Introduction to body chemistry

Processes that characterise life

Trillions of chemical reactions happen simultaneously in the body. They drive the processes that keep a human body 'alive'. Collectively, they are known as metabolism.

Metabolism is made up of numerous metabolic pathways. A metabolic pathway is a sequence of chemical reactions that follow a set of 'instructions' contained in the body's DNA.

There are seven processes that characterise all living organisms, including humans.

- **Sensitivity:** detecting and responding to changes within the body and its surroundings.
- **Nutrition:** obtaining food (nutrients) needed to supply energy to drive other the processes and provide building materials for the structures in the body.
- **Respiration:** releasing energy from nutrients. Some processes use oxygen (aerobic respiration). Others do not need oxygen (anaerobic respiration).
- **Excretion:** eliminating waste products of the body's metabolism, e.g. carbon dioxide produced in respiration, and toxic substances.
- **Growth:** synthesising proteins and other materials needed to make or repair parts of body structures.
- **Movement:** moving structures or materials within the body or moving the whole of the body from place to place.
- **Reproduction:** generating new individuals (offspring).

Chemical changes in the body

Chemical compounds enter the body. They are breathed in, swallowed or (more rarely) absorbed through the skin. Many are vital to the processes listed above. Some are 'foreign' to the body and can lead to illness or disease.

Once in the body chemical compounds undergo conventional chemical reactions such as neutralisation, hydrolysis, oxidation and reduction. However, they are not random. Instead each is part of a metabolic pathway. Metabolism can be:

- anabolism, with anabolic pathways which build molecules in the body, or
- catabolism, with catabolic pathways which break molecules down in the body.

All are controlled by a group of proteins called enzymes. Enzymes are biochemical catalysts that alter the rate of reactions. However, unlike most chemical catalysts, enzymes are highly selective and only promote specific reactions.

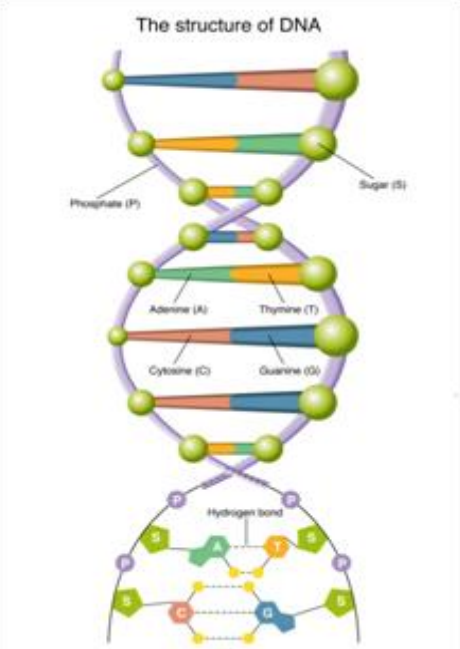

Figure 1 Through base pairing, DNA is also able to replicate itself so that the code can be passed on to new individuals.

Deoxyribonucleic acid, DNA

DNA contains the instructions for building the body and for regulating the chemical processes that go on inside it. Specific regions of DNA are genes that provide the code for making different proteins, either to use to build biological structures or to make enzymes.

DNA and the way it works are common to all living

organisms. Recombinant DNA can be formed by transferring a section of DNA, forming the gene for making a specific protein, from one species to another. In this way medicinal drugs that correspond exactly to compounds made in the body can be synthesised by other species. For example, human insulin can be synthesised by bacteria grown in bioreactors. This can be taken by diabetes sufferers who are insulin deficient because their own bodies cannot make enough.

From elements to organism

Each structure in the body has a specific purpose and function. The structures are organised in successive levels from chemical to the whole body:

Chemical → Cell → Tissue → Organ → System → Organism (whole body)

Chemical: The body is made from atoms of elements. They are combined to form molecules such as proteins, carbohydrates, lipids and nucleic acids (including DNA).

Water makes up 60% of body mass. It is mixed with other substances to form solutions, colloids and suspensions. The most abundant colloids are small proteins dispersed in body fluids such as blood plasma.

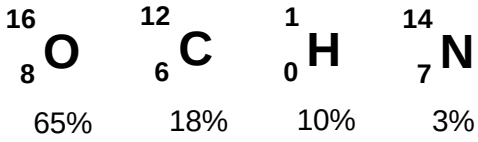

Figure 2 Oxygen, carbon, hydrogen and nitrogen make up 96% of a body's mass.

Cell: A cell is the smallest part of the body that can carry out the processes associated with life. Cells arrange and package the non-living chemical components into living structures. Each cell has a membrane coat that controls movement of materials in and out of it. This membrane maintains a difference between conditions in the cell and outside it. There are different specialist cells, such as muscle, nerve, kidney tubule and secretory cells.

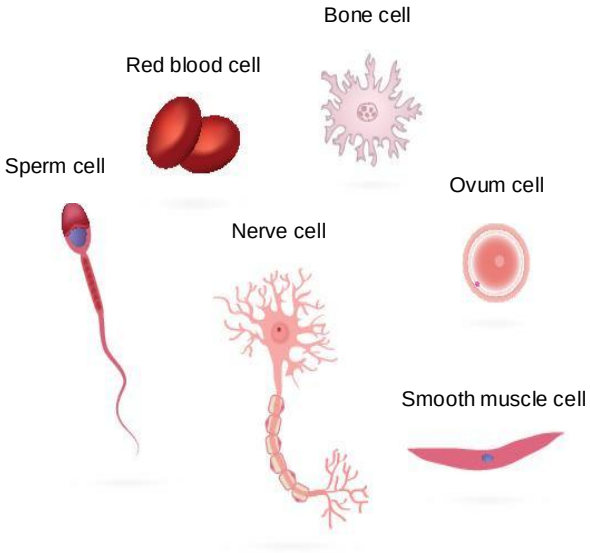

Figure 3 Examples of human cells.

Tissue: Tissues consist of cells with similar structure and function grouped together. There are four primary types:

- Epithelial tissue, specialised as lining tissue (acting as boundaries with the environment or with body cavities), or as secretory tissue in glands.
- Connective tissue, which mainly provides support, includes ligaments, tendons, bone and cartilage with a matrix of abundant intercellular material secreted and maintained by relatively few cells dispersed within it. Some cells can release materials like elastin and collagen to form fibres. Also includes blood.
- Muscle, composed of cells specialised for contraction. May be skeletal, cardiac or smooth, bringing about movement of the skeleton, pumping of blood by the heart and movement in tubes and organs (such as the small intestine) respectively.

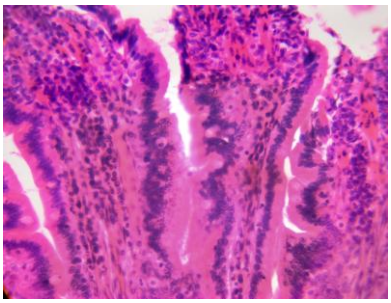

Figure 4 Stomach tissues under a microscope.

- Nervous, made up of cells which transmit electrical impulses to relay information about changes in the body or outside or to control changes, such as hearing sounds or regulating blood pressure.

Organ: Organs are made up of two or more tissues organised to perform a specific function or functions. For example, the stomach stores ingested food to begin the process of digestion, and moves partially digested food on to the intestines. It includes:

- epithelial tissue, which includes glands that secrete gastric juice, lining cells that protect the underlying tissues from the acid and protein digesting enzymes in the gastric juice, and lining of blood vessels;
- connective tissue holding the layers of the stomach together;
- smooth muscle tissue, which contracts to mix food with gastric juice and to push the food into the intestine;
- nervous tissue that helps regulate muscle contraction.

System: A body system is a collection of organs that perform related functions to achieve a particular activity. The excretory system, for example, includes the kidneys with the renal arteries and veins and their branches, the ureters, bladder and urethra. They act together to produce urine and eliminate it from the body.

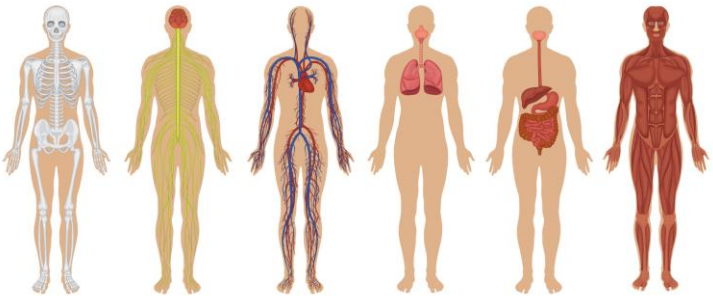

Figure 5 Some of the main systems in a human body.

The systems[1] are: digestive, musculo-skeletal, respiratory, cardiovascular, excretory, nervous, endocrine, reproductive, integumentary and immune.

Organism: An organism, such as a human being, consists of closely controlled and coordinated systems integrated into a single living system. It is separated from its external environment, but can exchange materials with it in a controlled way.

Homeostasis

Enzymes control the chemical reactions that sustain life. Conditions inside the body must enable enzymes to catalyse the multitude of chemical reactions needed for life processes. Maintaining these conditions even when external conditions vary, sometimes quite considerably, is essential. This maintenance is called homeostasis.

Materials flow in and out of cells constantly, but concentrations inside and outside are maintained. A dynamic equilibrium is established. Various mechanisms also maintain body temperature.

Examples of what can go wrong

Disturbing the delicate chemical balance in the body and delaying its return to normal may cause illness. Every illness results from chemical reactions that give rise to characteristic symptoms.

Sometimes the body's own defences cause changes which make us feel ill, for example, by raising body temperature (fever) to slow growth of viruses.

[1] All of these systems have a separate information sheet.

Medicinal drugs may be used to bring about chemical changes which relieve symptoms or cure disease.