**02. The Cell**

The cell is the basis of all living things. To understand the structure and function of the body, we need to understand the structure and function of its smallest living part - the cell.

A cell is the smallest unit of matter that can live independently and reproduce itself. Cells exist in all shapes and sizes - elongated, square, star-shaped and oval - and have many different functions. A group of cells form tissue.

**TOPIC 1: STRUCTURE OF THE CELL**

**WHAT IS A CELL MADE OF?**

* Protoplasm, a slightly opaque, colourless jelly-like substance. It is 70% water plus
* Organic and inorganic salts
* Carbohydrates
* Lipids (fatty substance)
* Nitrogenous substances; these are amino acids obtained from protein
* Compounds of all of the above substances.

**CELL MEMBRANE**

A fine, semi-permeable membrane made of protein threads and lipids (fats), which has two functions: to keep the nucleus and the cytoplasm in the cell but to let other substances, like fats and proteins, out. It works as a filter between the fluid inside the cell and the tissue fluid outside it. Some substances can cross this membrane but others are blocked. Substances go in and out of cells in several different ways:

* **Diffusion:**  the membrane has tiny holes, or pores, between Its proteins and lipids through which small molecules, like oxygen and carbon dioxide, can pass.
* **Osmosis:** the process of transferring water across the membrane by osmotic pressure - when the concentration or pressure of a solution is greater on one side of the membrane, water passes through to that side until the concentration is equal on both sides. When both sides of the membrane have solutions of the same pressure, it is called isotonic pressure.
* **Dissolution (Or dissolving):** fatty substances are too big to diffuse through the tiny pores, so they dissolve into the fatty or lipid part of the membrane.
* **Active transport:** when substances are too large to pass directly through the membrane, or are not soluble in fat, a carrier substance in the cell membrane takes them from the outside to the inside. Glucose and amino acids are both transferred by active transport. It is active because energy is used.
* **Filtration:** the movement of water and soluble substances across a membrane caused by the difference in pressure either side of the membrane. The force of a fluid’s weight pushes against a surface and the fluid is thus moved through the membrane. This is called hydrostatic pressure which is the process responsible for the formation of urine in the kidneys. Waste products are filtered out of the blood into the kidney tubules because of a difference in hydrostatic pressure.

**CYTOPLASM**

Cytoplasm is the protoplasm inside the cell but outside the nucleus. It contains several different structures and substances:

* **Mitochondria**

These organelles (little organs) are sometimes referred to as the epower houses of the cell, since they supply the cell with energy. Cell survival depends upon the chemical reactions that take place within the mitochondria, which result in a release of energy and the formation of ATP (adenosine triphosphate), the main energy transporter within the cell.

* **Ribosomes**

The 'protein factories' of a cell. They produce enzymes and other protein compounds; protein is used for the growth and repair of a cell

* **Endoplasmic reticulum**

A network of membranes that forms the 'circulatory system' of a cell Rough Endoplasmic Reticulum, so named because of the ribosomes present on its surface, is most prevalent and transports the protein made by the ribosomes throughout the cell. The less widespread Smooth Endoplasmic Reticulum is involved in lipid and steroid production.

* **Golgi apparatus**

Golgi apparatus is formed at one end from vesicles which bud off from the endoplasmic reticulum, and at the other end vesicles are released into the cell. This process forms a communication network from deep within the cell to its membrane. Golgi vesicles are also used to make lysosomes.

* **Lysosomes**

These organelles contain digestive enzymes which destroy worn-out parts of a cell and bacteria. They break down parts of food allowing them to be used for energy transfer within the cell.

* **Vacuoles**

These are spaces within the cytoplasm. They contain waste materials or secretions formed by the cytoplasm and are used for storage or digestion purposes in different kinds of cells.

* **Centrioles**

These are paired, rod-like organelles that lie at right angles to each other. They are made of fine tubules which play an important role in mitosis (cell reproduction).

* **Centrosomes**

Dense areas of cytoplasm containing the centrioles.

**NUCLEUS**

The largest organelle, the nucleus, controls the cells processes of growth, repair and reproduction. It contains nucleoli, chromatin and nucleoplasm all enclosed by the nuclear membrane.

* **Nucleolus**

A small body within the nucleus (usually 1-2 per nucleus) that controls the formation of ribosomes which then move into the cytoplasm of the cell.

* **Chromatin and Chromosomes**

Chromatin is loosely coiled strands of DNA (deoxyribonucleic acid). Just prior to cell division, the chromatin becomes more tightly coiled, forming chromosomes.

Chromosomes consist of two chromatids, each comprising one DNA molecule, held together by a centromere. DNA is organised into functional units called genes which control cell activities and inheritance. Each species is determined by the number of chromosomes in the nucleus. Human cells contain 46 chromosomes, 23 from each parent.

* **Nucleoplasm**

Specialised protoplasm, in which the nucleoli and chromatin/chromosomes are suspended along with nutrients and other necessary chemicals.

**TOPIC 2: CELL FUNCTION**

**WHAT DOES A CELL DO?**

It lives! The human body is made of cells, which form organs, tissues, and fluid. Blood, for example, is a liquid tissue made of several different types of cells. What a cell does is reproduced on a larger scale throughout the body and throughout human life: breathing, digesting, excreting, reproducing, sensing, growing, moving, dying.

When a cell goes wrong, if it is not replaced or repaired, the body goes wrong since cell failure and a subsequent inability to perform its usual functions is the origin of disease and illness.

If you want to understand a relationship to the rest of the body think of this:

* A group of cells of similar type and function join to form a tissue
* A group of tissues of related function join to form an organ (example: stomach, lung, heart)
* A group of organs of related function join to form a system (example: digestive, respiratory, vascular)
* A group of systems join together to form an organism (example: a human body).

**Summary of functions**

* **Movement:** whole cells, like blood cells, can move and parts of cells move, like the cilia of ciliated cells, but only in one direction.
* **Respiration:** this is controlled absorption of oxygen that combines with nutrients in an oxidative reaction. This results in energy production and the formation of ATP. The waste produced is carbon dioxide.
* **Sensitivity:** cells are able to respond to stimuli, which can be mechanical, electrical, thermal or chemical.
* **Growth:** cells grow and repair themselves by making protein.
* **Reproduction:** all cells grow to maturity and the majority then reproduce themselves. This can be simple cell division (mitosis) or sexual reproduction (meiosis).
* **Excretion:** waste which might be harmful to the cell in large amounts, e.g. urea or carbon dioxide, is removed.
* **Metabolism:** the chemical reactions that occur inside the cell.
* **Anabolism:** the chemical activity involved in the process of making new products (usually proteins) for growth and repair.
* **Catabolism:** the chemical activity involved in the breakdown of substances into simple forms, which results in the production of energy and waste. The energy is used to perform various cell functions.

**TOPIC 3: CELL REPRODUCTION**

**HOW DO CELLS GROW/REPRODUCE?**

Cells grow in number through a process called mitosis whereby exact replicas of chromosomes in parent cells are duplicated to form daughter cells. Cells reproduce sexually through meiosis, a process which produces genetic variation.

**MITOSIS**

Mitosis is the multiplication of cells i.e. the continuous process of making new cells for growth and repair, and in order for life to continue when old cells die. Mitosis is faster in children and slows in later life. There are four main stages of mitosis during which the cell is actively dividing, and one resting stage.

1. **Prophase**
* The centrosome divides into two centrioles. These move away from each other, though still joined by the spindle-like threads of the centrosome.
* Towards the end of the prophase the chromatin in the nucleus shortens and thickens, forming into visible pairs of rods called chromosomes (made of condensed chromatin and DNA).
* Each chromosome consists of two chromatids joined by a centromere.
* The nucleolus disappears.
1. **Metaphase**
* The nuclear membrane of the nucleus disappears.
* The chromosomes arrange themselves at the centre of the cell, each attached to the spindle by its centromere.
* By the end of the metaphase, each individual chromosome can be seen distinctly as two chromatids starting to pull apart.
1. **Anaphase**
* The centromere stretches as the centrioles are drawn further apart.
* Pairs of chromatids divide and identical halves of the pairs move to each end of the cell.
* At the end of the anaphase, the spindle threads of the centrioles divide to form new centromeres and the cell membrane begins to constrict in the centre.
1. **Telophase**
* A new nuclear membrane appears around each set of chromosomes.
* The spindle fibres disintegrate and the centrioles replicate.
* The cell membrane continues to constrict until two cells are formed. These two daughter cells will be identical copies of the original single parent cell. Eventually, the daughter cells will also divide and the whole process continues throughout life.

**Interphase**

* The interval in the cell cycle between two cell divisions when the individual chromosomes cannot be distinguished.
* It is the time when DNA is replicated in the cell nucleus.
* The cell carries out normal metabolic activities.
* Nuclear protein is synthesized.
* Cell increases in size.

**MEIOSIS**

Meiosis is the reproduction of cells that results in a gamete/ sex cell. In the first stage of meiosis, the centromeres do not split and so whole chromosomes move to opposite poles on the spindle. This results in daughter cells with half the number of chromosomes of the parent cell. In humans this is 23 chromosomes in the male sperm and 23 chromosomes in the female ovum. When a male sperm fuses with a female ovum, a zygote with 46 chromosomes is created. If the halving didn’t occur, doubling of chromosome numbers would result in each new generation. The zygote will divide by mitosis, and the organism that results from the cell division is an embryo which develops into a foetus.

**TOPIC 4: TISSUE TYPES MADE FROM CELLS**

Cells make tissue. There are four types of tissue: epithelial, connective, nervous and muscular.

**EPITHELIAL TISSUE** (also known as epithelium)

Simple epithelium usually functions as a covering or lining for organs and vessels. Compound epithelium provides external protection, for example fingernails, and internal elasticity, for example the lining of the mouth.

**Simple epithelium**

Simple epithelium consists of a single layer of cells attached to a basement membrane. Goblet cells are often found in simple epithelium. These cells secrete mucus. There are four types of simple epithelium: squamous or pavement, cuboidal, columnar and ciliated.

* **Squamous**

**Structure:** single layer of flattened cells attached to a basement membrane

**Function:** forms a thin, often permeable lining for the heart, blood and lymph vessels, and alveoli of the lungs; allows diffusion and filtration.

* **Cuboidal**

**Structure:** single layer of cube-shaped cells attached to a basement membrane.

**Function:** forms lining of kidney tubules as well as some glands; can secrete

* **Columnar**

**Structure:** single layer of tall, rectangular cells attached to a basement membrane; resilient.

**Function:** forms lining in very active parts of the body such as the stomach, intestines and urethra; some of the cells secrete mucus and some absorb mucus, depending on where they are in the body.

* **Ciliated**

**Structure:** single layer of mostly columnar cells (sometimes combined with squamous or cuboidal cells) attached to a basement membrane. Tiny hair-like projections, or cilia, stick out from the cell membrane.

**Function:** the cilia work in waves, all moving together in the same direction. They help to remove mucus, foreign matter and debris, keeping passageways and linings clear. The respiratory system is lined with these cells.

**COMPOUND EPITHELIUM**

Compound epithelium has many layers of cells and no basement membrane. It is formed from a combination of deep layers of columnar cells plus flatter cells towards the surface. It protects delicate parts of the body. There are two types: stratified and transitional.

**Stratified**

* **Keratinised (dry)**

**Structure:** compound epithelium with dry surface cells; forms a dead layer e.g. hair, skin, nails. It is keratinised (i.e. the surface layer has dried out into keratin, a fibrous protein which creates a waterproof layer). Skin is stratified, keratinised, squamous epithelium.

**Function:** the keratinisation prevents deeper layers from drying out and protects them.

* **Non-keratinised (wet)**

**Structure:** compound epithelium with wet surface cells e.g. inside mouth, lining of oesophagus, conjunctiva (mucous membrane) of eyes.

**Function:** provides lubrication.

**Transitional**

**Structure:** similar to stratified epithelium except that the surface cells are not flattened and thus can change shape when necessary; cube-shaped surface cells and deeper pear-shaped cells.

**Function:** found in organs that need waterproof and expandable lining e.g. bladder and ureters.

**NERVOUS TISSUE**

**Structure:** arranged in bundles of fibres, composed of nerve cells and neuroglia. The cells have long fibrous processes.

On a nerve cell these processes are called dendrites and axons.

**Function:** capable of transmitting signals to and from the brain; protective.

**MUSCULAR TISSUE**

There are three types of muscle tissue:

* **Skeletal -** striated and voluntary
* **Smooth -** non-striated and involuntary
* **Cardiac** - striated and involuntary

**Structure:** all muscle is made of 75% water, 20% protein, 5% mineral salts, glycogen, glucose and fat.

**skeletal:** to help support and move the body

**Smooth:** to carry out involuntary functions, example: peristalsis

**Cardiac:** heart muscle to pump blood.

**CONNECTIVE TISSUE**

Connective tissues are the supporting tissues of the body; they have mostly mechanical functions and connect more active tissues (like bones and muscles).

**Structure:** can be semi-solid, solid or liquid; can have fibres present or not.

**Function:** mainly mechanical connecting other more active tissues.

There are eight types:

* Areolar
* Adipose
* Lymphoid
* Yellow elastic
* White fibrous
* Bone
* Blood
* Cartilage.

**AREOLAR**

This is loose connective tissue, the most general connective tissue found in the human body.

**Structure:** semi-solid and permeable thus allowing fluids to pass through; it contains yellow elastic and white fibres as well as fibrocytes and mast cells which produce histamine (protection) and heparin (anti-coagulant, prevents clotting).

**Function:** found all over the body connecting and supporting other tissues e.g. under the skin, between muscles, supporting blood vessels and nerves and in the alimentary canal.

**ADIPOSE**

This is also known as fatty tissue.

**Structure:** made up of fat cells containing fat globules; found between muscle fibres and, with areolar tissue, under the skin giving the body a smooth, continuous outline; also found around the kidney and the back of the eyes.

**Function:** protective and insulatory properties: helps retain body heat because it is a poor conductor of heat; also a food reserve.

**LYMPHOID**

**Structure:** semi-solid tissue; has some white fibres but not in bundles; lots of cells, the majority are lymphocytes and reticular cells which have a disease control function - the cell engulfs bacteria and destroys it.

**Function:** forms lymphatic system cells and blood cells and thus protects against disease; found in lymph nodes, thymus, the spleen, the tonsils, in the wall of the large intestine, the appendix and the glands of the small intestine.

**YELLOW ELASTIC**

**Structure:** mainly composed of elastic fibres and very few cells; this tissue is capable of considerable extension and recoil.

**Function:** to enable stretch and recoil e.g. forms lung tissue, bronchi and trachea, arteries especially the large ones, stomach, bladder and any other organs that need to stretch and recoil.

**WHITE FIBROUS**

**Structure:** strongly connective but not very elastic; consists mainly of closely packed bundles of collagen fibres with only a few cells in rows between the fibres; the fibres run in the same direction.

**Function:** connection and protection of parts of the body e.g. forms ligaments and the periosteum of bone; forms the outer protection of organs e.g. around the kidneys, the dura of the brain, the fascia of muscles and the tendons.

**BONE**

**Structure:** hardest structure in the body; two types, compact and cancellous - compact is dense bone for strength, cancellous for structure bearing and cellular development; composition of bone is 25% water, 30% organic material, 45% inorganic salts.

**Function:** to support and protect the body and all its organs, as well as produce cells in bone marrow.

**BLOOD**

**Structure:** fluid connective tissue, containing 45% cells and 55% plasma. Cell content is erythrocytes (red blood cells), leucocytes (white blood cells) and thrombocytes (platelets).

**Function:** to transport food and oxygen to all the cells of the body and to remove waste from them (erythrocytes), to fight infection (leucocytes) and to clot (thrombocytes).

**CARTILAGE**

**Structure:** firm, tough tissue; solid and contains cells called chondrocytes; there are three types:

* **Hyaline**

**Structure:** bluish-white, smooth; chondrocyte cells are grouped together in nests in a solid matrix; particularly resilient.

**Function:** connecting and protecting: found on articular surfaces of joints i.e. parts of bone which form joints; forms costal cartilages and parts of the larynx, trachea and bronchi.

* **Yellow elastic cartilage**

**Structure:** yellow elastic fibres running through a solid matrix. Contains fibrocyte and chondrocyte cells which lie between multidirectional fibres.

**Function:** flexibility; found in parts of the body that need to move freely like the pinna (cartilage part of the ear) and epiglottis.

* **White fibrocartilage**

**Structure:** white fibres closely packed in dense masses; contains chondrocyte cells; extremely tough and slightly flexible.

**Function:** to absorb shock e.g. it forms intervertebral discs as well as the semi-lunar cartilages, the shock absorbers positioned between the articulating surfaces of the knee joint bones; also found in hip and shoulder sockets.

**Summary**

The cell:

* Is a microscopic building block
* Is a microcosm of body functions: ingesting, excreting, breathing, reproducing, moving, dying
* Reproduces by division
* Makes tissues; there are four main tissue types in the body.