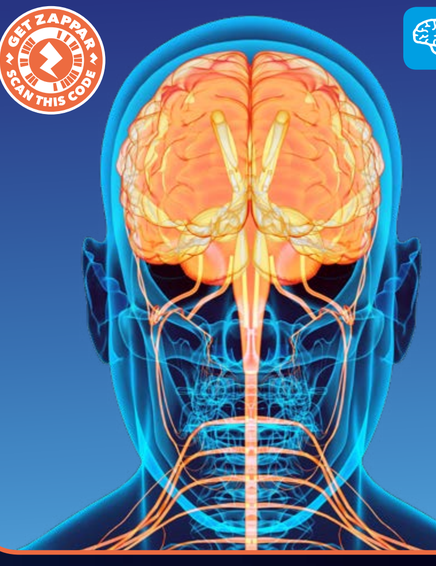
SECRETS OF THE HUMAN BODY

JOURNEY THROUGH THE MAIN ORGAN SYSTEMS AND REVEAL THEIR SECRETS. BRING THE HUMAN BODY AND ITS ASTONISHING COMPLEXITY TO LIFE WITH THE HELP OF AUGMENTED REALITY.

CENTRAL NERVOUS SYSTEM



Your brain and spinal cord make up your central nervous system (CNS) and coordinate the activity of the rest of your body. For example, your CNS tells you when to draw breath, controls your heart rate, and enables you to perceive the world around you and to take action within it. The brain also controls your thoughts and your emotions. The CNS is a complex network of different cell types connected by nerve fibres. Neurons are cells responsible for firing electrical messages around this network, allowing parts of the CNS to talk to each other. The greatest secret of this system is how the exact same electrical message, known as the action potential, can be perceived so differently. When it occurs in one part of the CNS you perceive pain, yet if it occurs elsewhere in the CNS you feel hungry or recall a memory.

SYSTEM FACTS

- The number of neurons you have is not fixed once you develop into adulthood. You can continue to generate new neurons if necessary.
- Some cells in the CNS are responsible for wrapping themselves around nerve fibres, thus providing electrical insulation. This enables faster action potentials in the insulated fibres.
- While scientists can pinpoint certain functions to specific parts of the CNS, the so-called 'neural correlate of consciousness' remains elusive.

CARDIOVASCULAR SYSTEM

The cardiovascular system consists of the heart, blood vessels and blood. The heart pumps blood into the pulmonary vascular system, which supplies the lungs, and into the systemic vascular system, which supplies blood to the rest of the body. Blood leaving the heart is under high pressure and is carried by arteries, which have thick, muscular, elastic walls. It returns to the heart under low pressure, helped by the muscles in the legs, and is carried by veins, which have thin, floppy walls and, unlike arteries, valves that make sure the blood flows in only one direction. Capillaries are small, narrow blood vessels with very thin walls, only one cell thick, allowing the blood within them to deliver nutrients and oxygen to the cells of the body and to pick up their waste products.

SYSTEM FACTS

- If the blood vessels in the human body were placed end to end, they would stretch for over 100,000 miles. Ten capillaries are as thick as one human hair.
- The average human contains five litres of blood which is pumped around the body around 1500 times a day.
- Oxygen is transported around the body by red blood cells. A pinprick of blood contains 5 million of them.

DIGESTIVE SYSTEM

There are several organs that comprise the digestive system including the stomach, the small and large intestines and the liver. The purpose of this system is to break down the food and drink we consume so that the component nutrients can be circulated by the blood, which then picks up waste products and carries them away to be excreted. Carbohydrates make up the main source of the body's energy, but we also need other macronutrients as well as micronutrients to support healthy bodily functions. The breakdown of food starts in our mouth with the action of digestive enzymes present in saliva – for example, carbohydrates need to be broken down into much simpler sugar molecules. The liver helps to regulate the storage or use of sugar within the body and produces bile, which breaks down fats. It is also responsible for detoxifying any alcohol or medicines that we consume.

SYSTEM FACTS

- The digestive system, like the brain, contains an extensive network of neurons and has been termed 'the second brain'.
- These neurons exchange information with the brain – for example signalling pain or discomfort in the digestive system, or signalling hunger or a feeling of fullness.
- In turn the brain can regulate the speed at which substances flow through the digestive system.

SKELETAL SYSTEM

The skeletal system provides a hard framework for our body with articulated joints and a system of struts (bones) that our muscles and tendons can lever against to generate movement. Some bones, such as the skull and the ribs, also provide vital protection for the delicate tissues inside the body. Bone consists of a matrix of collagen fibres and a mineral deposit within this matrix. Cells called osteoblasts lay down this mineral deposit, which is made from a mix of calcium, silicon, carbonate and zinc, amongst other chemicals. Osteoblasts, together with osteoclasts, are cells capable of remodelling bones over time – for example, repairing them following an injury. There are two types of bone composition within the human body: cancellous bone, which has a honeycomb or sponge-like structure conferring lightness, and compact bone, which is denser and heavier and confers strength. As an example, the femur (the long bone within the thigh) consists of a central section of compact bone with cancellous bone at each end, balancing the need for strength and lightness. Bones also contain blood vessels and are therefore capable of bleeding when damaged.

SYSTEM FACTS

- The surface of the skull is made up of plates of bone that abut each other to create distinctive skull 'landmarks'. Major brain blood vessels lie directly underneath these points.
- As we age the production of osteoblasts decreases, leading to brittle bones that are more liable to break.
- The bones within our joints contain proprioceptors that tell our brain where our joints are in three-dimensional space, helping to create our bodily sense.

MUSCULAR SYSTEM

Some muscles of the human body, such as those in the calves and upper arms, lie close to the skin, where they can be seen contracting and relaxing to move the bones to which they are connected. However, some muscle tissue, such as that in the heart and intestines, lies much deeper within the body, where its contractions generate a flow of blood, nutrients or digestive secretions. Muscles cannot contract without a signal telling them to do so in the form of electrical impulses, or action potentials, generated by neurons. When looked at under a microscope, muscle tissue takes one of three visibly different forms: skeletal, smooth or cardiac. Skeletal muscles can be signalled to contract at will, so they are also known as voluntary muscles and include those in the calves and upper arms, but also those in the face (creating facial expressions, for example). Smooth and cardiac muscle tissue, on the other hand, is also known as involuntary muscle tissue because it contracts automatically, outside of conscious willed control.

SYSTEM FACTS

- Muscles also play a supportive and protective role in the human body – for example, neck muscles help to hold up the head and protect the spinal column.
- Muscles contain tiny sensors known as spindles that send information to the brain, reporting on each muscle's length and tension as it contracts.
- Muscle cells can be 30cm long. They bundle together to form fibres, each of which has a blood supply running alongside it providing it with oxygen and glucose to fuel contraction.

Bring your poster to life...

1 DOWNLOAD
Download Zappar app onto your smartphone or tablet.

2 SCAN
Scan the zapcodes to see the organs appear in 3D.

3 ZAP
Watch the brain, heart and liver come to life.

The Open University

BBC

Find out more about the systems in the human body visit
www.open.edu/openlearn/humanbody

BBC

The Open University

SECRETS OF THE HUMAN BODY

The human body is a collection of cells that together form tissues, organs and organ systems. This poster reveals some of the secrets of this amazing structure and its functions.

Learning with The Open University

Academic Excellence

The OU's academics are some of the leading experts in their field and apply their passion to their research when preparing study materials, which means that you get to learn from the best.

Find out more about the OU academics who have worked on this television series and this poster:

Dr Claire L Rostron
Senior Lecturer in Health Sciences

Claire joined the Department of Life Health and Chemical Sciences at The Open University in April 2007. Her research interests lie in motivated behaviour and, more recently, type 2 diabetes. She has worked as qualification director for Health Sciences and continues to support curriculum development in this area.

Find out more about Claire's academic experience and academic profile:

www.open.ac.uk/people/cr4397

Dr Kerry Murphy
Senior Lecturer in Neurophysiology

Kerry is an IB Diplomat holder (UWCA), has an honours degree in Physiology from Dundee University and a PhD in Neurophysiology from University College, London. Kerry is a founding member of the Huntington's Disease Research Forum based at The Open University.

Find out more about Kerry's academic experience and academic profile:

www.open.ac.uk/people/kpsm2

The Open University (OU) is the UK's largest academic community, with over 170,000 students studying for over 120 qualifications in a range of fascinating and challenging subjects. Around 70 per cent of our students fit study around their job and busy, changing lives, proving that you don't have to put your life on hold to get the qualification you need. Wherever you study, your OU tutor, study advisers and other students are as close by as you need them to be – online, via email, by phone and face to face.

For more information or to request a prospectus visit **www.open.ac.uk/courses**

Accessible

If you have little or no knowledge or experience of studying, the OU's 'Access modules' are open to all and an ideal starting point. They have been specially designed to help you find out what it's like to study with the OU, get a taste for the subjects we offer, develop your study skills, build your confidence and prepare you for further study.

For more information visit **www.open.ac.uk/access**

Affordable

Studying with the OU is more affordable than you might think. You may even be able to study for free. For more information on all of the funding options available to you visit **www.open.ac.uk/fees**

Study

The Open University offers a range of qualifications for those interested in science and health:

BSc (Honours) Health Sciences (Q71)

You'll study the essential scientific concepts underpinning the function of the human mind and body, including the incidence, diagnosis and treatment of disease and disability, and the maintenance and improvement of health in different populations.

BSc (Honours) Natural Sciences (Q64)

Whether you're keen to study a specific area of science, or you're not yet sure where your interests lie, there are study options available to you. You can choose a broad study route, where you select modules in areas of interest to you, or a specialist route in biology, chemistry, earth sciences, environmental science, physics or astronomy and planetary science.

Some of the modules you can study on your pathway to a qualification within science are:

Science and health: an evidence-based approach (SDK100)

This key introductory module introduces the science of human health and is structured around eight globally important health topics ranging from nutrition and infectious diseases to pain and breast cancer screening. Each topic integrates key concepts in the biological, chemical and physical sciences with psychology and health statistics to illuminate the causes of disease and disability and the consequence for individuals and populations.

Human Biology (SK299)

This module explores the human body, focusing on the major body systems including the cardiovascular, respiratory, endocrine and nervous systems, their functions and dysfunctions. There is an emphasis on the richness of interactions between the individual and their environment.

For more information visit **www.open.ac.uk/courses** or call our Student Registration & Enquiry Service on **0300 303 5303**

For more information about Open University broadcasts and associated free learning, visit our website **www.open.edu/openlearn/whats-on**

Grateful acknowledgement is made of the following sources: iStock images.

Published in 2017 by The Open University, Walton Hall, Milton Keynes, MK7 6AA, to accompany the BBC/OU series *The Human Body: Secrets of Your Life Revealed* first broadcast on BBC TWO.

Broadcast Commissioner for the OU:
Dr Caroline Ogilvie

Commissioning Executive for the BBC:
Craig Hunter

Series Producer for BBC: Nigel Paterson

Media Fellow for the Open University:
Dr Mark Brandon

Academic Consultant for the OU:
Dr Claire Rostron & Dr Kerry Murphy

OU poster 'Secrets of the Human Body'

Authors: Dr Claire Rostron & Dr Kerry Murphy

Graphic Designer: Glen Darby

Broadcast Project Manager: David Bloomfield

Printed in the UK by Portland Print

SUP 047615

RESPIRATORY SYSTEM

The cells of the body consume oxygen to release energy from glucose, a process called cellular respiration that also produces the waste gas carbon dioxide. Single-celled organisms are able to obtain oxygen directly from their surroundings and expel carbon dioxide by simple diffusion across their cell walls. Humans can't do this but instead have a pulmonary respiratory system that provides a moist surface area where oxygen can be taken up from the air and carbon dioxide removed from the body, which happens in the lungs. A person at rest will inhale and exhale about seven litres of air each minute. Inhaled air, which contains about 20% oxygen, enters through the mouth and nose, passing down the trachea and into the two bronchi, each supplying a lung. It then passes through ever smaller passages, called bronchioles, and is delivered to millions of tiny air sacs known as alveoli. It is here that gaseous exchange occurs. Oxygen is taken up into the blood passing through the small capillaries that surround the alveoli and carbon dioxide is expelled into the air sacs, to be removed during the next exhalation.

SYSTEM FACTS

- The right lung is larger than the left lung.
- The combined surface area of the alveoli is about the size of a tennis court.
- It is the level of carbon dioxide in the blood, and not oxygen, that determines the rate and depth of breathing.
- Nose hair acts as a filter, cleaning the air before it enters the lungs.
- The fastest recorded sneeze was 165 km/hr.

ENDOCRINE SYSTEM

The glands of the body that secrete hormones into the blood are collectively referred to as the endocrine system. Most are involved in the homeostatic control of the body's internal environment – for example, the thyroid gland, located in the neck, releases thyroid hormones that regulate the way the body uses energy. These hormones also help the body to maintain its core temperature. When body temperature falls, they stimulate cells to consume more energy, and in doing so release some of it in the form of heat, warming the body. Most endocrine glands are controlled by hormones secreted by the pituitary gland, located in the brain. This in turn is controlled by a brain region called the hypothalamus. Together they form the pituitary-hypothalamic axis.

SYSTEM FACTS

- There are eight hormone-secreting glands including the pituitary gland, thyroid gland, parathyroid gland, pancreas, pineal gland, hypothalamus, adrenal gland and reproductive glands (gonads).
- Sleep is also regulated by the endocrine system; the pineal gland releases the hormone melatonin, which promotes sleep, when light levels are low.
- Some hormones work by binding to receptors on the surface of their target cells while others diffuse across the cell membrane and interact with DNA in the cell nucleus, switching genes on or off.

LYMPHATIC SYSTEM

The lymphatic system has three main roles: it maintains fluid balance in the tissues of the body, it is part of the immune system, and it is essential for the absorption of fats and fat-soluble vitamins from the gut. As blood is pumped around the body, about 10% of its fluid component – blood plasma – leaks out of the capillaries to bathe the cells in fluid rich in nutrients and oxygen. This fluid is then collected by lymph vessels and returned to the blood by draining into the veins at the base of the neck. The lymphatic system connects organs involved in immunity, including the thymus and bone marrow, and transports immune cells around the body. It has a series of lymph nodes that house collections of immune cells that remove foreign material, such as infectious microorganisms, from the lymph fluid passing through them.

SYSTEM FACTS

- In the gut, lymphatic vessels called lacteals absorb fats.
- The tonsils are large clusters of lymphatic cells.
- The body has over 500 lymph nodes.
- Swollen lymph nodes are a sign of infection.
- Lymph is named after the Roman goddess of wells and springs, Lympha.

BRAIN

It may account for only 2% of body weight but the brain is perhaps the most remarkable biological structure known to science. It is a colossal processing house for information, containing over 85 billion neurons. It is organised into discrete but interconnected structures, the largest being the cerebral cortices, which account for 75% of the brain's mass. It is these that make the human brain unique, being involved in language and consciousness. However, over 90% of the decisions that take place in the brain occur at a subconscious level. The processing and intellectual power of the brain derives from not only the huge number of neurons, but also the synaptic connections they make with each other. It is estimated that a typical brain has over 100 trillion synapses. The capacity for the human brain to learn and adapt to challenging situations is also remarkable. This occurs because the network of synaptic connections in the brain is plastic, enabling the brain to refine its processing pathways or make new ones. However, all of this processing power comes at a cost; 20% of the blood pumped by the heart goes to the brain.

ORGAN FACTS

- A two-year-old's brain is about 80% of the size of an adult brain.
- 60% of the human brain is composed of fat.
- Brain size does not determine intelligence; Einstein's brain was 10% smaller than the average brain.
- The brain generates up to 25 watts of electricity – enough to power a dim lamp.
- Half of the genes in the human genome are involved in the development and maintenance of the brain.

HEART

The heart is a muscular pump that pushes blood around the body. In fact, it is actually two pumps, each consisting of an upper chamber, the atrium, which collects the blood returned to the heart by the veins, and a muscular lower chamber, the ventricle, which pumps blood into the arteries. The right side of the heart receives deoxygenated blood from the systemic vascular system and pumps it at low pressure into the pulmonary artery, which supplies the lungs. Meanwhile the left side of the heart receives oxygenated blood from the lungs and pumps it at high pressure into the aorta, the artery that supplies the rest of the body. The contraction of the heart is highly coordinated and is initiated by a small cluster of pacemaker cells, called the sino-atrial node (SAN), located in the upper right atrium. The SAN generates a cardiac action potential that is then propagated throughout the heart muscle, causing it to contract. The cardiac action potential is different to that seen in neurons; it has a longer duration, regulated by specialised calcium channels.

ORGAN FACTS

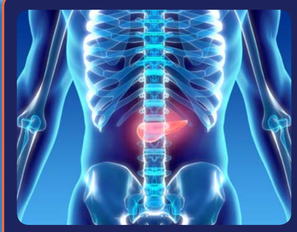
- If a beating heart were removed from the body, it would continue to beat.
- The SAN is influenced by the autonomic nervous system and circulating hormones, such as adrenaline.
- The human heart beats over 100,000 times a day.
- The first heart cell in a developing foetus starts beating as early as four weeks.
- If the heart pumped blood into the lungs at the same pressure it pumps blood into the systemic system, the lungs would fill with fluid.

LIVER

The liver is the largest gland and largest solid organ in the human body, located below the diaphragm. It is divided into two main lobes which are further divided into 100,000 smaller lobes called lobules. Over 60% of cells in the liver are hepatocytes, which absorb nutrients and detoxify and remove harmful substances from the blood, including alcohol. The liver also produces bile, which is secreted into the gut to aid the digestion and absorption of fats and fat-soluble vitamins. Bile also contains waste products that are eliminated in the faeces, such as bilirubin, which is produced when the liver breaks down old red blood cells and gives faeces its distinctive colour. When blood glucose is high, the liver converts it into glycogen to be stored in the liver and converted back to glucose when the body needs energy. During times of starvation or fasting, glycogen is able to make 'new' glucose and other energy molecules from other components of the body. The liver also fights infection in the gut, containing over half of the body's supply of macrophages (immune cells that kill bacteria).

ORGAN FACTS

- A healthy liver is able to regenerate itself.
- At any given time, 13% of the body's blood supply is passing through the liver.
- A hepatocyte has an average life span of about 150 days.
- Drinking too much alcohol can cause liver diseases, such as fatty liver, hepatitis and cirrhosis.
- Once full of glycogen, the liver coverts glucose into fatty acids, to be stored as fat.



PANCREAS

A part of the endocrine and digestive systems, the pancreas could be considered as two glands in one. The majority of it produces enzymes that help us to digest the food we eat. These enzymes are secreted through the pancreatic duct running through the middle of the pancreas and into the small bowel. However, throughout the pancreas there are small islands of tissue called islets of Langerhans. Cells in these islets release the hormones insulin and glucagon into the blood. Insulin signals the body's cells to take in glucose and turn it into energy so that they can function. If insulin is not produced by the pancreas, or it does not function normally, cells cannot take up glucose and circulating blood sugar levels remain high, as happens in people with diabetes. But insulin and glucagon work in a regulated partnership with each other. Glucagon is released by the pancreas when circulating blood glucose is low, telling the liver to start releasing more glucose into the blood stream in order to raise blood glucose levels. The balance of insulin and glucagon keeps blood glucose within a tight range normally.

ORGAN FACTS

- The pancreas is a long, flat, spongy organ sitting behind your stomach.
- The pancreas helps to neutralise chyme from its acidic pH of 2.
- Chyme is the semi-digested mass of food passed from our stomach to our intestines.
- There are different pancreatic enzymes capable of breaking down proteins, fats, starches and sugars.
- High blood glucose levels can damage the kidneys and other organs, as well as the blood vessels in the eye.

THYMUS

The thymus, part of the lymphatic system, may look like a minor structure but it plays an important role in protecting the body from infection and the development of cancer, which occurs when the body's cells grow abnormally following a mutation in their DNA. The thymus works like a training centre preparing soldiers for battle. The 'soldiers' in this case are T cells, part of our immune system, which are born in the bone marrow but travel to the thymus to mature and develop into specialist T cells. One type of T cell is the killer T cell, which scans the rest of the body's cells to see if they have become infected or mutated, eradicating any cancerous or infected cells it finds. The other main type of T cell is the helper T cell, which helps other cells of the immune system to produce antibodies. Unfortunately, the 'soldier' selection process is quite rigorous and most cells that make it to the thymus die without successfully completing the training steps to become mature T cells of a specific type.

ORGAN FACTS

- The thymus is also part of the endocrine system and produces hormones to help T-cell development.
- The thymus grows during childhood but shrinks from puberty and on into adulthood.
- Like the brain, the thymus has two identical lobes with a region of outer tissue called the cortex.
- If the thymus does not develop properly, the immune system becomes compromised.
- The thymus can be removed in adulthood since its training role occurs during childhood development.

SKIN

Our largest bodily organ, the skin, provides a protective barrier. Skin layers contain blood vessels, hair follicles and sweat ducts, along with sensory cells that allow us to detect simple touch stimuli, like a tickle or a caress, and help us to identify objects and surfaces by touch. Some also signal pain from tissue damage, intense heat or a knock or punch. As our skin performs such an important protective function, any damage to it needs to be repaired as quickly as possible, which is the function of the inflammatory response. During an inflammatory response, such as that arising from a cut or tear to the skin, chemical messengers trigger the dilation of blood vessels, which enables greater blood flow as the vessels become wider. This increased blood flow produces the sensation of heat and delivers immune cells, like T cells, to help destroy any bacteria that have entered through the cut. Platelets in the blood also stimulate tissue repair to seal the cut. In addition, any damaged cells or other debris are removed via the lymphatic system. It's a highly coordinated protective repair process.

ORGAN FACTS

- Not all skin is created equal. Some skin areas (e.g. your lips) contain more sensory cells than others.
- Your skin contains several different types of sensory cells that respond to pain and touch.
- One type of sensory cell, the Pacinian corpuscle, looks a bit like an onion.
- Amputees with phantom limb pain can feel pain from damaged limbs that have been removed.
- Phantom limb pain is due to a mix-up and rewiring of nerve signals from the body to the brain.

Find out more about the systems in the human body visit **www.open.edu/openlearn/humanbody**