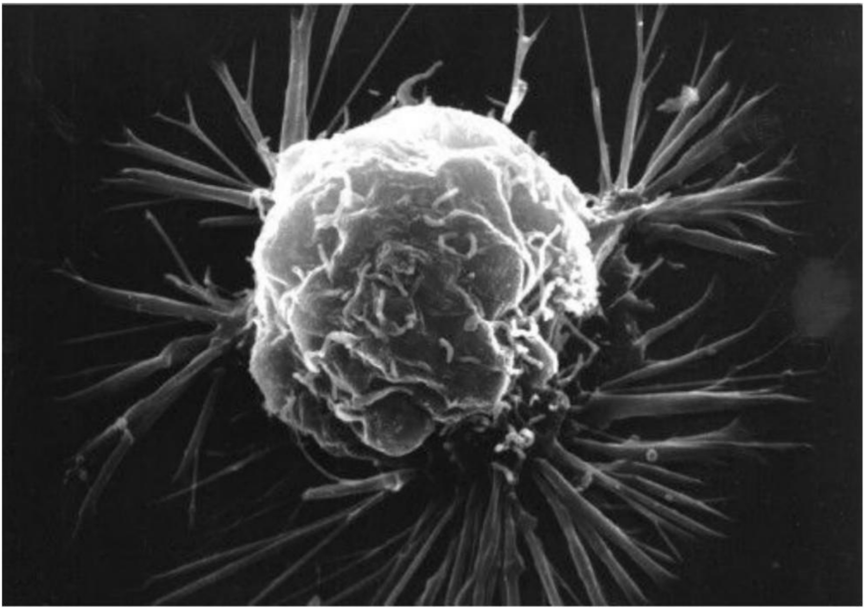


A cancerous cell, such as this malignant breast cell, will spread to other tissues and organs.

Chapter 2
THE SKIN, SKELETON AND MUSCLES

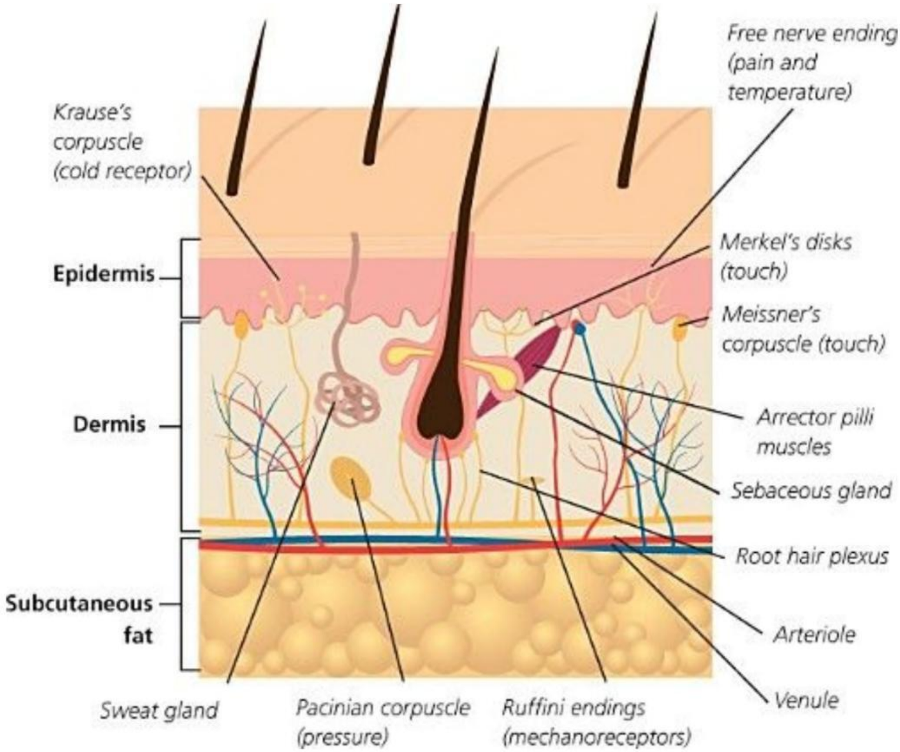
The Skin

How you look is dictated by the skin and the structures associated with it, such as hair, nails and eyelashes. The body also has a very definite shape, which is largely decided by two body systems – the skeletal system and the muscular system.

Covering It All

The skin is your body's largest organ. It covers the outer surface of the body and extends into the oral and anal canals. Being the main boundary between the body and the outside world, it's not surprising that the skin is the first line of defence against harmful organisms, or pathogens. It also helps to regulate your body temperature and hydration levels, and provides sensory information about your surroundings, such as sensitivity to touch, heat and cold. Being the most visible part of your body, the skin also makes clear the effects of ageing, as seen when it wrinkles with age.

Your skin has two main layers – the outer epidermis and the inner dermis. Beneath these layers is the subcutaneous (fat) layer, which is sometimes called the superficial fascia, since it also includes part of the connective tissue that covers muscles. The layered structure of the skin provides a physical barrier to trauma, while the skin secretions also provide a degree of chemical protection against bacteria. The impervious (waterproof) nature of skin, and its role as a physical barrier, also protects the body from chemical agents like bacterial toxins, which may make the body ill.



The top layer of skin, the epidermis, is made up of flattened, dead skin cells. At the bottom of these is the living epidermal layer where new skin cells are created before rising to the surface. Beneath the epidermis is the dermis, which contains most of the sensory receptors, as well as the hair follicles and sweat glands. Note the bumps, or dermis projections, known as papillae, which stick up from the dermis into the epidermis. Many of these have tiny blood vessels to carry nutrients up to the epidermis, since the upper layer does not have its own blood supply.

Epidermis

As the epidermis is your body's first physical barrier to the outside world, it needs to be tough to provide sufficient protection. The epidermis has multiple layers, the lowest layer – the basal layer – is a single layer of cells connected to a basement ("cementing") membrane, which separates the epidermis from the dermis. The cells in this basal layer continually divide and the daughter cells produce all the outer layers within the epidermis. This is why the basal layer is often referred to as the "germinal" layer. Dotted around these lower layers are the melanocytes. These special cells produce the protein pigment melanin that gives skin its colour.

As the cells ascend, each one of them gradually loses its nucleus and becomes filled with a protein called keratin, which makes the epidermis tough and waterproof. As a result, the cells become flat, hard and die, creating a cornified outer layer. This outermost layer gives the epidermis the toughness needed to act as a barrier against external physical stresses and other threats, such as bacteria and harmful chemicals. In adults, the epidermis is 0.5 to 3 mm ($^1/_{50}$ to $^1/_{10}$ in) thick, depending upon the thickness of the cornified layer and the physical stresses placed on that area of skin. For instance, the epidermis of the eyelids is very thin, while the epidermis of the soles of the feet is very thick. As the outer layer of skin, it is not surprising that cells are continuously lost from the epidermis during day-to-day living through wear and tear. The attrition (loss) is substantial – in fact most of the "house dust" in bedding is made up of these lost cells!

The epidermis needs to be replaced every 35 to 45 days. The energy demands for this cell replacement need to be met by a network of blood vessels within the dermis, since the epidermis is "avascular", meaning it doesn't have its own blood supply.

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