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Learning Programs for Biology Education

Visualizing Human Physiology: Introduction to the Human Machine

Study Guide

Supplement to Video Program

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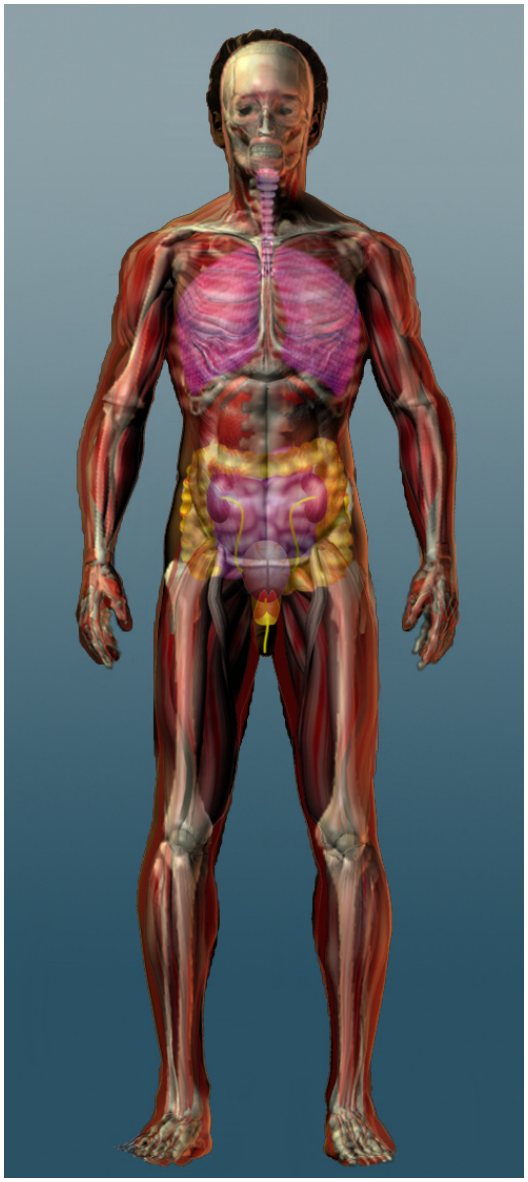


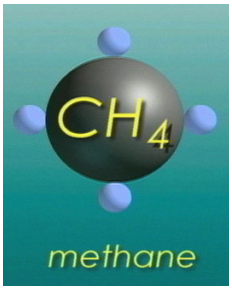
Every individual human organism is an organic super factory – a living machine made up of systems that process fuel, build products, repair damage, expel waste, and defend against microbial invaders.

The physiological systems of the human body –

– muscular movement
– circulation
– digestion
– respiration
– nerves
– glands
– immunity
– and reproduction

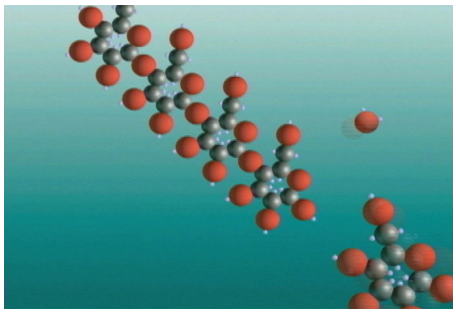
– contribute to the individual's success and achievement of the basic imperatives of survival and reproduction. How these systems function is determined at the most basic level of physiological structure – by the cells that make up the characteristic tissues and organs of each individual.

The Molecular Building Blocks of Life

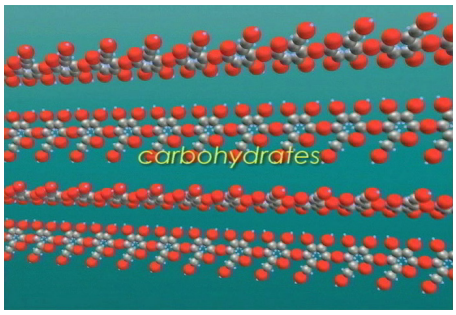


The molecules that make up living things are all based on **carbon**. Such molecules are identified as **organic**.

Because of its electromagnetic qualities, a carbon atom has four bonding sites. It can bond with hydrogen – in this case forming the molecule CH4 – methane gas.



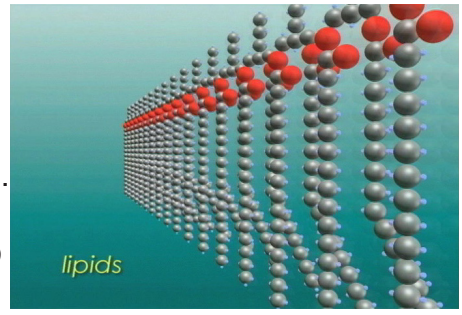
Carbon atoms can also bond with each other. Chains of carbon-based atoms can be combined with the help of an enzyme. An OH (oxygen and hydrogen) unit from one building block molecule and an H (hydrogen) from another are removed, forming H2O (water). Such reactions, known as **condensation reactions**, can assemble building block molecules into long chains of repeating units called **polymers**.



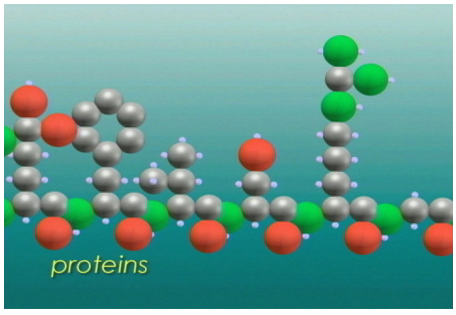
Four kinds of biologically produced polymers play major roles in life: carbohydrates – lipids – proteins – and nucleic acids.

Sugars are **simple carbohydrates**. Starch, a **polysaccharide**, is a **complex carbohydrate**, made from many sugar molecules.

When an animal eats a starch – its digestive enzymes render the polymer back to its building block sugars, ready for absorption.

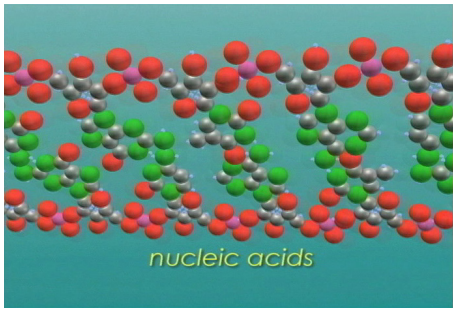


Lipids are made of short carbon chains called fatty acids. The **plasma membrane** of living cells is a double layer of **phospholipids** composed of two fatty acids attached to a phosphate containing head. The heads are **hydrophilic** (attracted to water), so in water they orient like this – heads pointing out. The tails are hydrophobic and so point in. This orientation to water is responsible for the typical bilayer configuration of all cell membranes.



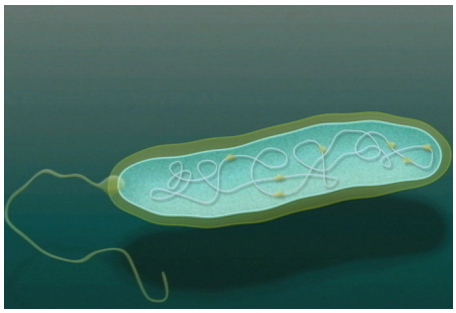
Another lipid configuration has three fatty acids combined with a glycerol: a **triglyceride** – the energy-storing fat produced by animals. A third type of lipid, **cholesterol**, is found in cell membranes and is used by cells for synthesizing certain steroid hormones. Fats and carbohydrates are chains of similar building block molecules.

Proteins are also polymers, but are made from 20 different **amino acid** building blocks. Amino acids can be fit together in any combination by synthesizing enzymes.

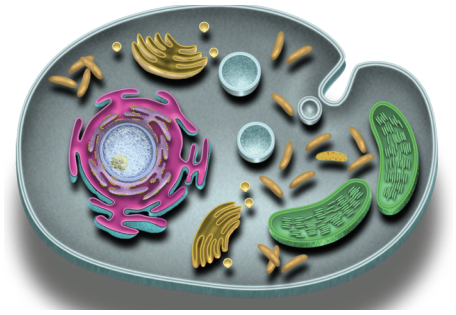


Nucleic acids are polymers made from four kinds of building block **nucleotides**. Nucleotides are the genetic code molecules that make up RNA and DNA.

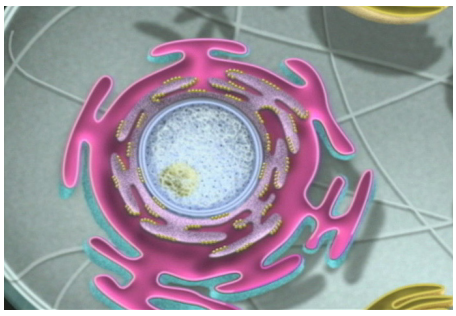
The Cellular Nature of the Human Machine



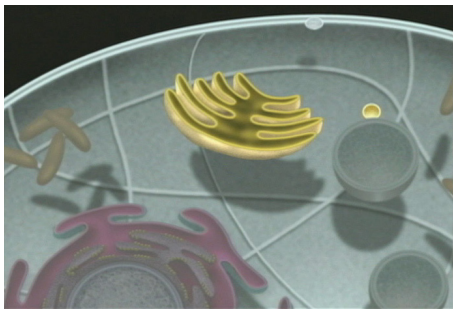
Two kinds of cells make up the living world. **Eukaryotic cells** with their DNA surrounded by a membranous envelope, a nucleus – and **Prokaryotic cells** in which the DNA is not isolated from the cell interior – bacteria. A bacterial chromosome is a single loop of DNA containing several thousand genes. The earliest cell microfossils were left by prokaryotes, bacteria-like organisms that appear to have been the only forms of life on earth for around two billion years. Then, around 1.5 billion years ago, the first eukaryotic cells appeared – cells with nuclei probably containing multiple chromosomes.



Eukaryotic cells have another feature not found in prokaryotes – membrane bound **organelles**. Even the simplest multicellular animal contains a variety of cell types – and complex animals like humans have more yet.

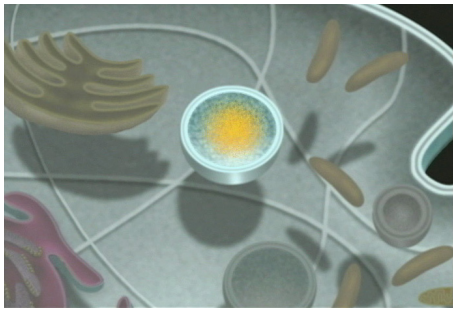


The plasma membrane surrounds a cell, and contains a soup of dissolved substances and enzymes called the **cytosol**. Suspended in the cytosol are the cell organelles, including the **nucleus**. The nucleus is surrounded by a nuclear envelope and contains the cell's DNA and associated proteins.

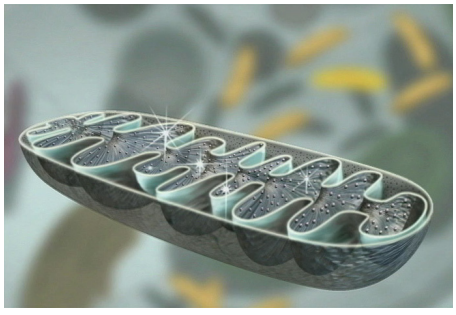


The **Rough Endoplasmic Reticulum**: Extending out from the nucleus is a maze of membranous chambers where RNA messages from the nucleus are translated into proteins on tiny structures called **ribosomes**.

These products are processed in the **Golgi complex**. Budding from the Golgi membranes, vesicles break free and transport protein throughout the cell.

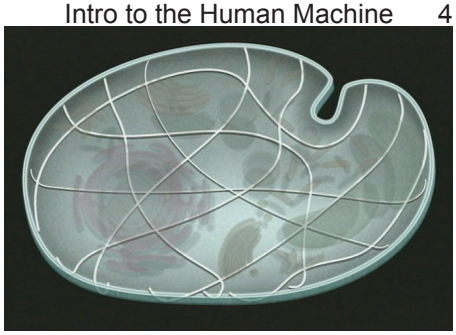


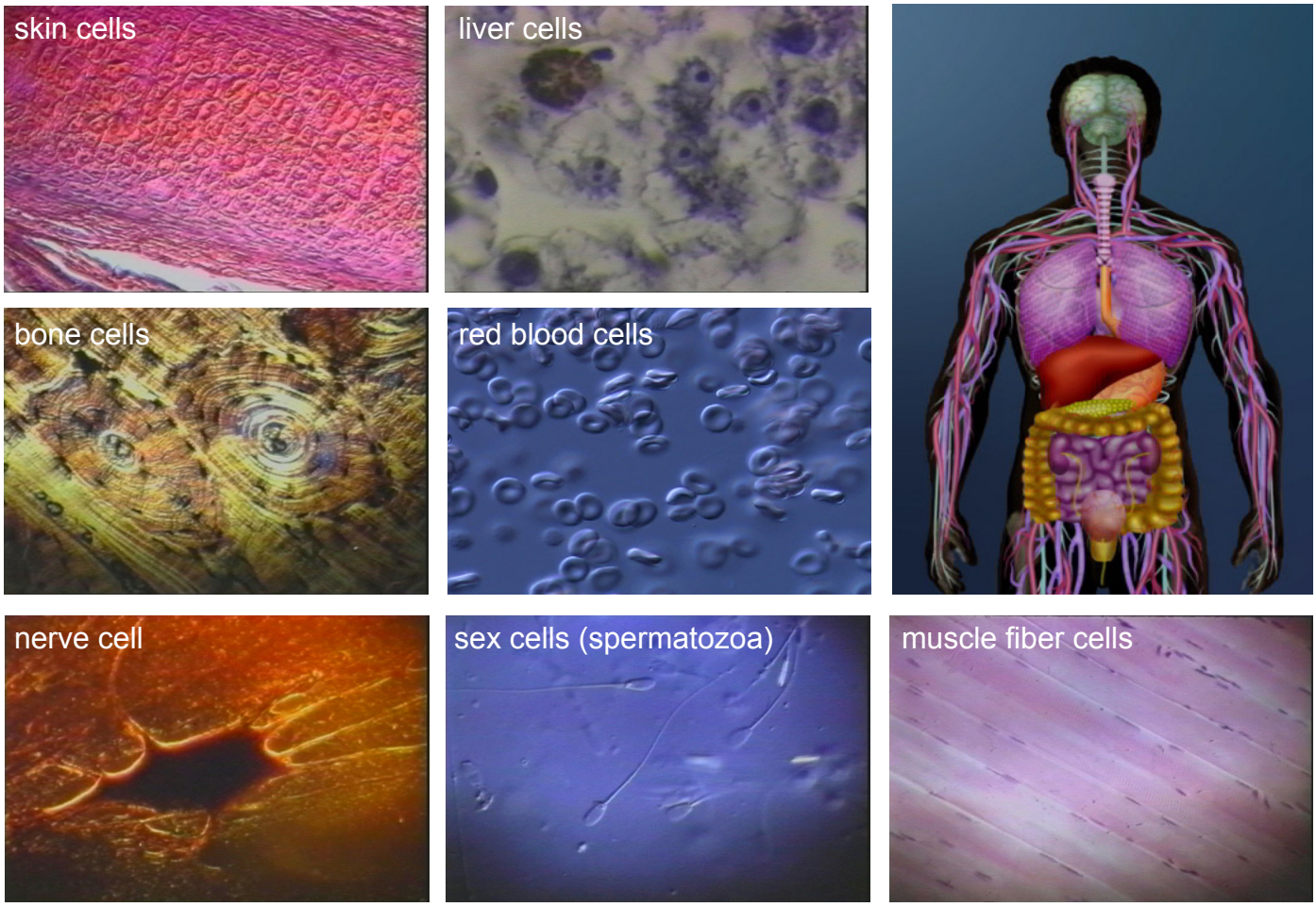
Lysosomes are a special class of vesicle that carry the cell's powerful digestive enzymes.



The cytosol swarms with **mitochondria**, bacteria-sized bodies that use oxygen to metabolize sugars and fats.

A cell's shape is maintained by a meshwork of structural proteins that form tubes, cables, and girders – the components of the **cytoskeleton**.





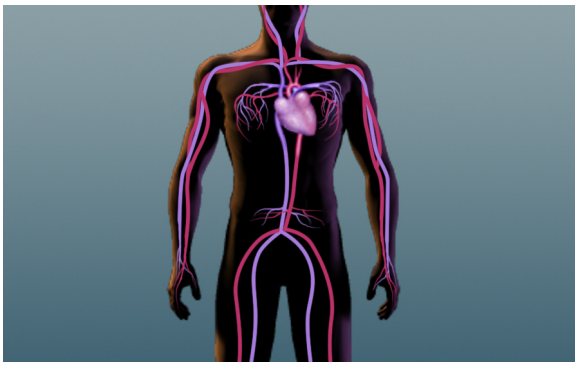
A Variety of Cells from the Human Body

Similar cell types form the foundation of **tissues**, such as muscle, ligament, and the different layers that make up skin. Tissues, in turn, form the substance of **organs** – the specialized structures that form the physiological systems of the human body.

Notes (this space is text-interactive):

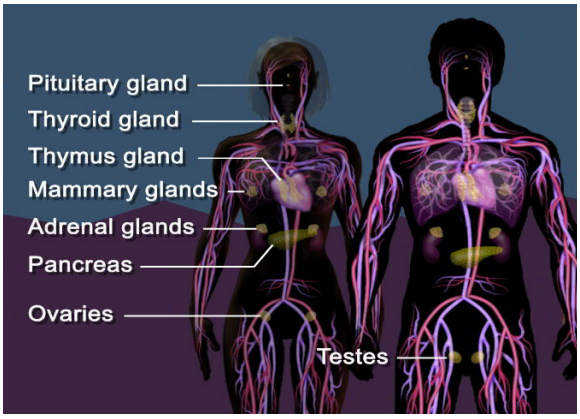
An Overview of Physiological Systems

Circulation
Every cell in the human body requires oxygen. Driven by the heart and lungs, the circulatory and respiratory systems carry oxygen from the lungs to every cell in the body. The medium for transport, blood, also delivers energy and other molecules from digestion, hormones from the endocrine system, and immune cells wherever such products are needed.

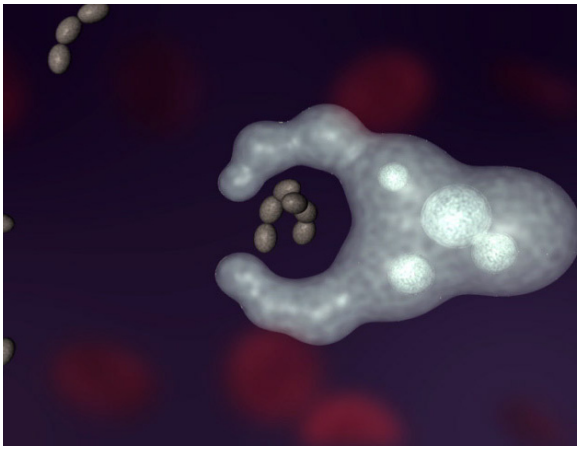


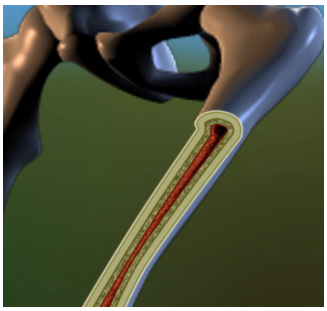
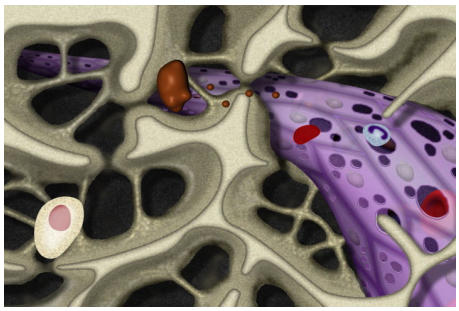
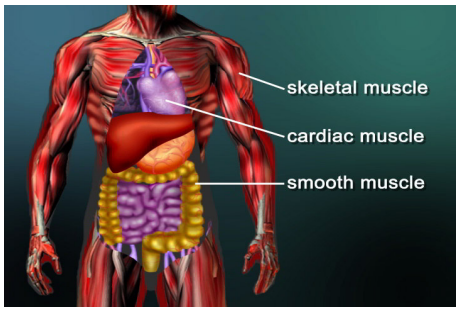
Digestion
Energy is the primary ingredient extracted from food – energy to power all the processes of life. Serviced by an intricate network of blood vessels the stomach and intestinal tract are the setting for the human digestive system, where food is broken down into its molecular components for use as energy, building blocks, and chemical facilitators. Also from food molecules come such necessary chemicals as nucleic acids, the molecules that when bonded by specialized enzymes form DNA and the various types of RNA, the informational code molecules used in cellular reproduction. Food molecules also provide – amino acids – the building block molecules of proteins and enzymes, the long molecules that give life its shape. The system then eliminates the unusable material – as waste.

Hormones
Critical to the regulatory functions of growth and behavior are hormones produced by the **endocrine system**. Located throughout the body this system is made up of various specialized glands where complex hormone molecules are assembled and injected into the circulatory system.



Immunity
The human body is under constant siege by microscopic invasion in the form of bacteria and viruses. The **Lymphatic** System, in league with the circulatory system, responds to invasion by producing a variety of immune cells that attack and destroy most microbial and viral pathogens. The immune system may be susceptible to a variety of immune disorders, as well as specialized viral attack from **HIV**, the **human immuno virus** that causes **AIDS**.

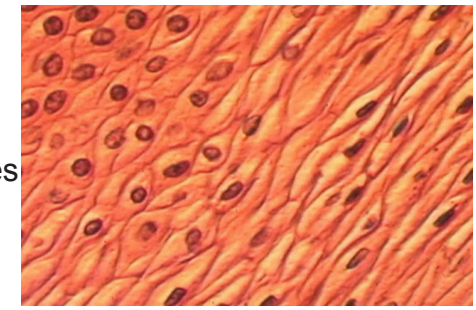
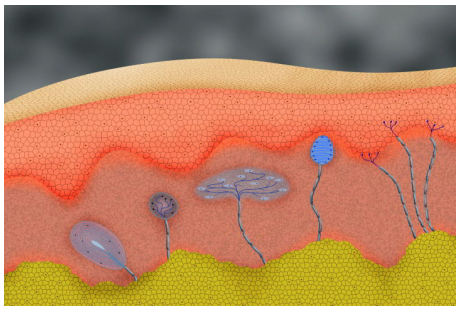


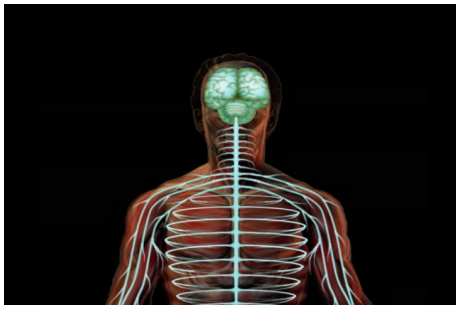
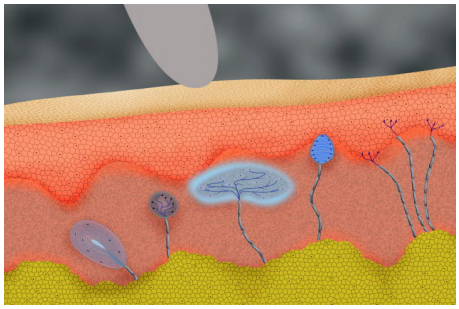
Skeleton and Muscles
Bone is comprised of bone cells. Bone marrow is where five different kinds of blood cells are produced, including red blood cells (**RBCs**).

The human skeleton is the frame upon which muscles attach. Three kinds of muscle provide the means for large mechanical movement – for limbs, organs, and heart.

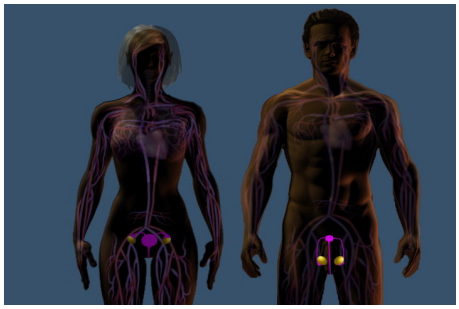
Skin
Surrounding everything is a tough multi-layered covering; skin provides protection from the environment, and is embedded with specialized receptors – nerves – for sensing the surrounding environment and regulating temperature.

Nerves
The bio-electrical impulses generated by sensory receptors in the skin are carried along strands of nerve cells – to the spinal cord – and ultimately to the brain – but also send signals from the brain to our muscles via motor nerve cells.

Reproduction
The human reproductive system traces its physiological template to the model pioneered by the placental invertebrates, that appeared on Earth over one hundred-thirty million years ago. Much older, however, are the genetic roots of reproduction, and are basic to the simplest organisms – the exchange of genetic material from two individuals. The exchange ensures a mixing of genes, resulting in diverse gene pools, improving the odds of survival and species success. Embryonic development, from fertilization to birth, reveals many evolutionary insights, visually placing Homo sapiens in its place on the tree of life.




amino acid
carbohydrate
carbon
cholesterol
circulation
condensation reaction
cytoskeleton
cytosol
digestion
endocrine system
eukaryotic
golgi complex
hormone
human immuno virus
hydrophilic
immunity
lipid
lymphatic System
lysosome
mitochondria
muscle
nerve
nucleus
nucleic acid
nucleotide
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organelles
organic
plasma membrane
phospholipids
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reproduction
rough endoplasmic reticulum
ribosome
RBC
skeleton
skin
tissue
triglyceride

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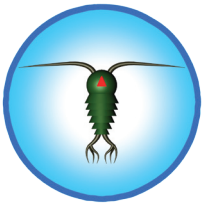

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