HUMAN ANATOMY
THE DEFINITIVE VISUAL GUIDE

CONTENT PREVIOUSLY PUBLISHED IN THE COMPLETE HUMAN BODY
HUMAN ANATOMY
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FOREWORD

Anatomy is a very visual subject, and illustrated anatomy books have been around for centuries. In the same way that a map must represent the physical features of a landscape, anatomical illustrations must convey the detailed layout of the human body. The mapmaker is concerned with the topography of a landscape, while the anatomist focuses on the topography of the body. The maps—whether of landscapes or the body—are collected into books known as atlases. The first anatomical atlases appeared in the Renaissance period, but students of anatomy today still rely heavily on visual media. Plenty of students still use atlases, alongside electronic resources.

Anatomical depictions have changed through time, reflecting the development of anatomical knowledge, changing styles and taste, and the constraints of different media. One of the earliest and most well-known atlases is Andreas Vesalius’ *De humani corporis fabrica* (On the structure of the human body), published in 1543. The anatomical illustrations in this book took the form of a series of posed, dissected figures standing against a landscape. It was a book intended not just for medical students, but for a general readership. The heavy use of images to convey information made sense for this visual subject, and also helped to make anatomy accessible.

The late seventeenth century saw a striking change in anatomical depictions. Flayed figures, gracefully arranged against landscapes, gave way to brutally realistic illustrations of cadaveric specimens in the dissection room. The connection between anatomy and death was impossible to ignore in these pictures. The style of anatomy illustration has also been influenced by the methods available to capture and print images. As lithography replaced woodcut printing, it was possible to render anatomy in finer detail. Anatomical illustrators leaped on the potential offered by color printing, using different colors to pick out arteries, veins, and nerves. More recently, the advent of photography meant that anatomy could be captured more objectively. It would be reasonable to suppose that photography would offer the best solution to the challenges facing the medical illustrator, but the task requires more than objectivity and fidelity. Images need to be uncluttered, and sometimes a simple line drawing can convey information better than a photograph of an actual dissection. The challenge facing the medical illustrator has always centered on what to keep in and what to leave out.

The development of medical imaging, including the use of X-rays, ultrasound, and MRI (magnetic resonance imaging), has had a huge impact on medicine, and has also had a profound effect on the way we visualize and conceptualize the body. Some anatomy atlases are still based on photographic or drawn representations of dissected, cadaveric specimens, and these have their place. But a new style has emerged, heavily influenced by medical imaging, featuring living anatomy. The supernatural, reanimated skeletons and musclemen of the Renaissance anatomy atlases, and the later, somewhat brutal illustrations of dissected specimens, have been replaced with representations of the inner structure of a living woman or man.

Historically, and by necessity, anatomy has been a morbid subject. The general reader may understandably have been put off by opening an atlas to be confronted with images of dead flesh, slightly shrunken eyeballs resting in dissected sockets, and dead guts spilling out of opened abdomens. But the depiction of living anatomy, informed by medical imaging techniques, reveals anatomy in all its glory, without the gore.

The illustrations in this atlas are all about living anatomy. Most of the images in this book are founded on a 3-D reconstruction of the anatomy of a whole body, drawn up in digital media and based on scans. We have grappled with the challenge of what to keep in and what to leave out. It’s overwhelming to see all the elements at the same time, so the anatomy of this idealized living human is stripped down, revealing the bones, muscles, nerves, blood vessels, and organs of the body in turn. The result is, I hope, an anatomy atlas that will be useful to any student of anatomy as well as appealing to anyone with an interest in the structure of the human body.

PROFESSOR ALICE ROBERTS

The body piece by piece
A series of MRI scans show horizontal slices through the body, starting with the head and working downward, through the thorax and upper limbs, to the lower limbs and finally the feet.
The human body comprises trillions of cells, each one a complex unit with intricate workings in itself. Cells are the building blocks of tissues, organs, and eventually, the integrated body systems that all interact—allowing us to function and survive.
DNA (deoxyribonucleic acid) is the blueprint for all life, from the humblest yeast to human beings. It provides a set of instructions for how to assemble the many thousands of different proteins that make us who we are. It also tightly regulates this assembly, ensuring that the components of the assembly do not run out of control.

THE MOLECULE OF LIFE
Although we all look different, the basic structure of our DNA is identical. It consists of chemical building blocks called bases, or nucleotides. What varies between individuals is the precise order in which these bases connect into pairs. When base pairs are strung together they can form functional units called genes, which “spell out” the instructions for making a protein. Each gene encodes a single protein, although some complex proteins are encoded by more than one gene. Proteins have a wide range of vital functions in the body. They form structures such as skin or hair, carry signals around the body, and fight off infectious agents such as bacteria. Proteins also make up cells, the basic units of the body, and carry out the thousands of basic biochemical processes needed to sustain life. However, only about 1.5 per cent of our DNA encodes genes. The rest consists of regulatory sequences, structural DNA, or has no obvious purpose – so-called “junk DNA”.

PACKAGING DNA
The human genome is composed of approximately 3 billion bases of DNA—about 6/ft (2m) of DNA in every cell if it were stretched from end to end. So our DNA must be packaged in order to fit inside each cell. DNA is concentrated into dense structures called chromosomes. Each cell has 23 pairs of chromosomes (46 in total)—one set from each parent. To package DNA, the double helix must first be coiled around histone proteins, forming a structure that looks like a string of beads. These histone “beads” wind around and lock together into densely coiled “chromatin”, which, when a cell prepares to divide, further winds back on itself into tightly coiled chromosomes.

MAKING PROTEINS
Proteins consist of building blocks called amino acids, strung together in chains and folded. Every three base pairs of DNA codes for one amino acid. The body makes 20 different amino acids—others are obtained from the diet. Protein synthesis occurs in two steps: transcription and translation. In transcription, the DNA double helix unwinds, exposing single-stranded DNA. Complementary sequences of a related molecule called RNA (ribonucleic acid) then create a copy of the DNA sequence that locks into the exposed DNA bases to be translated into protein. This “messenger RNA” travels to ribosomes, where it is translated into strings of amino acids. These are then folded into the 3D structure of a particular protein.
**BASE PAIRS**
DNA consists of building blocks called bases. There are four types: adenine (A), thymine (T), cytosine (C), and guanine (G). Each base is attached to a phosphate group and a deoxyribose sugar ring to form a nucleotide. In humans, bases pair up to form a double-stranded helix in which adenine pairs with thymine, and cytosine with guanine. The two strands are “complementary” to each other. Even if they are unwound and unzipped, they can realign and rejoin.

**GENES**
A gene is a unit of DNA needed to make a protein. Genes range in size from just a few hundred to millions of base pairs. They control our development, but are also switched on and off in response to environmental factors. For example, when an immune cell encounters a bacterium, genes are switched on that produce antibodies to destroy it. Gene expression is regulated by proteins that bind to regulatory sequences within each gene. Genes contain regions that are translated into protein (exons) and non-coding regions (introns).

**THE HUMAN GENOME**
Different organisms contain different genes, but a surprisingly large proportion of genes are shared between organisms. For example, roughly half of the genes found in humans are also found in bananas. However, it would not be possible to substitute the banana version of a gene for a human one because variations in the order of the base pairs within each gene also distinguish us. Humans possess more or less the same genes, but many of the differences between individuals can be explained by subtle variations within each gene. In humans, DNA differs by only about 0.2 per cent, while human DNA differs from chimpanzee DNA by around 5 per cent. Human genes are divided unevenly between 23 pairs of chromosomes, and each chromosome consists of gene-rich and gene-poor sections. When chromosomes are stained, differences in these regions show up as light and dark bands, giving chromosomes a striped appearance. We still don’t know the exact number of protein-coding genes in the human genome, but researchers currently estimate between 20,000 and 25,000.

**GENETIC ENGINEERING**
This form of gene manipulation enables us to substitute a defective gene with a functional one, or introduce new genes. Glow-in-the-dark mice were created by introducing a jellyfish gene that encodes a fluorescent protein into the mouse genome. Finding safe ways of delivering replacement genes to the correct cells in humans could lead to cures for many types of inherited diseases—so-called gene therapy.
It is hard to comprehend what 75 trillion cells looks like, but observing yourself in a mirror would be a good start. That is how many cells exist in the average human body – and we replace millions of these cells every single day.

**CELL ANATOMY**

The cell is the basic functional unit of the human body. Cells are extremely small, typically only about 0.01mm across – even our largest cells are no bigger than the width of a human hair. They are also immensely versatile: some can form sheets like those in your skin or lining your mouth, while others can store or generate energy, such as fat and muscle cells. Despite their amazing diversity, there are certain features that all cells have in common, including an outer membrane, a control center called a nucleus, and tiny powerhouses called mitochondria.

Liver cell

These cells make protein, cholesterol, and bile, and detoxify and modify substances from the blood. This requires lots of energy, so liver cells are packed with mitochondria (orange).

**CELL METABOLISM**

When a cell breaks down nutrients to generate energy for building new proteins or nucleic acids, it is known as cell metabolism. Cells use a variety of fuels to generate energy, but the most common one is glucose, which is transformed into adenosine triphosphate (ATP). This takes place in structures called mitochondria through a process called cellular respiration: enzymes within the mitochondria react with oxygen and glucose to produce ATP, carbon dioxide, and water. Energy is released when ATP is converted into adenoside diphosphate (ADP) via the loss of a phosphate group.

Mitochondrion

While the number of mitochondria varies between different cells, all have the same basic structure: an outer membrane and a highly folded inner membrane, where the production of energy actually takes place.
CELL TRANSPORT

Materials are constantly being transported in and out of the cell via the cell membrane. Such materials include fuel for generating energy, or building blocks for protein assembly. Some cells secrete signalling molecules to communicate with the rest of the body. The cell membrane is studded with proteins that help transport, allow cells to communicate, and identify a cell to other cells. The membrane is permeable to some molecules, but others need active transport through special channels in the membrane. Cells have three methods of transport: diffusion, facilitated diffusion, and active transport.

**Diffusion**
Molecules passively cross the membrane from areas of high to low concentration. Water and oxygen both cross by diffusion.

**Facilitated diffusion**
A carrier protein, or protein pore, binds with a molecule outside the cell, then changes shape and ejects the molecule into the cell.

**Active transport**
Molecules bind to a receptor site on the cell membrane, triggering a protein, which changes into a channel that molecules travel through.

**MAKING NEW BODY CELLS**

While the cells lining the mouth are replaced every couple of days, some of the nerve cells in the brain have been there since before birth. Stem cells are specialized cells that constantly divide and give rise to new cells, such as blood cells. Cell division requires that a cell’s DNA is accurately copied and then shared equally between two “daughter” cells, by a process called mitosis. The chromosomes are first replicated before being pulled to opposite ends of the cell. The cell then divides to produce two daughter cells, with the cytoplasm and organelles being shared between the two cells.
BODY COMPOSITION

Cells are building blocks from which the human body is made. Some cells work alone—such as red blood cells, which carry oxygen—but many are organized into tissues. These tissues form organs, which in turn form specific body systems, where cells with various functions join forces to accomplish one or more tasks.

CELL TYPES
There are more than 200 types of cells in the body, each type specially adapted to its own particular function. Every cell contains the same genetic information, but not all of the genes are “switched on” in every cell. It is this pattern of gene expression that dictates the cell’s appearance, its behavior, and its role in the body. A cell’s fate is largely determined before birth, influenced by its position in the body and the cocktail of chemical messengers that it is exposed to in that environment. Early during development, stem cells begin to differentiate into three layers of specialized cells called the ectoderm, endoderm, and mesoderm. Cells of the ectoderm will form the skin and nails, the epithelial lining of the nose, mouth, and anus, the eyes, and the brain and spinal cord. Cells of the endoderm will become the inner linings of the digestive tract, the respiratory linings, and glandular organs. Mesoderm cells will develop into muscles, and the circulatory and excretory systems.

STEM CELLS
A few days after fertilization, an embryo consists of a ball of “embryonic stem cells” (ESCs). These cells have the potential to develop into any type of cell in the body. Scientists are trying to harness this property to grow replacement body parts. As the embryo grows, the stem cells become increasingly restricted in their potential and most are fully differentiated by the time we are born. Only a small number of stem cells remain in parts of the adult body, including in the bone marrow. Scientists believe that these cells could also be used to help cure diseases.

Red blood cells
Unlike other cells, red blood cells lack a nucleus and organelles. Instead, they have an oxygen-carrying protein (hemoglobin), which gives blood its red color.

Epithelial cells
The skin cells and the cells lining the lungs and reproductive tracts are among the barrier cells, called epithelial cells, which line the cavities and surfaces of the body.

Adipose (fat) cells
These cells are highly adapted for storing fat—the bulk of their interior is taken up by a large droplet of semi-liquid fat. When we gain weight, they fill up with more fat.

Nerve cells
These electrically excitable cells transmit electrical signals down an extended stem called an axon. Found throughout the body, they enable us to feel sensations.

Photoreceptor cells
Located in the eye, these are of two types—cone and rod (left). Both have a light-sensitive pigment and generate electrical signals when struck by light, helping us see.

Smooth muscle cells
One of three types of muscle cell, smooth muscle cells are spindle-shaped cells found in the arteries and the digestive tract that produce contractions.

Ovum (egg) cells
The largest cells in the female human body, eggs are female reproductive cells. Like sperm, they have just 23 chromosomes.

Sperm cells
Sperm are male reproductive cells, with tails that enable them to swim up the female reproductive tract and fertilize an egg.

LEVELS OF ORGANIZATION
The overall organization of the human body can be visualized as a hierarchy of levels. At its lowest are the body’s basic chemical constituents, forming organic molecules, such as DNA, the key to life. As the hierarchy ascends, the number of components in each of its levels—cells, tissues, organs, and systems—decreases, culminating in a single being at its apex. Cells are the smallest living units, with each adapted to carry out a specific role, but not in isolation. Groups of similar cells form tissues, which in turn form organs with a specific role. Organs with a common purpose are linked within a system, such as the cardiovascular system, shown right. These interdependent systems combine to produce a human body (see pp.16–17).
TISSUE TYPES

Cells of the same kind often group together to form tissues that carry out a specific function. However, not all cells within a tissue are necessarily identical. The four main types of tissue in the human body are muscle, connective tissue, nervous tissue, and epithelial tissue. Within these groups, different forms of these tissues can have very different appearances and functions. For example, blood, bone, and cartilage are all types of connective tissue, but so are fat layers, tendons, ligaments, and the fibrous tissue that holds organs and epithelial layers in place. Organs such as the heart and lungs are composed of several different kinds of tissue.

**Smooth muscle**
Able to contract involuntarily in long, wavelike motions, smooth muscle is found in sheets on the walls of specific organs. It is vital for maintaining blood pressure and for pushing food through the system.

**Cartilage**
Its high water-content makes this tissue rubbery yet stiff. It is composed of cells, called chondrocytes, set in a matrix of gel-like materials secreted by the cells. Cartilage is found in the bone joints and in the ear and nose.

**Dense connective tissue**
This contains fibroblast cells, which secrete the fibrous protein called type I collagen. The fibers are organized into a regular parallel pattern, making the tissue very strong. This tissue type occurs in the base layer of skin.

**Epithelial tissue**
This tissue forms a covering or lining for internal and external body surfaces. Some epithelial tissues can secrete substances such as digestive enzymes; others can absorb substances like food or water.

**Skeletal muscle**
This tissue enables voluntary limb movements. Its cells are arranged into bundles of fibers that connect to bones via tendons. They are packed with filaments that slide over one another to produce contractions.

**Spongy bone**
Spongy bone is found in the center of bones (see p.24) and is softer and weaker than compact bone. The latticelike spaces in spongy bone are filled with bone marrow or connective tissue.

**Loose connective tissue**
This tissue type also contains cells called fibroblasts, which secrete loosely-organized fibers that make the tissue pliable. Loose connective tissue holds organs in place and provides support.

**Adipose tissue**
A type of connective tissue, adipose tissue is composed of fat cells called adipocytes, as well as some immune cells, fibroblast cells, and blood vessels. Its main task is to store energy, and to protect and insulate the body.

**Nervous tissue**
This forms the brain, spinal cord, and the nerves that control movement, transmit sensation, and regulate many body functions. It is mainly made up of networks of nerve cells (see opposite).
BODY SYSTEMS

The human body can do many different things. It can digest food, think, move, even reproduce and create new life. Each of these tasks is performed by a different body system—a group of organs and tissues working together to complete that task. However, good health and body efficiency rely on the different body systems working together in harmony.

SYSTEM INTERACTION

Think about what your body is doing right now. You are breathing, your heart is beating, and your blood pressure is under control. You are also conscious and alert. If you were to start running, specialized cells called chemoreceptors would detect a change in your body’s metabolic requirements and signal to the brain to release adrenaline. This would in turn signal the heart to beat faster, boosting blood circulation and providing more oxygen to the muscles. After a while, cells in the hypothalamus might detect an increase in temperature and send a signal to the skin to produce sweat, which would evaporate and cool you down.

The individual body systems are linked together by a vast network of positive and negative feedback loops. These use signalling molecules such as hormones and electrical impulses from nerves to maintain equilibrium. Here, the basic components and functions of each system are described, and examples of system interactions are examined.

BREATHING IN AND OUT

The mechanics of breathing rely upon an interaction between the respiratory and muscular systems. Together with three accessory muscles, the intercostal muscles and the diaphragm contract to increase the volume of the chest cavity. This draws air down into the lungs. A different set of muscles is used during forced exhalation. These rapidly compress the chest cavity, forcing air out of the lungs.

ENDOCRINE SYSTEM

The endocrine system communicates with the other systems, enabling them to be monitored and controlled. It uses chemical messengers, called hormones, which are secreted into the blood by specialized glands.

LYMPHATIC AND IMMUNE SYSTEM

The lymphatic system includes a network of vessels and nodes, which drain tissue fluid and return it to the veins. Its main functions are to maintain fluid balance within the cardiovascular system and to distribute immune cells around the body. Movement of lymphatic fluid relies on the muscles within the muscular system.

RESPIRATORY SYSTEM

Every cell in the body needs oxygen and must dispel carbon dioxide in order to function. The respiratory system ensures this by breathing air into the lungs, where the exchange of these molecules occurs between the air and blood. The cardiovascular system transports oxygen and carbon dioxide between the cells and the lungs.

NERVOUS SYSTEM

The brain, spinal cord, and nerves collect, process, and disseminate information from the body’s internal and external environments. The nervous system communicates through networks of nerve cells, which connect with other systems. The brain controls and monitors all the other systems to ensure they are performing normally.
As well as oxygen, every cell needs energy in order to function. The digestive system processes and breaks down the food we eat so that a variety of nutrients can be absorbed from the intestines into the circulatory system. These are then delivered to the cells of every body system in order to provide them with energy.

The muscular system is made up of three types of muscle: skeletal, smooth, and cardiac. It is responsible for generating movement – both in the limbs and within the other body systems. For example, smooth muscle aids the digestive system by helping to propel food down the esophagus and through the stomach, intestines, and rectum. The respiratory system needs the thoracic muscles to contract to fill the lungs with air (see opposite).

This system uses bones, cartilage, ligaments, and tendons to provide the body with structural support and protection. It encases much of the nervous system within a skull and vertebrae, and the vital organs of the respiratory and circulatory systems within the ribcage. The skeletal system also supports our immune and the circulatory systems by manufacturing red and white blood cells.

Although the reproductive system is not essential for maintaining life, it is needed to propagate it. Both the testes of the male and the ovaries of the female produce gametes in the form of sperm and eggs, which fuse to create an embryo. The testes and ovaries also produce hormones including estrogen and testosterone, thus forming part of the endocrine system.

The urinary system filters and removes many of the waste products generated by cells of the body. It does this by filtering blood through the kidneys and producing urine, which is collected in the bladder and then excreted through the urethra. The kidneys also help regulate blood pressure within the cardiovascular system by ensuring that the correct amount of water is reabsorbed by the blood.
Anterior surface regions

The anterior surface of the body is divided into general anatomical areas by imaginary lines drawn on the body. The location of many of these lines is defined by reference to underlying features such as muscles or bony prominences; for example, the cubital fossa is defined by reference to epicondyles of the humerus, and the pronator teres and brachioradialis muscles. Many of the regions may be divided into smaller areas. For instance, the upper part of the anterior thigh contains the femoral triangle.

Posterior surface regions

As with the anterior surface, the posterior surface can also be divided into anatomical regions. The anterior surface of the abdomen is divided by planes and mapped into nine regions—allowing doctors to describe precisely where areas of tenderness or lumps are felt on abdominal examination. The back is not divided into as many regions. This illustration shows some of the terms used for the broader regions of back of the body.
TERMINOLOGY AND PLANES

Anatomical language allows us to describe the structure of the body accurately and unambiguously. The illustrations here show the main regions of the anterior (front) and posterior (back) surfaces of the body. Sometimes it is easier to understand anatomy by dividing the body into two dimensional slices. The orientation of these planes through the body also have specific anatomical names. There are also terms to describe the relative position of structures within the body.

Directions and relative positions
As well as defining parts of the body, anatomical terminology also allows us to precisely and concisely describe the relative positions of various structures. These terms always refer back to relative positions of structures when the body is in the "anatomical position" (shown above). Medial and lateral describe positions of structures toward the midline, or toward the side of the body, respectively. Superior and inferior refer to vertical position—toward the top or bottom of the body. Proximal and distal are useful terms, describing a relative position toward the center or periphery of the body.

Anatomical terms for planes and movement
The diagram above shows the three planes—sagittal, coronal, and transverse—cutting through a body. It also illustrates some medical terms that are used to describe certain movements of body parts: flexion decreases the angle of a joint, such as the elbow, while extension increases it; adduction draws a limb closer to the sagittal plane, while abduction moves it further away from that plane.
Body Systems

The human body is made up of eleven functional systems. No one system works in isolation: for example the endocrine and nervous systems work closely to keep the body regulated, while the respiratory and cardiovascular systems combine to deliver vital oxygen to cells. To build the clearest picture of how the body is put together it is, however, helpful to strip back our anatomy and consider it system by system. This chapter gives an overview of the basic structure of each system before looking at each region in detail.
SKIN, HAIR, AND NAIL

The skin is our largest organ, weighing about 9lb (4kg) and covering an area of about 21 square feet (2 square meters). It forms a tough, waterproof layer, which protects us from the elements. However, it offers much more than protection: the skin lets us appreciate the texture and temperature of our environment; it regulates body temperature; it allows excretion in sweat; communication through blushing; gripping thanks to ridges on our fingertips, and vitamin D production in sunlight. Thick head hairs and fine body hairs help to keep us warm and dry. All visible hair is in fact dead; hairs are only alive at their root. Constantly growing and self-repairing, nails protect fingers and toes but also enhance their sensitivity.
SKIN, HAIR, AND NAIL

Basal epidermal layer
New skin cells are made here

Arrector pili muscle
Tiny bundles of smooth muscle; these contract to raise the hairs in response to cold

Tactile sensor

Epidermis
Outermost layer of the skin, comprising constantly renewing layers of cells called keratinocytes

Dermis
Inner layer, composed of dense connective tissue, containing the nerves and blood vessels that supply the skin

Hypodermis
Layer of loose connective tissue under the skin, also known as superficial fascia

Touch sensor

SECTION THROUGH SKIN

In just one square centimeter (1/6 in²) of the skin, there are, on average, 21 1/2 in (55 cm) of nerve fibers, 27 1/2 in (70 cm) of blood vessels, 15 sebaceous glands, 100 sweat glands, and over 200 sensory receptors.
The human skeleton gives the body its shape, supports the weight of all our other tissues, provides attachment for muscles, and forms a system of linked levers that the muscles can move. It also protects delicate organs and tissues, such as the brain within the skull, the spinal cord within the arches of the vertebrae, and the heart and lungs within the ribcage. The skeletal system differs between the sexes. This is most obvious in the pelvis, which is usually wider in a woman than in a man. The skull also varies, with men having a larger brow and more prominent areas for muscle attachment on the back of the head. The entire skeleton tends to be larger and more robust in a man.

### Bone Structure

Most of the human skeleton develops first as cartilage, which is later replaced by bone throughout fetal development and childhood. Both bone and cartilage are connective tissues. Bone tissue consists of cells that are embedded in a mineralized matrix, making it extremely hard and strong. Bone is full of blood vessels and repairs easily.

**Long bone**

Long bones are found in the limbs, and include the femur (shown above), humerus, radius, ulna, tibia, fibula, metatarsals, metacarpals, and phalanges. A long bone has flared ends (epiphyses), which narrow to form a neck (metaphysis), tapering down into a cylindrical shaft (diaphysis). Cartilage growth plates near the ends of bones allow rapid growth in childhood, but disappear by adulthood.

### Compact bone

Also called cortical bone, compact bone is made up of osteons: concentric cylinders of bone tissue, each around 0.1–0.4mm in diameter, with a central vascular canal. Bone is full of blood vessels; those in the osteons connect to blood vessels within the medullary cavity of the bone as well as to vessels in the periosteum on the outside.
**OVERVIEW**

**POSTERIOR (BACK)**

- **Clavicle**: Traces a sinuous curve at the base of the neck; it acts as a strut supporting the shoulder.

- **Scapula**: Connects the arm to the trunk, and provides a secure but mobile anchor for the arm, allowing the shoulders to be retracted backward, protracted forward, and elevated.

- **Ulna**: Wide at its proximal end, where it articulates with the humerus at the elbow, this bone tapers down to a pointed styloid process near the wrist.

- **Radius**: Forearm bone; it can rotate around the ulna to alter the orientation of the hand.

- **Carpals**: Eight small bones in the base of the hand. Two articulate with the radius to form the wrist joint.

- **Metacarpals**: Five slender bones, hidden in the base of the thumb and the palm of the hand.

- **Phalanges**: Fourteen bones in each hand: two form the thumb, with three (proximal, middle, and distal) in each finger.

**SIDE**

- **Thoracic vertebrae**: U-shaped bone; provides attachments for muscles of the tongue, as well as the ligaments suspending the larynx in the neck.

- **Hyoid bone**: Named after the Latin for hip.

- **Cranium**: End of the spine made up of three to five tiny vertebrae; means cuckoo in Greek.
The skull comprises the cranial and mandible. It houses and protects the brain and the eyes, ears, nose, and mouth. It encloses the first parts of the airway and the alimentary canal, and provides attachment for the muscles of the head and neck. The cranial itself comprises more than 20 bones that meet each other at fibrous joints called sutures. In addition to the main bones labeled on these pages, there are sometimes extra bones along the sutures. In a young adult skull, the sutures are visible as tortuous lines between the cranial bones; they gradually fuse with age. The mandible of a newborn baby is in two halves, with a fibrous joint in the middle. The joint fuses during early infancy, so that the mandible becomes a single bone.
First rib
Several small muscles in the neck attach to the small, C-shaped first rib.

Maxilla
Latin word for jaw; the maxilla bears the upper teeth and also encloses the nasal cavity.

Ramus of mandible
Part of the mandible, named after the Latin for branch.

Clavicle
Bone that supports the shoulder and gives attachment to the trapezius and sternocleidomastoid muscles.

Mental protuberance
The chin's projecting lower edge—more pronounced in men than in women.

Mental foramen
Hole that transmits branches of the mandibular nerve; mental can refer to the chin (mentum in Latin).

Mandible
The jawbone, its name comes from the Latin verb meaning to chew.

Alveolar process of maxilla
Part of the maxilla that holds the upper teeth; alveolus (meaning small cavity) refers to a tooth socket.

Cervical vertebra
There are seven vertebrae in the neck region of the spine.
The cervical spine includes seven vertebrae, the top two of which have specific names. The first vertebra, which supports the skull, is called the atlas, after the Greek god who carried the sky on his shoulders. Nodding movements of the head occur at the joint between the atlas and the skull. The second cervical vertebra is the axis, from the Greek word for axe, so-called because when you shake your head from side to side, the atlas rotates on the axis. In this side view, we can also see more of the bones that make up the cranial, as well as the head on his shoulders. Nodding movements of the front bone.

- **Coronal suture**: The articulation between the frontal and parietal bones.
- **Squamosal suture**: The articulation between the parietal and squamous parts of the temporal bone.
- **Parietomastoid suture**: The articulation between the parietal and mastoid parts of the temporal bone.
- **Occipitomastoid suture**: The articulation between the occipital bone and the mastoid part of the temporal bone.
- **Lambdoid suture**: The articulation between the squamous part of the temporal bone and the parietal bone.
- **Zygomatic arch**: Formed by the zygomatic process of the temporal bone projecting forward to meet the zygomatic bone.
- **Condyle**: Condylar process projects upwards to end as the condyle, or head of the mandible, which articulates with the cranium at the temporo-mandibular joint.
- **Zygomatic bone**: From the Greek for yoke; it forms a link between the bones of the face and the side of the skull.
- **Pterion**: Area on side of skull where the frontal, parietal, temporal, and sphenoid bones come close together; it is a key surgical landmark as the middle meningeal artery runs up inside the skull at this point and may be damaged by a fracture to this area.
- **Coronal process of mandible**: This is where the temporalis muscle attaches to the jawbone.
- **Lacrimal bone**: Tears drain from the surface of the eye into the nasolacrimal duct, which lies in a groove in this bone.
- **Nasal bone**: From the Greek for yoke; it forms a link between the bones of the face and the side of the skull.

**Head and Neck**

**Skeletual System**

**Frontal bone**

- **Pterion**: Area on side of skull where the frontal, parietal, temporal, and sphenoid bones come close together; it is a key surgical landmark as the middle meningeal artery runs up inside the skull at this point and may be damaged by a fracture to this area.

**Temporal bone**

- **Fracture**: Skull bone that forms the side and top of the head and extends backward above the ear.

**Occipital bone**

- **Fracture**: Skull bone that forms the back of the skull.

**Squamous suture**: The articulation between the parietal and squamous parts of the temporal bone.

**Zygomatic bone**: From the Greek for yoke; it forms a link between the bones of the face and the side of the skull.

**Squamous suture**: The articulation between the parietal and squamous parts of the temporal bone.

**Zygomatic arch**: Formed by the zygomatic process of the temporal bone projecting forward to meet the zygomatic bone.

**Condyle**: Condylar process projects upwards to end as the condyle, or head of the mandible, which articulates with the cranium at the temporo-mandibular joint.

**Zygomatic bone**: From the Greek for yoke; it forms a link between the bones of the face and the side of the skull.
Alveolar process of mandible
The part of the jawbone bearing the lower teeth

Maxilla

Mental foramen

Hyoid bone
Takes its name from the Greek for U-shaped; it is a separate bone, lying just under the mandible, which provides an anchor for muscles forming the floor of the mouth and the tongue; the larynx hangs below it

Ramus of mandible

Angle of mandible
Where the body of the mandible turns a corner to become the ramus

Styloid process
Named after the Greek for pillar, this pointed projection sticks out under the skull and forms an anchor for several slender muscles and ligaments

Mastoid process
The name of this conical projection under the skull comes from the Greek for breast

Body of mandible

Ramus of mandible

Hyoid bone
Takes its name from the Greek for U-shaped; it is a separate bone, lying just under the mandible, which provides an anchor for muscles forming the floor of the mouth and the tongue; the larynx hangs below it
The most striking features of the skull viewed from these angles are the holes in it. In the middle, there is one large hole—the foramen magnum—through which the brain stem emerges to become the spinal cord. But there are also many smaller holes, most of them paired. Through these holes, the cranial nerves from the brain escape to supply the muscles, skin, and mucosa, and the glands of the head and neck. Blood vessels also pass through some holes, on their way to and from the brain. At the front, we can also see the upper teeth sitting in their sockets in the maxillae, and the bony, hard palate.
This section—right through the middle of the skull—lets us in on some secrets. We can clearly appreciate the size of the cranial cavity, which is almost completely filled by the brain, with just a small gap for membranes, fluid, and blood vessels. Some of those blood vessels leave deep grooves on the inner surface of the skull: we can trace the course of the large venous sinuses and the branches of the middle meningeal artery. We can also see that the skull bones are not solid, but contain trabecular bone (or diploe), which itself contains red marrow. Some skull bones also contain air spaces, like the sphenoidal sinus visible here. We can also appreciate the large size of the nasal cavity, hidden away inside the skull.

- **Frontal bone**: Forms the anterior cranial fossa, where the frontal lobes of the brain lie, inside the skull.
- **Frontal sinus**: One of the paranasal air sinuses that drain into the nasal cavity, this is an air space within the frontal bone.
- **Nasal bone**: Forms part of the nasal skeleton.
- **Pituitary fossa**: Fossa is the Latin word for ditch; the pituitary gland occupies this small cavity on the upper surface of the sphenoid bone.
- **Sphenoidal sinus**: Another paranasal air sinus; it lies within the body of the sphenoid bone.
- **Superior nasal concha**: Part of the ethmoid bone, which forms the roof and upper side walls of the nasal cavity.
- **Middle nasal concha**: Like the superior nasal concha, this is also part of the ethmoid bone.
- **Inferior nasal concha**: A separate bone, attached to the inner surface of the maxilla; the conchae increase the surface area of the nasal cavity.
- **Anterior nasal crest**: Presents a curvature of the bone.
- **Palatine bone**: Joins to the maxilla and forms the back of the hard palate.
- **Pterygoid process**: Sticking down from the greater wing of the sphenoid bone, this process flanks the back of the nasal cavity and provides attachment for muscles of the palate and jaw.
Parietal bone

Grooves for arteries
Meningeal arteries branch on the inside of the skull and leave grooves on the bones

Squamous part of the temporal bone

Squamosal suture

Lambdoid suture

Internal acoustic meatus
Hole in petrous part of the temporal bone that transmits both the facial and vestibulocochlear nerves

Occipital bone

External occipital protuberance
Projection from occipital bone that gives attachment to the nuchal ligament of the neck; much more pronounced in men than in women

Hypoglossal canal
Hole through occipital bone, in the cranial base, which transmits the hypoglossal nerve supplying the tongue muscles

Styloid process

INTERIOR OF SKULL
HEAD AND NECK

In this view of the skull, we can clearly see that it is not one single bone, and we can also see how the various cranial bones fit together to produce the shape we are more familiar with. The butterfly-shaped sphenoid bone is right in the middle of the action—it forms part of the skull base, the orbits, and the side walls of the skull, and it articulates with many of the other bones of the skull. The temporal bones also form part of the skull's base and side walls. The extremely dense petrous parts of the temporal bones contain and protect the delicate workings of the ear, including the tiny ossicles (malleus, incus, and stapes) that transmit vibrations from the eardrum to the inner ear.

FIBROUS JOINTS

In places, the connective tissue between developing bones solidifies to create fibrous joints. Linked by microscopic fibers of collagen, these fixed joints anchor the edges of adjacent bones, or bone and tooth, so that they are locked together. Such joints include the sutures of the skull, the teeth sockets (gomphoses), and the lower joint between the tibia and fibula.

Gomphosis

This name comes from the Greek word for bolted together. The fibrous tissue of the periodontal ligament connects the cement of the tooth to the bone of the socket.

SUTURE

These joints exist between flat bones of the skull. They are flexible in the skull of a newborn baby, and allow growth of the skull throughout childhood. The sutures in the adult skull are interlocking, practically immovable joints, and eventually fuse completely in later adulthood.
Alveolar process of maxilla
Projects down from the maxilla and forms the sockets for the upper teeth

Alveolar process of mandible
Projects up from the mandible and forms the sockets for the lower teeth

Vomer

Mastoid process

Lacrimal bone

Nasal bone

Zygomatic bone
This roughly triangular bone connects the frontal bone, maxilla, and temporal bone

Maxilla
Articulates with the opposite maxilla in the midline, with the nasal, frontal, and lacrimal bones above, and the sphenoid, ethmoid, and palatine bones

Nasal bones
Two bones, attaching to the frontal bone above and the maxillae to the side, form the bridge of the nose

Orbital surface of maxilla

Maxilla and nasal bones

Orbital plate of ethmoid bone

Temporal bone
Articulates with the parietal, sphenoid, and occipital bones and contains the ear apparatus, including the ossicles

Mastoid process

Zygomatic bone

Ramus of mandible

Mandible

Angle of mandible
The masseter muscle attaches down to this angle, which tends to be slightly flared outward in men

Nasal bone

Body of mandible
The mandible develops as two separate bones, which fuse in infancy

Orbital surface of maxilla

Maxilla

Occipital bone
Forms the lower part of the back of the skull

Zygomatic bone

Ossicles of the ear

Malleus

Stapes

Incus
First rib
Smaller and more curved than all the other ribs; the thoracic inlet is formed by the first rib on each side, together with the manubrium sterni and the body of the T1 vertebra

Second costal cartilage
The upper seven ribs are true ribs, and all attach directly to the sternum via costal cartilages

Third rib

Fourth rib

Fifth rib

Sixth rib

Seventh rib

Eighth to tenth ribs
The costal cartilages of these ribs each attach to the costal cartilage above

Eleventh and twelfth ribs
These are also called floating ribs because they do not attach to any others
The skeleton of the thorax plays several extremely important roles. It not only acts as an anchor for muscle attachment, but during breathing the ribs move up and out to increase the volume inside the thoracic cavity and draw air into the lungs. It also forms a protective cage around the precious organs inside: the heart and lungs. The bony thorax includes the 12 thoracic vertebrae, 12 pairs of ribs and costal cartilages, and the breastbone, or sternum. The upper seven ribs all articulate with the sternum via their costal cartilages. The eighth to the tenth costal cartilages each join to the cartilage above, creating the sweeping curve of the ribcage below the sternum on each side. The eleventh and twelfth ribs are short and do not join any other ribs—they are sometimes referred to as free or floating ribs.
The twelfth rib is even shorter than the eleventh, and tucked underneath muscles, so it cannot be felt. Unlike most ribs, the twelfth has no costal groove.
There are cartilaginous joints between the vertebrae at the back of the thorax, and between the parts of the sternum at the front. The joints between the ribs and the vertebrae at the back are synovial, allowing the ribs to move during breathing. When taking a breath, the anterior (front) ends of the upper ribs, along with the sternum, lift up and forward to increase the chest's front-to-back diameter, while the lower ribs move up and out, increasing the side-to-side diameter. Most ribs have a costal groove marking the lower border, on the inner surface, where nerves and vessels of the thoracic wall lie.
The spine, or vertebral column, occupies a central position in the skeleton, and plays several extremely important roles: it supports the trunk, encloses and protects the spinal cord, provides sites for muscle attachment, and contains blood-forming bone marrow. The entire vertebral column is about 28in (70cm) long in men, and 24in (60cm) long in women. About a quarter of this length is made up by the cartilaginous intervertebral discs between the vertebrae. The number of vertebrae varies from 32 to 35, mostly due to variation in the number of small vertebrae that make up the coccyx. Although there is a general pattern for a vertebra—most possess a body, a neural arch, and spinous and transverse processes—there are recognizable features that mark out the vertebrae of each section of the spine.
Thoracic vertebrae have heart-shaped bodies.

Lamina

Facet for apex of sacrum

Vertebral foramen

Superior articular facet

Spinous process

Long and sloping in the thoracic spine

Facet for coccyx

Vertebral bodies are larger at lower spinal levels—they have progressively more weight to bear; bodies of lumbar vertebrae are kidney-shaped, and large compared with the size of the vertebral foramen.

Zygapophyseal (facet) joint

Synovial joints between the adjacent articular processes allow variable degrees of movement in different sections of the spine; in disk degeneration, these joints end up bearing more weight and may be a source of back pain.

Inferior articular process

Spinous process

Large and square in the lumbar spine

Lumbar curvature

Appears about a year after birth, when an infant starts to walk

Anterior sacral foramen

Anterior branches of sacral spinal nerves pass through these holes; posterior branches emerge through the posterior foramina

Sacral curvature

Five vertebrae fuse during development to form the sacrum

Sacral cornu

Articulates with sacral cornu

Lumbar curvature

Appears about a year after birth, when an infant starts to walk

Vertebral foramen

Lateral part

Formed from fused lateral parts of the sacral segments; articulates with the pelvis at the sacroiliac joint

Body

Thoracic vertebrae have heart-shaped bodies

Superior articular facet

Spinous process

Long and sloping in the thoracic spine

Body

Vertebral bodies are larger at lower spinal levels—they have progressively more weight to bear; bodies of lumbar vertebrae are kidney-shaped, and large compared with the size of the vertebral foramen.

Transverse process

Forms a joint with the ribs on each side

Inferior articular process

Long and thin

THORACIC

LUMBAR

SACRUM

COCCYX
The bony boundaries of the abdomen include the five lumbar vertebrae at the back, the lower margin of the ribs above, and the pubic bones and iliac crest of the pelvic bones below. The abdominal cavity itself extends up under the ribcage, as high as the gap between the fifth and sixth ribs, due to the domed shape of the diaphragm. This means that some abdominal organs, such as the liver, stomach, and spleen, are, in fact, largely tucked up under the ribs. The pelvis is a basin shape, and is enclosed by the two pelvic (or innominate) bones, at the front and sides, and by the sacrum at the back. Each pelvic bone is made of three fused bones: the ilium at the rear, the ischium at the lower front, and the pubis above it.
**CARTILAGINOUS JOINTS**

Semi-movable cartilaginous joints are formed by bones separated by a disc of resilient and compressible fibrocartilage, which allows limited movement. Cartilaginous joints include the junctions between ribs and costal cartilages, joints between the components of the sternum, and the pubic symphysis. The intervertebral discs are also specialized cartilaginous joints.

**Pubic bone**
Forms the front of the bony pelvis

**Pubic symphysis**
At the front of the bony pelvis, the two pubic bones meet each other. The articular surface of each is covered with hyaline cartilage, with a pad of fibrocartilage joining them in the middle.

**Intervertebral disc**
Each fibrocartilage pad or disk between vertebrae is organized into an outer annulus fibrosus and an inner nucleus pulposus.

**Anterior superior iliac spine**
This is the anterior (front) end of the iliac crest

**Ala of sacrum**
The bony masses to the sides of the sacrum are called the alae, which means wings in Latin

**Anterior sacral foramina**
Anterior (frontal) branches of the sacral spinal nerves pass out through these holes

**Pubic symphysis**
A cartilaginous joint between the two pubic bones

**Pubic tubercle**
This small bony projection provides an attachment point for the inguinal ligament

**Obturator foramen**
This hole is largely closed over by a membrane, with muscles attaching on either side; its name comes from the Latin for stopped up

**PELVIS**

**Pubic bone**
Forms the front of the bony pelvis

**Pubic symphysis**
At the front of the bony pelvis, the two pubic bones meet each other. The articular surface of each is covered with hyaline cartilage, with a pad of fibrocartilage joining them in the middle.

**Zygapophyseal joint**
Small synovial joints between the neural arches at the back of the spine

**Atlas (first cervical vertebra)**

**Axis (second cervical vertebra)**

**Hyaline cartilage**
Inner, gel-like center of the disk

**Nucleus pulposus**
Outer, fibrous ring of the disk

**Annulus fibrosus**
Outer fibrous ring of the disk

**Anterior superior iliac spine**
This is the anterior (front) end of the iliac crest

**Ala of sacrum**
The bony masses to the sides of the sacrum are called the alae, which means wings in Latin

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**Pubic tubercle**
This small bony projection provides an attachment point for the inguinal ligament

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This hole is largely closed over by a membrane, with muscles attaching on either side; its name comes from the Latin for stopped up
The orientation of the facet joints (the joints between the vertebrae) of the lumbar spine means that rotation of the vertebrae is limited, but flexion and extension can occur freely. There is, however, rotation at the lumbosacral joint, which allows the pelvis to swing during walking. The sacroiliac joints are unusual in that they are synovial joints (which are usually very movable), yet they are particularly limited in their movement. This is because strong sacroiliac ligaments around the joints bind the ilium (part of the pelvic bone) tightly to the sacrum on each side. Lower down, the sacrospinous and sacrotuberous ligaments, stretching from the sacrum and coccyx to the ilium, provide additional support and stability.
Twelfth rib

Lumbar vertebrae
Five vertebrae make up the lumbar spine

Lumbosacral joint
Where the fifth lumbar vertebra meets the sacrum

Posterior sacral foramina
Posterior branches of the sacral spinal nerves pass through these holes

Superior pubic ramus
This extension of the pubic bone is named after the Latin for branch

Obturator foramen

Ischiopubic ramus

Ischial tuberosity

(POSTERIOR) BACK
The bony pelvis is the part of the skeleton that is most different between the sexes, because the pelvis in the female has to accommodate the birth canal, unlike the male pelvis. Comparing the pelvic bones of a man and a woman, there are obvious differences between the two. The shape of the ring formed by the sacrum and the two pelvic bones—the pelvic brim—tends to be a wide oval in the woman and much narrower and heart-shaped in a man. The subpubic angle, underneath the joint between the two pubic bones, is much narrower in a man than it is in with a woman. As with the rest of the skeleton, the pelvic bone also tends to be more chunky or robust in a man, with more obvious ridges where muscles attach.
**PELVIS**

**Sacral promontory**
The upper margin of the sacrum projects into the heart-shaped pelvic brim.

**Sacroiliac joint**
Male joints tend to be larger than those of the female, and this one is no exception.

**Iliac crest**
Gives attachment to the muscles of the abdominal wall and is more robust or chunky in the male.

**Superior pubic ramus**

**Pubic symphysis**

**Greater sciatic notch**

**Ischiopubic ramus**
Thicker in the male pelvis, with a turned-out edge where the crus of the penis attaches.

**Iliac crest**
Gives attachment to the muscles of the abdominal wall and is more robust or chunky in the male.

**Pelvic brim**
Heart-shaped in the male and narrower than in the female pelvis.

**MALE PELVIS ANTERIOR (FRONT)**

**MALE PELVIS VIEWED FROM ABOVE**
The scapula and clavicle make up the shoulder girdle, which anchors the arm to the thorax. This is a very mobile attachment—the scapula “floats” on the ribcage, attached to it by muscles only (rather than by a true joint) that pull the scapula around on the underlying ribs, altering the position of the shoulder joint. The clavicle has joints—it articulates with the acromion of the scapula laterally (at the side) and the sternum at the other end—and helps hold the shoulder out to the side while allowing the scapula to move around. The shoulder joint, the most mobile joint in the body, is a ball-and-socket joint, but the socket is small and shallow, allowing the ball-shaped head of the humerus to move freely.
Trochlea of humerus
Forms a joint with the ulna; its name comes from the Latin for pulley

Medial epicondyle
Flexor muscles of the forearm attach to this projection from the inner side of the humerus

Lateral epicondyle
Forms an anchor for the extensor muscles of the forearm

Radial fossa
The head of the radius swings around to occupy this shallow cavity when the elbow is flexed

Coronoid fossa
This depression accommodates the coronoid process of the ulna when the elbow is fully flexed

Capitulum of humerus
Ball-like part of the humerus that articulates with the head of the radius; its name comes from the Latin for little head

Shaft of humerus
Like other long bones, this is a cylinder of compact (or cortical) bone, containing a marrow cavity

Coronoid process

Radius

Ulna
SHOULDER
AND UPPER ARM

The back of the scapula is divided into two sections by its spine. The muscles that attach above this spine are called supraspinatus; those that attach below are called infraspinatus. They are part of the rotator cuff muscle group, which enables shoulder movements and stabilizes the shoulder joint. The spine of the scapula runs to the side and projects out above the shoulder joint to form the acromion, which can be easily felt on the top of the shoulder. The scapula rests in the position shown here when the arm is hanging at the side of the body. If the arm is abducted (raised to the side), the entire scapula rotates so that the glenoid cavity points upward and the inferior angle moves outward.
A deep cavity on the posterior surface of the humerus; it accommodates the olecranon of ulna when the elbow is fully extended—as shown here.
Acromioclavicular ligament
Strengthens the fibrous capsule of the acromioclavicular joint, between the lateral end of the clavicle and the acromion of the scapula.

Coracoacromial ligament
Tendon of supraspinatus muscle runs under this ligament, and may become compressed in impingement syndrome.

Glenohumeral ligaments
Reinforce the front of the fibrous capsule of the shoulder joint.

Coracoclavicular ligament
Transverse scapular ligament
Clavicle
Acromion
Coracoid process
Humerus
Scapula
Shoulder joint (anterior/front)
In any joint, there is always a play off between mobility and stability. The extremely mobile shoulder joint is therefore naturally unstable, and so it is not surprising that this is the most commonly dislocated joint in the body. The coracoacromial arch, formed by the acromion and coracoid process of the scapula with the strong coracoacromial ligament stretching between them, prevents upward dislocation; when the head of the humerus dislocates, it usually does so in a downward direction. The elbow joint is formed by the articulation of the humerus with the forearm bones: the trochlea articulates with the ulna, and the capitulum with the head of the radius. The elbow is a hinge joint, stabilized by collateral ligaments on each side.
Styloid process of radius
- Pointed projection taking its name from the Greek for pillar-shaped
- One of the carpal bones, along with the other bones between the radius and ulna

Scaphoid
- Convex bone named after the Greek for boat-shaped
- Articulates with the lunate and the triquetrum
- The most commonly fractured wrist bone

Trapezium
- Four-sided bone named after the Greek for table
- Articulates with the first metacarpal of the thumb

Trapezoid
- Also four-sided; this bone's name means table-shaped in Greek
- Articulates with the fourth and fifth metacarpals

Proximal phalanx
- Articulates with the first metacarpal

Distal phalanx
- Articulates with the second metacarpal

Lunate
- Crescent-shaped bone named after the Latin for moon
- Articulates with the triquetral and capitate

Hamate
- Articulates with the fourth and fifth metacarpals

Tuberosity of ulna
- Brachialis muscle attaches here

Coronoid process
- Forms anterior margin of the trochlear notch of the ulna, which accommodates the trochlea of the humerus

Tuberosity of ulna
- Sharp ridges on facing edges of the radius and ulna provide attachment for the forearm's interosseous membrane

Shaft of radius
- Like the ulna, this is triangular in cross section

Shaft of ulna
- Medial epicondyle

Capitulum of humerus
- Bowl-shaped surface articulates with the capitulum of the humerus

Head of radius
- Bowl-shaped surface articulates with the capitulum of the humerus

Trochlea of humerus
- This concave surface articulates with the head of the radius, forming the proximal radioulnar joint

Medial epicondyle

Interosseous border of radius
- Sharp ridges on facing edges of the radius and ulna provide attachment for the forearm's interosseous membrane

Lateral epicondyle

Head of ulna
- Articulates with the lower end of the radius, at the distal radioulnar joint

Capitulum of humerus
- Lateral epicondyle

Radial notch of ulna
- This concave surface articulates with the head of the radius, forming the proximal radioulnar joint

Radial tuberosity
- Biceps tendon attaches here

Shaft of ulna
- Head of radius
- Articulates with the capitulum of humerus

Radius
- Head of radius
- Bicep tendon attaches here

Scaphoid
- Convex bone named after the Greek for boat-shaped
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- Brachialis muscle attaches here

Coronoid process
- Forms anterior margin of the trochlear notch of the ulna, which accommodates the trochlea of the humerus

Tuberosity of ulna
- Sharp ridges on facing edges of the radius and ulna provide attachment for the forearm's interosseous membrane
The two forearm bones, the radius and ulna, are bound together by a flat sheet of ligament called the interosseous membrane, and by synovial joints between the ends of the two bones. Known as radioulnar joints, these joints allow the radius to move around the ulna. Hold your hand out in front of you, palm upward. Now turn your hand so that the palm faces the ground. This movement is called pronation, and is achieved by bringing the radius to cross over the ulna. The movement that returns the palm to an upward-facing position is called supination. Since the forearm bones are bound together by ligaments, joints, and muscles, it is common for both bones to be involved in a serious forearm injury. Often, one bone is fractured and the other dislocated. The skeleton of the hand comprises the eight carpal bones (bones between the radius and ulna), five metacarpals, and fourteen phalanges.
SKELETAL SYSTEM

HAND AND WRIST JOINTS

The radius widens out at its distal (lower) end to form the wrist joint with the closest two carpal bones, the lunate and scaphoid. This joint allows flexion, extension, adduction, and abduction (see pp. 16–17). There are also synovial joints (see p. 60) between the carpal bones in the wrist, which increase the range of motion during wrist flexion and extension. Synovial joints between metacarpals and phalanges allow us to spread or close our fingers, as well as flexing or extending the whole finger. Joints between the individual finger bones, or phalanges, enable fingers to bend and straighten. In common with many other primates, humans have opposable thumbs. The joints at the base of the thumb are shaped differently from those of the fingers. The joint between the metacarpal of the thumb and the wrist bones is especially mobile and allows the thumb to be brought across the palm of the hand so that the tip of the thumb can touch the other fingertips.
HAND AND WRIST JOINTS

PALMAR/ANTERIOR (FRONT)

**Ulna**

**Pisiform**

**Hook of hamate**

**Radial radiocarpal ligament**

**Styloid process of ulna**

**Ulnar radiocarpal ligament**

**Palmar radiocarpal ligament**

**Proximal phalanx**

**Deep transverse metacarpal ligament**

**Proximal interphalangeal joint**

**Deep transverse metacarpal ligament**

**First metacarpal**

**Carpometacarpal joint of the thumb**

**Capitate bone**

**Radiate carpal ligament**

**Hand X-ray**

This X-ray of the hand clearly shows the carpal bones in the wrist and the joints between them. Near the metacarpophalangeal joint of the thumb, the thumb’s tiny sesamoid bones, embedded in tendons, are also visible.
**Head of femur**
Ball-shaped head articulates with the acetabulum to form the hip socket.

**Neck of femur**
Intertrochanteric line
Runs between the greater and lesser trochanters; the fibrous capsule of the hip joint attaches to the front of the femur along this line.

**Acetabulum**
Receives the head of the femur to form the hip socket; its name comes from the Latin for vinegar cup.

**Lesser trochanter**
The psoas muscle, which flexes the hip, attaches to this bony projection; trochanter comes from the Greek word for running.

**Femur**
Greater trochanter
A projection onto which some gluteal muscles attach.

**Obturator foramen**
The obturator nerve and vessels pass through this hole to enter the inner compartment of the thigh.

**Ischiopubic ramus**
Ischial tuberosity
The obturator nerve and vessels pass through this hole to enter the inner compartment of the thigh.
HIP AND THIGH

The leg or, to be anatomically precise, the lower limb, is attached to the spine by the pelvic bones. This is a much more stable arrangement than that of the shoulder girdle, which anchors the arm, because the legs and pelvis must bear our body weight as we stand or move around. The sacroiliac joint provides a strong attachment between the ilium of the pelvis and the sacrum, and the hip joint is a much deeper and more stable ball-and-socket joint than that in the shoulder. The neck of the femur joins the head at an obtuse angle. A slightly raised diagonal line on the front of the neck (the intertrochanteric line) shows where the fibrous capsule of the hip joint attaches to the bone.
Acetabulum

The three bones that comprise the pelvic bones—the ilium, ischium, and pubis (which fuse toward the end of puberty to form a single bone)—all come together in the base of the acetabulum.
HIP AND THIGH

The shaft of the femur (thighbone) is cylindrical, with a marrow cavity. The linea aspera runs down along the back of the femoral shaft. This line is where the inner thigh's adductor muscles attach to the femur. Parts of the quadriceps muscle also wrap right around the back of the femur to attach to the linea aspera. At the bottom—or distal—end, toward the knee, the femur widens to form the knee joint with the tibia and the patella. From the back, the distal end of the femur has a distinct double-knuckle shape, with two condyles (rounded projections) that articulate with the tibia.
The hip joint is very stable. Its fibrous capsule is strengthened by ligaments that attach from the neck of the femur to the pelvic bone. These are the iliofemoral and pubofemoral ligaments at the front and the ischiofemoral ligament at the back. Inside the joint capsule, a small ligament attaches from the edge of the acetabulum (hip socket) to the head of the femur.

The knee joint is formed by the articulation of the femur with the tibia and patella. Although primarily a hinge joint, the knee also permits some rotation to occur. These complex movements are reflected by the complexity of the joint: there are crescent-shaped articular disks (menisci) inside the joint, powerful collateral ligaments on either side of the joint, as well as crossed-over cruciate ligaments binding the femur to the tibia, and numerous extra pockets of synovial fluid, called bursae, that lubricate tendons around the joint.
The majority of the body's 320 or so joints, including those in the finger, knee, and shoulder, are free-moving synovial joints. The joint surfaces are lined with smooth hyaline cartilage to reduce friction, and contain lubricating synovial fluid.

**Complex joint**
A complex synovial joint, such as the knee, has articular discs or menisci inside the synovial cavity. The knee is also a compound hinge joint, as it involves more than two bones. Its complex anatomy allows it to move in flexion and extension, but some sliding and axial rotation of the femur on the tibia also occurs.
The tibia is the main weight-bearing bone of the lower leg. The fibula, which attaches to the tibia below the knee joint, provides extra areas for the attachment of muscles in the shin and calf and also forms part of the ankle joint. The foot comprises the tarsal bones, metatarsals, and phalanges. The arrangement of these bones is very similar to that of the carpals, metacarpals, and phalanges. In fact, each limb can be seen to be constructed to a common plan, with a limb girdle providing attachment to the thorax or spine, a single long bone in the first segment, two long bones in the second, a collection of small bones (at the wrist or ankle), and a fan of long, slender bones forming fingers or toes.

**Tibia**
- **Shaft of tibia:** The shaft of the tibia is triangular in section.
- **Medial surface of tibia:** This smooth surface lies just below the skin in the shin.
- **Anterior border:** This sharp edge can be easily felt on the front of the shin.

**Fibula**
- **Shaft of fibula:** The shaft of the fibula contains a marrow cavity.
- **Shaft of tibia:** This also contains a marrow cavity.
- **Medial malleolus:** Malleolus means small hammer in Latin; the medial malleolus is part of the tibia, and articulates with the medial, or inner, surface of the talus.
- **Lateral malleolus:** The expanded lower end of the fibula, articulating with the lateral, or outer, side of the talus.

**Tarsal bones**
- **Medial cuneiform:** Cuneiform means wedge-shaped in Latin; this is the outermost of the three cuneiform bones in the foot.
- **Lateral cuneiform:** Cuneiform means wedge-shaped in Latin; this is the outermost of the three cuneiform bones in the foot.
- **Navicular:** With a name that means boat-shaped, this bone is shaped a bit like a small coracle.
- **Cuboid:** A roughly cube-shaped tarsal.

**Metatarsal bones**
- **First metatarsal:** The largest tarsal bone, projecting posteriorly to form a lever to which the Achilles tendon attaches.
- **Fifth metatarsal:** Five long metatarsal bones attach the tarsals to the phalanges, or toe bones.
- **Middle phalanx:** The second to fifth toes each have three phalanges: proximal, middle, and distal.
- **Distal phalanx:** Proximal phalanx comes from a Greek word for a line of infantry, and it refers to both the finger and toe bones; the big toe has just two phalanges: proximal and distal.

**Phalanges**
- **Proximal phalanx:** Proximal phalanx comes from a Greek word for a line of infantry, and it refers to both the finger and toe bones; the big toe has just two phalanges: proximal and distal.
- **Calcaneus:** Meaning heel bone in Latin, this is the largest tarsal bone, projecting posteriorly to form a lever to which the Achilles tendon attaches.
Foot and ankle

The ankle joint is a simple hinge joint. The lower ends of the tibia and fibula are firmly bound together by ligaments, forming a strong fibrous joint, and making a wrench shape that neatly sits around the nut of the talus. The joint is stabilized by strong collateral ligaments on either side. The talus forms synovial joints (see p.61) with the calcaneus beneath it, and the navicular bone in front of it. Level with the joint between the talus and the navicular is a joint between the calcaneus and the cuboid. These joints together allow the foot to be angled inward or outward—these movements are called inversion and eversion respectively. The skeleton of the foot is a sprung structure, with the bones forming arches, held together by ligaments and also supported by tendons.

X-ray on tiptoe

This X-ray shows the foot in action. The calf muscles are pulling up on the lever of the calcaneus to flex the ankle down (plantarflex), while the metatarsophalangeal joints are extended.
Top view of the foot bones
This is a dorsal-plantar X-ray of the foot, showing the bones as if you were looking down at your right foot. The two small bones near the head of the first metatarsal are sesamoid bones, embedded in the tendons of the short muscles operating the big toe.
MUSCULAR SYSTEM

OVERVIEW

There are three types of muscle in the body: skeletal, smooth, and cardiac. The main role of skeletal muscles is to generate movement. A muscle's movement, or “action” is produced when it contracts. The force it generates depends on the shape of the muscle. For instance, long, thin muscles contract a lot but exert low forces. Muscles attach to the skeleton by means of tendons, aponeuroses, and connective tissue called fascia. While muscles are well supplied with blood vessels and appear reddish, tendons have a sparse vascular supply and look white. The muscles in our body are located at varied depths. The deep layer sits closest to the bone, while the superficial one lies beneath the skin.

SKELETAL MUSCLE STRUCTURE

Skeletal muscle includes familiar muscles such as biceps or quadriceps. It is built up of parallel bundles of muscle fibers, which are conglomerations of many cells. These muscles are supplied by somatic motor nerves, which are part of the peripheral nervous system and are generally under conscious control.
OVERVIEW

Flexor compartment of the leg

These muscles combine to form the Achilles tendon, which can be ruptured if overstretched in a sporting injury.

Gluteus maximus

The word gluteus comes from the Greek for rump or buttock; maximus means the greatest in Latin.

Hamstring injuries are common in athletes: the long muscles in this compartment stretch across two joints—the hip and the knee—and are at risk of tearing if overstretched.

Flexor compartment of the thigh

These muscles bend or flex the knee; also known as the hamstrings.

Flexor compartment of the leg

The most superficial muscle here is gastrocnemius; the name comes from the Greek word for calf, translating literally as the belly of the calf.

Transversus abdominis

The innermost of three sheet-like anterolateral (front-side) abdominal muscles.

Flexor compartment of the arm

Includes muscles that extend the thumb or move it out to the side.

Temporalis

Deltoid

Short scapular muscles

Problems with these muscles can lead to osteoarthritis at the shoulder joint.

Serratus anterior

Anchors the scapula against the chest wall and also helps to move it.

Erector spinae

This muscle group, as its name suggests, helps to keep the spine erect.

Transversus abdominis

The innermost of three sheet-like anterolateral (front-side) abdominal muscles.

Flexor compartment of the forearm

Includes muscles that extend the wrist and fingers.

Occipital belly of occipitofrontalis

Stretches from the frontal bone to the occipital bone at the back of the skull.

Rhomboid muscles

Serratus anterior

Serratus posterior inferior

Erector compartment of the arm

Includes deep muscles that extend the thumb or move it out to the side.

Temporalis

Deltoid

Short scapular muscles

Problems with these muscles can lead to osteoarthritis at the shoulder joint.

Serratus anterior

Anchors the scapula against the chest wall and also helps to move it.

Erector spinae

Flexor compartment of the forearm

Some of these muscles originate from the medial epicondyle of the humerus.

Gluteus maximus

Flexor compartment of the thigh

Hamstring injuries are common in athletes: the long muscles in this compartment stretch across two joints—the hip and the knee—and are at risk of tearing if overstretched.

Flexor compartment of the arm

Contains one muscle, the triceps, which means three-headed; here we can see the two superficial parts of the muscle, the long and lateral heads.

Flexor compartment of the leg

These muscles combine to form the Achilles tendon, which can be ruptured if overstretched in a sporting injury.

Achilles tendon

The bony attachments of these muscles can become inflamed and painful in the condition “shin splints”.

Fibular (peroneal) muscles

Two muscles that evert the foot (move it outward), named after the fibula bone in the lower leg.

Flexor compartment of the leg

Deep muscles that move the foot downward at the ankle (plantarflexion), and that flex or curl the toes.

Flexor compartment of the thigh

Deep muscles that move the foot downward at the ankle (plantarflexion), and that flex or curl the toes.

Erector spinae

This muscle group, as its name suggests, helps to keep the spine erect.

Transversus abdominis

The innermost of three sheet-like anterolateral (front-side) abdominal muscles.

Extensor compartment of the forearm

Includes deep muscles that extend the thumb or move it out to the side.

Extensor compartment of the leg

The bony attachments of these muscles can become inflamed and painful in the condition “shin splints”.

Achilles tendon

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Deep muscles that move the foot downward at the ankle (plantarflexion), and that flex or curl the toes.
The muscles of the face have very important functions. They open and close the apertures in our faces—our eyes, noses, and mouths. But they also play an extremely important role in communication, and this is why these muscles are often known, collectively, as “the muscles of facial expression”. These muscles are attached to bone at one end and skin at the other. It is these muscles that allow us to raise our eyebrows in surprise, frown, or knit our brows in concentration, to scrunch up our noses in distaste, to smile gently or to grin widely, and to pout. As we age, and our skin forms creases and wrinkles, these reflect the expressions we have used throughout our lives. The wrinkles and creases lie perpendicular to the direction of the underlying muscle fibers.
Masseter
A muscle of mastication (chewing); it also raises the jaw and brings the teeth together

Risorius
Pulls on the corners of the mouth to produce an unpleasant grin

Anterior scalene
Attaches from cervical spine to first rib; flexes the neck forward or to the side

Inferior belly of omohyoid

Orbicularis oris
Muscle fibers encircle the mouth and bring lips together; when they contract more strongly, they form a pout

Sternohyoid
Pulls the hyoid bone down after it has been raised in swallowing

Levator scapulae
Attaches from cervical spine to top of scapula; it can raise the scapula or flex the neck to the side

Depressor anguli oris
Pulls down the corners of the mouth to form a sad expression

Trapezius
Attaches from the skull and spine to the scapula and clavicle; it can perform several actions, including flexing the neck to the side

Mentalis
Raises the lower lip, producing a thoughtful or doubtful expression

Depressor labii inferioris
Pulls the lower lip downward

Sternal head of sternocleidomastoid
Turns the head to the side

Clavicular head of sternocleidomastoid
Attaches from the skull and spine to the clavicle, and helps to perform several actions, including flexing the neck to the side
MUSCULAR SYSTEM

HEAD AND NECK

The muscles of mastication (chewing) attach from the skull to the mandible (jawbone), operating to open and shut the mouth, and to grind the teeth together to crush the food we eat. In this side view, we can see the two largest muscles of mastication, the temporalis and masseter muscles. Two smaller muscles attach to the inner surface of the mandible. Human jaws don’t just open and close, they also move from side to side, and these four muscles act in concert to produce complex chewing movements. In this view, we can also see how the frontal bellies (fleshy central parts) of the occipitofrontalis muscle are connected to occipital bellies at the back of the head by a thin, flat tendon, or aponeurosis. This makes the entire scalp movable on the skull.
Depressor anguli oris

Literally, the depressor of the corner of the mouth

Orbicularis oris

Latin for circular muscle of the mouth

Mentalis

This means of the chin in Latin

Risorius

From the Latin for laughter

Levator labii superioris

Literally, lifter of the upper lip

Zygomaticus major

Attaches from the zygomatic arch (cheek bone)

Depressor labii inferioris

The depressor of the lower lip

Sternothyroid

Attaches from the sternum to the thyroid cartilage

Thyrohyoid

Attaches from the hyoid bone to the thyroid cartilage of the larynx

Masseter

From the Greek for chewer

Sternohyoid

Attaches from the sternum to the hyoid bone

Superior belly of omohyoid

Attaches from the thyrohyoid bone to the hyoid bone

Posterior belly of omohyoid

Attaches from the sternum to the hyoid bone

Middle scalene

The scalene muscles are shaped like scalene triangles (where each side is a different length)

Posterior scalene

Splenius capitis

Named after the Latin for bandage of the head, this muscle draws the head backward

Levator scapulae

This is Latin for lifter of the shoulder blade

Middle scalene

Superior constrictor of pharynx

The superior constrictor is the first of three constrictor muscles of the pharynx

Omohyoid

Omo comes from the Greek for shoulder; this muscle is named after its attachments—from the hyoid bone to the shoulder blade

Anterior belly of digastric

Digastric means two-bellied

Posterior belly of digastric

The digastric pulls the mandible (lower jawbone) down to open the mouth, and pulls the hyoid bone up in swallowing

Inferior belly of omohyoid

Trapezius

Splenius capitis

Named after the Latin for bandage of the head,
MUSCULAR SYSTEM

Pharyngotympanic tube
Also known as the auditory or Eustachian tube, a slender muscle called salpingopharyngeus descends from its cartilage to contribute to the side wall of the pharynx.

Soft palate
A pair of muscles sweep down from the base of the skull on either side, into the soft palate; two others leave the palate and run down into the tongue and the pharynx.

Palatoglossal fold

Genioglossus
Attaches from the inside of the mandible and sweeps up into the tongue.

Hard palate

Geniohyoid
One of a pair of slender muscles lying side-by-side in the floor of the mouth that stretch from the mandible to the hyoid bone.

Mylohyoid
One of a pair of muscles forming a sheet that forms the floor of the mouth.

Thyroid cartilage
The largest cartilage of the larynx.

Hyoid bone

Thyroid gland

Trachea

Epiglottis
One of the cartilages of the larynx; it helps to protect the laryngeal inlet during swallowing.

Pharynx
A fibromuscular tube that extends from the base of the skull to the esophagus, and opens forward into the nasal cavity, oral cavity, and larynx.

The upper fold
Several small muscles within the larynx act on the vocal cords to move them closer together or further apart, or to tense them.

Cricoid cartilage
The lowest cartilage in the larynx.

Esophagus
A muscular tube that stretches from the pharynx to the stomach.
In the section through the head (opposite), we see the soft palate, tongue, pharynx, and larynx, all of which contain muscles. The soft palate comprises five pairs of muscles. When relaxed, it hangs down at the back of the mouth but, during swallowing, it thickens and is drawn upward to block off the airway. The tongue is a great mass of muscle, covered in mucosa. Some of its muscles arise from the hyoid bone and the mandible, and anchor it to these bones and move it around. Other muscle fibers are entirely within the tongue and change its shape. The pharyngeal muscles are important in swallowing, and the laryngeal muscles control the vocal cords. The muscles that move the eye can be seen on p. 122.
MUSCULAR SYSTEM

ANTERIOR (FRONT)

SUPERFICIAL

**Pectoralis major**
This great pectoral muscle attaches to the clavicle, the sternum, and the ribs; it inserts into the upper part of the humerus. It can pull the ribs up and out during deep breathing.

**Serratus anterior**
The digitations (fingerlike parts) of this muscle attach to the upper eight or nine ribs.

**Rectus abdominis**
This pair of straight muscles, crossed by fibrous bands, attaches to the lower margin of the sternum and ribcage.

**External oblique**
Outermost of the three muscle layers in the side of the abdomen. It attaches to the lower ribs and, along with other abdominal muscles, is drafted in during forced expiration, compressing the abdomen and, thus, pushing the diaphragm up, helping force air out of the lungs.

Clavicle
Sternocleidomastoid
The walls of the thorax are filled in, between the ribs, by the intercostal muscles. There are three layers of these muscles, and the muscle fibers of each layer lie in different directions. The main muscle for breathing is the diaphragm. Although the intercostal muscles are also active during respiration, their main job seems to be to prevent the spaces between the ribs from being "sucked in". Other muscles seen here may also be recruited to help with deep breathing. The sternocleidomastoid and scalene muscles in the neck can help by pulling the sternum and upper ribs upward. The pectoral muscles can also pull the ribs up and out, if the arm is held in a fixed position.
**MUSCULAR SYSTEM**

**POSTERIOR (BACK) DEEP**

- **Rhomboid minor**
  The four-sided rhomboid muscles act to pull the scapulae toward the midline

- **Spine of scapula**

- **Rhomboid major**

- **Infraspinatus**
  One of the rotator cuff, or short scapular muscles

- **Teres minor**

- **Teres major**

- **Vertebral (medial) border of scapula**

- **Inferior angle of scapula**

- **Spinalis**
  The innermost (most medial) part of the erector spinae; it attaches to the spinous processes of the vertebrae

- **Erector spinae muscle group**

- **Serratus posterior inferior**
  This muscle attaches from the lower thoracic and upper lumbar vertebrae to the lower four ribs; there is also a serratus posterior superior muscle, tucked under the rhomboids

- **Intercostal muscle**
The superficial muscles of the back include two large, triangular-shaped muscles—the massive latissimus dorsi and trapezius muscles. Although latissimus dorsi is called into action during forced expiration, squeezing the lower chest to expel air, it is really a climbing muscle: if you hang by your arms, it is largely the powerful latissimus that can allow you to pull your body weight up. Underneath those superficial muscles are the deeper extensor muscles of the spine, which can be felt as a distinct ridge on each side of the spine, especially in the lumbar (lower back) region. The most bulky of these muscles are collectively known as erector spinae, and play a vital role doing just that—keeping the spine erect, or extending a flexed spine.
Anterior longitudinal ligament
Runs down and binds together the bodies of the vertebrae

Internal intercostal membrane
The internal intercostal muscles give way to a membrane at the back of the thorax

Central tendon of diaphragm
Flat tendon pierced by the inferior vena cava

Muscular part of diaphragm
Supplied by the phrenic nerves

Right crus of diaphragm
The crura—literally, the "legs"—of the diaphragm attach to the bodies of the upper three lumbar vertebrae
The diaphragm, which divides the thorax and abdomen, is the main muscle of respiration. It attaches to the spine and to deep muscles in the back, around the margins of the rib cage, and to the sternum at the front. Its muscle fibers radiate out from a central, flat tendon to these attachments. The diaphragm contracts and flattens during inspiration, increasing the volume inside the chest cavity, and pulling air into the lungs; during expiration, it relaxes back into a domed shape. The intercostal muscles and diaphragm are “voluntary” muscle, and you can consciously control your breathing. But most of the time you don’t have to think about breathing, since they work to a rhythm set by the brain stem, producing about 12 to 20 breaths per minute in an adult.
Pectoralis major
- Attaches from the lower costal cartilages, down to the pubic bones

Serratus anterior

Rectus abdominis
- Attaches from the lower costal cartilages, down to the pubic bones

External oblique
- From the lower eight ribs, these muscle fibers pass inward and downward to attach to the iliac crest, and form a flat tendon or aponeurosis, which meets that of the opposite side at the linea alba

Linea alba
- The midline raphe, or seam, where the aponeuroses of the abdominal muscles on each side meet in the midline

Linea semilunaris
- This curved line marks the lateral (outer) edge of the rectus muscle and its sheath

Tendinous intersection
- The muscle bellies of rectus abdominis are divided up by these fibrous bands

Umbilicus

Iliac crest

Anterior superior iliac spine

Inguinal ligament
- The free, lower edge of the external oblique, attaching from the anterior superior iliac spine to the pubic tubercle

Pubic symphysis
- The midline joint between the two pubic bones
The abdominal muscles can move the trunk—flexing the spine to the front or to the side, or twisting the abdomen from side to side. They are very important muscles in posture, helping support the upright spine when we are standing or sitting, and are also called into action when we lift heavy objects. Because they compress the abdomen and raise the pressure internally, they are involved during defecation, micturition (emptying the bladder), and in forced expiration of air from the lungs. Right at the front, lying either side of the midline, there are two straight, straplike rectus abdominis muscles. These muscles are each broken up by horizontal tendons: in a well-toned, slim person, this creates the much-sought-after “six-pack” appearance. Flanking the recti muscles on each side are three layers of broad, flat muscles.
ABDOMEN AND PELVIS

The most superficial muscle of the lower back is the incredibly broad latissimus dorsi. Underneath this, lying along the spine on each side, there is a large bulk of muscle that forms two ridges in the lumbar region in a well-toned person. This muscle mass is collectively known as the erector spinae, and its name suggests its importance in keeping the spine upright. When the spine is flexed forward, the erector spinae can pull it back into an upright position, and even take it further, into extension. The muscle can be divided up into three main strips on each side: iliocostalis, longissimus, and spinalis. Most of the muscle bulk of the buttock comes down to just one muscle: the fleshy gluteus maximus, which extends the hip joint. Hidden beneath the gluteus maximus are a range of smaller muscles that also move the hip.
**Latissimus dorsi**
This massive muscle takes its attachment from a wide area: from the lower thoracic vertebrae, and from the lumbar vertebrae, sacrum, and iliac crest via the thoracolumbar fascia; its fibers converge on a narrow tendon, which attaches to the humerus.

**Gluteus maximus**
The largest and most superficial of the buttock muscles.
SHOULDER AND UPPER ARM

The triangular deltoid muscle lies over the shoulder. Acting as a whole, this muscle raises the arm to the side (abduction), but the fibers of the deltoid attaching to the front of the clavicle can also move the arm forward. The pectoralis major muscle can also act on the shoulder joint, flexing the arm forward or pulling it in to the side of the chest (adduction). The biceps brachii muscle forms much of the muscle bulk on the front of the arm. The biceps tendon inserts on the radius, and also has an aponeurosis (flat tendon) that fans out over the forearm muscles. The biceps is a powerful flexor of the elbow, and can also rotate the radius to position the lower arm so the palm faces upward (supination).
Biceps aponeurosis
This flat tendon blends into the fascia over the forearm

Brachialis
lying deeper than the biceps, only an edge of brachialis can be seen here

Biceps brachii
Supplied by the musculocutaneous nerve

Medial head of triceps
The triceps lies on the back of the humerus and can just be glimpsed here

Medial epicondyle of humerus

Biceps tendon
Attaches to the radial tuberosity

Brachioradialis
SHOULDER AND UPPER ARM

The posterior fibers of the deltoid attach from the spine of the scapula (shoulder blade) down to the humerus, and this part of the muscle can draw back the arm, or extend it. Latissimus dorsi (a broad muscle attaching from the back of the trunk and ending in a narrow tendon that secures onto the humerus) can also extend the arm. The triceps brachii muscle is the sole extensor of the elbow. In a superficial dissection (represented in this view) only two of the three heads of the triceps can be seen—the long and lateral heads. The triceps tendon attaches to the leverlike olecranon of the ulna, which forms the bony knobble at the back of the elbow.
POSTERIOR (BACK)

**Superficial**

- **Anconeus**
- **Triceps tendon**
- **Brachioradialis**
- **Long head of triceps**
  - Attaches to the scapula, just below the glenoid fossa
- **Lateral head of triceps**
  - This, and the long head of the triceps are superficial; the third, medial, head is hidden beneath them; all three are supplied by the radial nerve
- **Latissimus dorsi**
  - When the arm is extended upward, this large muscle can pull it down to the side of the body or, in the opposite direction, it can pull the weight of the body up, toward the arms (which is important for climbing)

**Medial epicondyle**

**Olecranon**

**Triceps tendon**

**Anconeus**

**Brachioradialis**

**Long head of triceps**
  - Attaches to the scapula, just below the glenoid fossa.
MUSCULAR SYSTEM

SHOULDER AND UPPER ARM

The deep muscles around the shoulder include the so-called rotator cuff group, two of which can be seen here: the subscapularis (which attaches from the deep surface of the scapula) and the supraspinatus (which runs from the scapula, over the shoulder joint, to attach to the humerus). The supraspinatus tendon passes through a narrow gap between the head of the humerus and the acromion of the scapula, and may become compressed and damaged here, in impingement syndrome. On the front of the humerus, the biceps (see p.85) has been removed to reveal brachialis, which runs from the lower humerus down to the ulna. Like the biceps, brachialis is a flexor of the elbow.
The name of this muscle simply means of the arm in Latin. It attaches from the front of the humerus to the tuberosity on the front of the ulna, and it flexes the elbow. It lies underneath the biceps.
More of the rotator cuff muscles—the supraspinatus, infraspinatus, and teres minor—can be seen from the back. In addition to moving the shoulder joint in various directions, including rotation, these muscles are important in helping to stabilize the shoulder joint: they hug the head of the humerus into its socket during movements at the shoulder. On the back of the arm, a deeper view reveals the third, medial head of the triceps, which attaches from the back of the humerus. It joins with the lateral and long heads to form the triceps tendon, attaching to the olecranon. Most of the forearm muscles take their attachment from the epicondyles of the humerus, just above the elbow, but the brachioradialis and extensor carpi radialis longus have higher origins from the side of the humerus, as shown here.
POSTERIOR (BACK)

Extensor carpi radialis longus
Takes its attachment from the lateral supracondylar ridge and lateral epicondyle of the humerus

Brachioradialis
Attaches from the lateral supracondylar ridge of the humerus

Triceps tendon

Intercostal muscle

Medial head of triceps

Brachialis

Flexor carpi ulnaris

Anconeus
Attaches from the lateral epicondyle of the humerus to the olecranon

Olecranon of ulna

Brachioradialis
Attaches from the lateral supracondylar ridge of the humerus

Extensor carpi radialis longus
Takes its attachment from the lateral supracondylar ridge and lateral epicondyle of the humerus
Medial epicondyle
Also called the common flexor origin; many of the superficial flexor muscles attach from this point.

Pronator teres
Attaches from the humerus and ulna down to the outer edge of the radius; it pronates the forearm, rotating the lower end of the radius around the ulna.

Flexor carpi radialis
Radial extensor of the wrist; it arises from the medial epicondyle of the humerus and inserts on the base of the second metacarpal, it flexes the wrist and abducts the hand.

Palmisanius longus tendon

Flexor carpi ulnaris superficialis
takes its attachment from the humerus, ulna, and radius; it runs across the wrist into the hand, to flex the fingers.

Brachialis
Brachioradialis
Runs along the outer edge of the forearm and attaches to the end of the radius; it flexes and stabilizes the elbow.

Intertendinous connections
Dorsal interosseous muscles

Extensor carpi radialis longus and brevis
takes its attachment from the humerus, ulna, and radius; it runs across the wrist into the hand, to flex the fingers.

Extensor pollicis longus
This fibrous tendon keeps the flexor tendons close to the wrist and helps prevent bowing outward.

Ulna

POSTERIOR (BACK) SUPERFICIAL

Tendons of interosseous muscles
Dorsal interosseous muscles
Intertendinous connections

POSTERIOR (BACK) SUPERFICIAL

Anterior (front) superficial
There are five superficial muscles on the front of the forearm, all taking their attachment from the medial epicondyle of the humerus. Pronator teres attaches across to the radius, and can pull this bone into pronation (held with the palm turned downward). The other muscles run farther down the forearm, becoming slender tendons that attach around the wrist, or continue into the hand. Flexor digitorum superficialis splits into four tendons, one for each finger. On the back of the forearm, seven superficial extensor muscles attach to the lateral epicondyle of the humerus. Most of these tendons run down to the wrist or into the hand.
Brachialis
Medial epicondyle of humerus
Also known as the common flexor origin

Flexor carpi ulnaris

Flexor pollicis longus
This long flexor of the thumb arises from the radius and interosseous membrane, its tendon runs into the thumb to attach to the base of the distal phalanx

Extensor carpi ulnaris

Dorsal interosseous muscles
These muscles spread the fingers

Extensor pollicis brevis
Extensor of the index finger, it joins the tendon of extensor digitorum (see pp.92–93) of the index finger

Extensor pollicis brevis
Short extensor of the thumb, it attaches to the proximal phalanx and pulls the thumb out to the side

Extensor retinaculum

Brachioradialis

Supinator
Stripping away the superficial muscles on the front of the forearm reveals a deeper layer attaching to the radius and ulna, and to the interosseous membrane between the bones. The long, quill-like flexor of the thumb (flexor pollicis longus) can be seen clearly. Deep muscles on the back of the forearm include the long extensors of the thumb and index finger and the supinator, which pulls on the radius to rotate the pronated arm (held with palm facing downward) into supination (with palm facing up). In the hand, a deep dissection reveals the interosseous muscles that act on the metacarpophalangeal joints in order to either spread or close the fingers.
The Gracilis muscle is long and thin, attaching from the pubis down to the inner (medial) surface of the tibia, and adducts the thigh.

Adductor longus attaches from the pubis to the middle third of the linea aspera, a ridge on the back of the femur.

Inguinal ligament is a thickening of the deep fascia over the outer (lateral) thigh, reaching from the iliac crest to the tibia.

Sartorius is named after the Latin for tailor; this muscle flexes, abducts, and laterally rotates the hip while flexing the knee—producing a cross-legged position, apparently the traditional posture of tailors.

Iliopsoas is a tensor of the deep fascia; it attaches from the iliac crest on top of the pelvis and inserts into the iliotibial tract. It helps to steady the thigh while standing upright.

Pectineus muscle attaches from the pubic bone to the femur, and flexes and adducts the hip.

Tensor fasciae latae is a tensor of the deep fascia; it attaches from the iliac crest on top of the pelvis and inserts into the iliotibial tract. It helps to steady the thigh while standing upright.

Iliotibial tract is a thickening of the deep fascia over the outer (lateral) thigh, reaching from the iliac crest to the tibia.
Most of the muscle bulk on the front of the leg is the four-headed quadriceps femoris. Three of its heads can be seen in a superficial dissection of the thigh: the rectus femoris, vastus lateralis, and vastus medialis. The quadriceps extends the knee, but it can also flex the hip, since the rectus femoris part has an attachment from the pelvis, above the hip joint. The patella is embedded in the quadriceps tendon; this may protect the tendon from wear and tear, but it also helps to give the quadriceps good leverage in extending the knee. The part of the tendon below the patella is usually called the patellar ligament. Tapping this with a tendon hammer produces a reflex contraction in the quadriceps—the “knee jerk”.

**HIP AND THIGH**

- **Rectus femoris**: The part of the quadriceps that can flex the hip as well as extend the knee.
- **Vastus lateralis**: Another large head of the quadriceps femoris.
- **Vastus medialis**: Another large head of the quadriceps femoris.
- **Prepatellar bursa**: The continuation of quadriceps tendon below the patella.
**Gluteus maximus**
Large muscle that arises from the back of the ilium and attaches to the iliotibial tract and the gluteal tuberosity of the femur; it extends the flexed thigh.

**Iliotibial tract**
This tough sheet of connective tissue stretches from the iliac crest to the upper tibia; when gluteus maximus pulls on this in the standing position, it braces the hip and knee.

**Vastus lateralis**

**Long head of biceps femoris**
This two-headed muscle is one of the hamstrings; the others are the semimembranosus and semitendinosus muscles.

**Semitendinosus**
This muscle has a long tendon, making up almost half of its length; one of the hamstrings.

**Adductor magnus**

**Gracilis**

**Semitendinosus**
This muscle has a long tendon, making up almost half of its length; one of the hamstrings.
On the back of the hip and thigh, a superficial dissection reveals the large gluteus maximus, an extensor of the hip joint, and the three hamstrings. The gluteus maximus acts to extend the hip joint, swinging the leg backward. While it doesn't really contribute to gentle walking, it is very important in running, and also when the hip is being extended from a flexed position, such as when getting up from sitting on the floor or when climbing the stairs. The hamstrings—the semimembranosus, semitendinosus, and biceps femoris muscles—attach from the ischial tuberosity of the pelvis and sweep down the back of the thigh to the tibia and fibula. They are the main flexors of the knee.
Adductor magnus
This muscle attaches, via a wide aponeurosis (band of fibrous tissue), to the entire length of the linea aspera, the ridge on the back of the femur.

Gracilis

Adductor brevis
Tucked in behind adductor longus and pectineus, this “short adductor” attaches from the pubis to the upper part of the linea aspera, the ridge on the back of the femur.
With the rectus femoris and sartorius muscles stripped away, we can see the deep, fourth head of the quadriceps, known as vastus intermedius. The adductor muscles that bring the thighs together can also be seen clearly, including the gracilis, which is long and slender, as its name suggests. The largest adductor muscle—the adductor magnus—has a hole in its tendon, through which the main artery of the leg (the femoral artery) passes. The adductor tendons attach from the pubis and ischium of the pelvis, and the sporting injuries referred to as “groin pulls” are often tears in these particular tendons.
Gluteus medius
- Lies underneath the gluteus maximus; it attaches from the ilium to the greater trochanter, together with gluteus minimus underneath it. This muscle abducts the hip and stabilizes it during walking.

Piriformis
- Laterally rotates the hip, turning the thigh outward.

Superior gemellus
- One of the two gemelli (twins) muscles lying either side of the obturator internus tendon, and working with that muscle.

Quadratus femoris
- Square muscle of the thigh; another lateral rotator of the hip joint.

Obturator internus
- Arising from the inner surface of the obturator membrane, inside the pelvis, this muscle emerges to attach to the neck of the femur; it rotates the hip joint to the side.

Ischial tuberosity

Greater trochanter of femur

Inferior gemellus

Adductor magnus

Vastus lateralis

Laterally rotates the hip, turning the thigh outward.
On the back of the hip, with the gluteus maximus removed, the short muscles that rotate the hip out to the side are clearly revealed. These include the piriformis, obturator internus, and quadratus femoris muscles. With the long head of the biceps femoris removed, we can now see the deeper, short head attaching to the linea aspera on the back of the femur. The semitendinosus muscle has also been cut away to reveal the semimembranosus underneath it, with its flat, membranelike tendon at the top. Popliteus muscle is also visible at the back of the knee joint, as is one of the many fluid filled bursae around the knee.
You can feel the medial surface of the tibia easily, just under the skin on the front of your lower leg, on the inner side. Move your fingers outward, and you feel the sharp border of the bone, and then a soft wedge of muscles alongside it. These muscles have tendons that run down to the foot. They can pull the foot upward at the ankle, in a movement called dorsiflexion. Some extensor tendons continue all the way to the toes. There are much bulkier muscles on the back of the leg, and these form the calf. The gastrocnemius, and soleus underneath it, are large muscles that join together to form the Achilles tendon. They pull up on the lever of the calcaneus, pushing the ball of the foot down. They are involved as the foot pushes off from the ground during walking and running.
MUSCULAR SYSTEM

- Prepatellar bursa
- Patellar ligament
- Fibular collateral ligament
- Head of fibula
- Vastus medialis
- Vastus lateralis
- Tibia
- Fibularis (peroneus) longus
- Extensor hallucis longus
- Extensor digitorum longus
Two muscles run along the outer, or lateral, side of the leg, down into the foot: the fibularis longus and fibularis brevis (see pp. 104–05). These muscles pull the outer side of the foot upward, in a movement called eversion. The tendon of fibularis longus runs right underneath the foot, to attach on the inner side, and helps to maintain the transverse arch of the foot. The flexor hallucis longus arises from the fibula and interosseous membrane, and sends its tendon down, behind the medial malleolus and into the sole of the foot, to attach to the distal phalanx of the big toe.
The nervous system contains billions of intercommunicating nerve cells, or neurons. It can be broadly divided into the central nervous system (brain and spinal cord) and the peripheral nervous system (cranial and spinal nerves and their branches). The brain and spinal cord are protected by the skull and vertebral column respectively. Twelve cranial nerves emerge from the brain and exit through holes in the skull to supply the head and neck; thirty-one pairs of spinal nerves leave via gaps between vertebrae to supply the rest of the body. You can also divide the nervous system by function. The part that deals more with the way we sense and interact with our surroundings is called the somatic nervous system. The part involved with sensing and controlling our internal environments—affecting glands or heart rate, for example—is the autonomic nervous system.
A single neuron such as the cell shown below from the central nervous system can make contact with hundreds of other neurons, creating an incredibly complex network of connections. Each neuron’s cell body has projections or, dendrites. One is usually longer and thinner than the rest, and this is the axon. Some axons within the brain are less than 1⁄32 in (1mm) in length; others, stretching from the spinal cord to limb muscles, can measure over 39in (1m) long.

**Axon**
- This carries nerve impulses away from the cell body

**Axon terminal**
- An end of the axon

**Myelin sheath**
- Layers of myelin insulate the axon; the sheath is made of fat-filled cells wrapped around the axon

**Node of Ranvier**
- Gap between sections of the myelin sheath

**Oligodendrocyte**
- Neuronal cell providing support and nourishment to the neuron

**Astrocyte**
- Neuronal cell providing support and nourishment to the neuron

**Nucleus**
- Cell body

**Cell body**
- Node of Ranvier

**Dendrite**
- A dendrite receives incoming nerve impulses

**Common fibular (peroneal) nerve**
- Lies on the outer side of the leg and is named after the bone around which it wraps; perona is an alternative Latin name for fibula

**Femoral nerve**
- Supplies sensation over the thigh and inner leg, and muscles in the front of the thigh, including the quadriceps

**Obturator nerve**
- Supplies the muscles and skin of the inner thigh

**Sciatic nerve**
- Largest nerve in the body, which supplies the hamstrings in the back of the thigh; its branches supply muscles and sensation in the lower leg and foot

**Tibial nerve**
- Named after the other bone of the lower leg—the tibia, or shinbone

**Cauda equina**
- Below the end of the spinal cord, the lumbar and sacral nerve roots continue for some way inside the vertebral canal, before emerging from the spine

**Lumbar plexus**
- Anterior branches of the lumbar spinal nerves form a network here, from which nerves emerge to supply the leg

**Sacral plexus**
- Anterior branches of sacral spinal nerves come together here as a network; the network provides nerves to the buttock and leg

**Radial nerve**
- Supplies most of the muscles in the front of the forearm, and also some in the hand

**Ulnar nerve**
- This nerve lies on the ulnar, or inner, side of the arm and forearm

**Femoral nerve**
- Supplies sensation over the thigh and inner leg, and muscles in the front of the thigh, including the quadriceps

**Obturator nerve**
- Supplies the muscles and skin of the inner thigh

**Sciatic nerve**
- Largest nerve in the body, which supplies the hamstrings in the back of the thigh; its branches supply muscles and sensation in the lower leg and foot
Compared to other animals, humans have massive brains for the size of our bodies. The human brain has grown larger and larger over the course of evolution, and it is now so overblown that the frontal lobes of the brain lie right over the top of the orbits that contain the eyes. Think about any other mammal, perhaps a dog or a cat for easy reference, and you will quickly realize what an odd shape the human head is—and most of that is a result of our huge brains. Looking at a side view of the brain, you can see all the lobes that make up each cerebral hemisphere: the frontal, parietal, temporal, and occipital lobes (individually colored, below). Tucked under the cerebral hemispheres at the back of the brain is the cerebellum (Latin for little brain). The brain stem leads down, through the foramen magnum of the skull, to the spinal cord.
Superior temporal gyrus
Includes the primary auditory cortex, where sensory information related to hearing is received.

Postcentral sulcus
Separates the postcentral gyrus from the rest of the parietal lobe.

Central sulcus
The division between the frontal and parietal lobes.

Postcentral gyrus
Lies just behind the central sulcus. The primary somatosensory cortex, which receives sensory information from all over the body.

Postcentral sulcus
Divides off the postcentral gyrus from the rest of the parietal lobe.

Lateral sulcus
A deep cleft dividing the frontal and parietal lobes from the temporal lobe below.

Superior temporal gyrus
Includes the primary auditory cortex, where sensory information related to hearing is received.

Superior temporal sulcus
Sulcus is a Latin word meaning groove or furrow.

Middle temporal gyrus

Inferior temporal gyrus

Preoccipital notch

Cerebellum
Sits under the occipital lobes at the back of the brain; responsible for coordinating movement and managing balance and posture.

Pons
Derived from Latin for bridge, this is the part of the brain stem between the midbrain and the medulla.

Medulla oblongata
The lowest part of the brain stem; it continues down to form the spinal cord. Contains important centers involved in controlling breathing, heart rate, and blood pressure.

Spinal cord

SIDE VIEW OF BRAIN
From an anatomist's point of view, the brain is quite an ugly and unprepossessing organ. It looks rather like a large, pinkish gray, wrinkled walnut—especially when viewed from above. The outer layer of gray matter, called the cortex, is highly folded. Underneath the brain we see some more detail, including some of the cranial nerves that emerge from the brain itself. To the naked eye, there is little to suggest that the brain is the most complicated organ in the human body. Its true complexity is only visible through a microscope, revealing billions of neurons that connect with each other to form the pathways that carry our senses, govern our actions, and create our minds.
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UNDERSIDE OF BRAIN

- Frontal pole
- Longitudinal (cerebral) fissure
- Straight gyrus
- Orbital gyri
- Lie around the edges of the H-shaped orbital sulcus, and seem to play some role in empathy
- Temporal pole
- Pituitary gland
- Parahippocampal gyrus
  - This part of the cortex, close to the hippocampus, plays an important role in memory and recognition
- Tuber cinereum
  - Small bump of gray matter under the brain; part of the hypothalamus (see p.116)
- Uncus
  - Hooked-under end of the parahippocampal gyrus; contains the primary olfactory cortex, receiving olfactory (smell) information
- Interpeduncular fossa
  - Area enclosed by the cerebral peduncles on each side, by the optic chiasma in front, and thepons of the brain stem behind
- Occipitotemporal fusiform gyrus
- Inferior temporal gyrus
- Spinal cord
- Occipital pole

- Olfactory bulb
  - Receives olfactory nerves, which have emerged from the top of the nasal cavity through the cribiform plate of the ethmoid bone, to enter the inside of the skull
- Olfactory tract
  - Carries olfactory (smell) information back to the uncus
- Orbital sulcus
- Optic chiasma
  - Where the two optic nerves meet and swap fibers with each other, to form the optic tracts; chiasma means a cross
- Lateral cerebral fossa
- Olfactory trigone
  - The olfactory tract splays out into this triangular shape, just in front of the anterior perforated substance
- Inferior temporal sulcus
- Anterior perforated substance
  - Area of gray matter between the olfactory trigone, the optic chiasma, and the uncus; pierced by small arteries from the anterior and middle cerebral arteries
- Mammillary bodies
  - Two breast-like bumps that are part of the limbic system, which is involved in memory, emotions, and behavior
- Cerebral peduncle
  - "Stalk" of the brain, containing motor nerve fibers that descend from the cerebral cortex to the brain stem and spinal cord
- Pons
- Cerebellum
- Pyramid
  - A prominence on the front of medulla containing motor nerve fibers that run from the cortex of the brain to the spinal cord
The largest part of the brain, the cerebrum, is almost completely divided into two cerebral hemispheres. This division is clearly seen when viewing the brain from the front, back, or top. The fissure between the hemispheres runs deep, but at the bottom of it lies the corpus callosum, which forms a bridge between the two sides. Areas of the brain that receive and process certain types of information, or govern movements, can be very widely separated. The visual pathways from the eyes end in the cortex of the occipital lobe at the back of the brain, and visual information is also processed in this lobe. But the nerve impulses that eventually reach the muscles to move the eyes begin in the cortex of the brain’s frontal lobe.
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BACK VIEW OF BRAIN

- Longitudinal (cerebral) fissure
- Parietal lobe
- Corpus callosum
- Occipital lobe
- Fissures
- The grooves in the cerebellum
- Folia
- The bulges in the cerebellum
- Cerebellar hemisphere
- Like the cerebrum, the cerebellum has two hemispheres
- Cerebellar vermis
- The median part of the cerebellum between the two hemispheres
- Medulla oblongata
- The lowest part of the brain stem
- Horizontal fissure of cerebellum
- The deepest fissure in the cerebellum
- Spinal cord

BACK VIEW OF BRAIN
The crossover point where the two optic nerves meet and swap fibers, then part company as the optic tracts, which continue on each side of the brain toward the thalamus.

Hypothalamus
- Plays an important role in regulating the internal environment of the body, by keeping a check on body temperature, blood pressure, and blood sugar level, for instance.

Pituitary gland
- Produces many hormones and forms a link between the brain and endocrine system.

Mammillary body
- Part of the limbic system of the brain.
This median sagittal section—a vertical slice right through the middle of the brain—shows clearly the corpus callosum, which links the two hemispheres. We also see that the brain is not solid: there are cavities within it. Two spaces (or ventricles) lie inside each hemisphere, while the third and fourth ventricles are located on the midline. These spaces are full of cerebrospinal fluid. Beneath and behind the cerebrum sits the cerebellum. The gray cortex of the cerebellum is more finely folded than that of the cerebrum, with fissures separating its leaves (or folia). Sliced through this way, the inside of the cerebellum reveals a beautiful, treelike pattern. In this section, we can also see clearly all the parts of the brain stem—the midbrain, pons, and medulla.
The brain is protected by three membranes called the meninges (which become inflamed in meningitis). The tough dura mater layer is the outermost covering, which surrounds the brain and the spinal cord. Under the dura mater is the cobweblike arachnoid mater layer. The delicate pia mater is a thin membrane on the surface of the brain. Between the pia mater and the arachnoid mater there is a slim gap—the subarachnoid space—which contains cerebrospinal fluid (CSF). Mainly produced by the choroid plexus in the brain's lateral ventricles, CSF flows through the third ventricle into the fourth, where it can escape via small apertures into the subarachnoid space.
**Body of Corpus Callosum**

**Anterior Horn of Lateral Ventricle**

**Part of the Lateral Ventricle Located in the Frontal Lobe**

**Inferior Horn of Lateral Ventricle**

**Front Part of the Lateral Ventricle, Which Projects Down into the Temporal Lobe**

**Third Ventricle**

**Part of the Lateral Ventricle That Extends into the Occipital Lobe**

**Median Aperture of the Fourth Ventricle**

**Midline Opening in the Roof of the Fourth Ventricle Where Cerebrospinal Fluid Can Drain**

**Fourth Ventricle**

**Cavity That Lies Between the Pons and the Cerebellum**

**Shells of the Meninges**

**Dura Mater**

**Covers the Skull**

**Hard Mother**

**Arachnoid Granulation**

**Pocket of the Subarachnoid Space, Where Cerebrospinal Fluid Flows Back into the Blood**

**Arachnoid Mater**

**Middle Layer of the Meninges**

**Pia Mater**

**A Thin Membrane That Is the Innermost of the Meninges, Lining the Brain Itself**

**Falx Cerebri**

**Connects the Two Lateral Ventricles**

**Interventricular Foramen**

**Caudate Nucleus**

**Thalamus**

**Septum Pellucidum**

**Hypothalamus**

**Cerebral Aqueduct**

**Connects the Third and Fourth Ventricles, Via the Midbrain**

**Coronal Section of Brain**

**Medial Aperture of the Fourth Ventricle**

**Midline Opening in the Roof of the Fourth Ventricle Where Cerebrospinal Fluid Can Drain**

**Septum Pellucidum**

**Connects the Two Lateral Ventricles**

**Body of Lateral Ventricle**

**Roofed by the Corpus Callosum**

**Fornix**

**Third Ventricle**

**Front Part of the Lateral Ventricle, Which Projects Down into the Temporal Lobe**

**Mammillary Body**

**Coronal Section of Brain**

**Ventricles of Brain**

**Cerebral Aqueduct**

**Connects the Third and Fourth Ventricles, Via the Midbrain**

**Posterior Horn of Lateral Ventricle**

**Part of the Lateral Ventricle That Extends into the Occipital Lobe**

**VENTRICLES OF BRAIN**

**MENINGES SECTION**
The 12 pairs of cranial nerves (the standard abbreviation for which is CN) emerge from the brain and brain stem, leaving through holes, or “foramina”, in the base of the skull. Some nerves are purely sensory, some just have motor functions, but most contain a mixture of motor and sensory fibers. A few also contain autonomic nerve fibers. The olfactory nerve and the optic nerve attach to the brain itself. The other 10 pairs of cranial nerves emerge from the brain stem. All the cranial nerves supply parts of the head and neck, except the vagus nerve. This has branches in the neck, but then continues on to supply organs in the thorax and down to the abdomen. Careful testing of cranial nerves, including tests of sight, eye and head movement, taste, and so on, can help doctors to pinpoint neurological problems in the head and neck.
Vagus nerve (CN X)
Mental nerve
Continuation of the inferior alveolar nerve, supplying sensation over the chin
Buccal branch of facial nerve
Supplies the muscles of the upper lip
Facial nerve (CN VII)
Colored bright yellow on this illustration
Zygomatic branch of facial nerve
Supplies orbicularis oculi muscle
Temporal branch of facial nerve
Supplies the frontal belly of occipitofrontalis and orbicularis oculi muscles
Optic nerve (CN II)
Carries sensory information from the retina of the eye
Infraorbital nerve
Branch of the maxillary division of the trigeminal nerve, supplying sensation over the cheek
Marginal mandibular branch of facial nerve
Supplies muscles of the lower lip and chin
Lingual nerve
Branch of the mandibular division of the trigeminal nerve, supplying sensation to the tongue
Glossopharyngeal nerve (CN IX)
Hypoglossal nerve (CN XII)
Vagus nerve (CN X)
Greater auricular nerve
A branch of the second cervical nerve, supplying sensation to the skin of the back of the head
Posterior auricular nerve
A branch of the facial nerve, supplying the occipital belly of occipitofrontalis muscle
Auriculotemporal nerve
Branch of the mandibular division of the trigeminal nerve, supplying sensation to part of the ear and temple
Trigeminal nerve (CN V)
Colored deep orange on this illustration; splits into ophthalmic, maxillary, and mandibular divisions
Infraorbital branch
Branch of the maxillary division of the trigeminal nerve, supplying sensation to the cheek
Inferior alveolar nerve
Branches of this nerve innervate the lower teeth, the gums, the lower lip, and the chin
Ophthalmic nerve
A branch of the trigeminal nerve, supplying sensation to the upper part of the face
Cervical branch of facial nerve
Supplies platysma muscle in the neck
Hypoglossal nerve (CN XII)
Facial nerve (CN VII)
Colored bright yellow on this illustration
Cervical branch of facial nerve
Supplies platysma muscle in the neck
Accessory nerve (CN XI)
The eyes are precious organs. They are well protected inside the eye sockets, or bony orbits, of the skull. They are also protected by the eyelids, and bathed in tears produced by the lacrimal glands. Each eyeball is only 1 in (2.5 cm) in diameter. The orbit provides an anchor for the muscles that move the eye, and the rest of the space inside the orbit is largely filled up with fat. Holes and fissures at the back of this bony cavern transmit nerves and blood vessels, including the optic nerve, which carries sensory information from the retina to the brain. Other nerves supply the eye muscles and the lacrimal glands, and even continue on to the face to supply sensation to the skin of the eyelids and forehead.
Lateral rectus muscle

Vitreous humor
Means glassy fluid in Latin. The main filling of the eyeball, it is liquid in the center but more gel-like at the edges

Sclera
From the Greek for hard; the tough, outer coat of the eyeball

Conjunctiva
Thin mucous membrane covering the front of the eyeball, as well as the inner surfaces of the eyelids, but not the cornea

Iris
From the Greek for rainbow; contains smooth muscle: circular fibers constrict the pupil, while radial muscle fibers dilate it

Cornea
Transparent outer layer of the front of the eye; continuous with the sclera

Pupil

Aqueous humor
Watery fluid occupies the anterior and posterior chambers of the eye, either side of the iris

Lens
Made up of long, transparent cells called lens fibers; tends to become less clear in old age

Suspensory ligament
Attaches the lens to the ciliary body

Ciliary body
Contains smooth muscle fibers that pull to alter the shape of the lens in order to focus

Medial rectus muscle

Lateral rectus muscle

Optic disk
Retinal nerve fibers create a donutlike bulge where they gather to form the optic nerve

Optic nerve
Carries visual information from the retina back to the brain

Blind spot
Where retinal nerve fibers leave the back of the retina the eye has no sensory cells; the brain fills in the missing information, so that we are not aware of the tiny blind spot in each eye

Retina
Inner, sensory lining of the eyeball, forms as an outgrowth of the brain itself during embryological development

Conjunctiva
Thin mucous membrane covering the front of the eyeball, as well as the inner surfaces of the eyelids, but not the cornea

Sclera
From the Greek for hard; the tough, outer coat of the eyeball

HORIZONTAL SECTION THROUGH THE EYEBALL
The ear can be divided up into external, middle, and internal parts. The external ear includes the auricle on the outside of the head, and the external acoustic meatus—the canal that leads to the eardrum, or tympanic membrane. The middle ear is an air space inside the temporal bone. It contains the ossicles (ear bones) and is linked to the pharynx by the pharyngotympanic, or Eustachian, tube. Minute hair cells inside the inner ear convert vibrations in the fluid within the cochlea into an electrical nerve impulse. Similar hair cells in the vestibular apparatus (the semicircular canals, utricle, and saccule) convert mechanical stimuli, produced by motions of the head, into nerve impulses. The sensory nerves leaving the inner ear join to form the vestibulocochlear nerve.
Lateral semicircular canal: This is positioned horizontally.

Anterior semicircular canal: Positioned vertically, but at right angles to the plane of the posterior semicircular canal.

Vestibular nerve: Carries sensory information from the vestibular apparatus—including the semicircular canals.

Antihelix: A curved prominence, parallel to the helix.

Concha: This hollow is named after the Greek for shell.

Cochlear nerve: Conveys sensory information about sound from the cochlea.

Cochlea: Not surprisingly, cochlea means snail in Latin.

Vestibule: Contains the utricle and saccule, organs of balance.

Round window: Vibrations can travel in the fluid inside the cochlea, all the way up to its apex and back down to the round window.

Pharyngotympanic tube: Passage connecting the middle ear to the back of the throat, and allowing air pressure either side of the eardrum to be equalized.

Vestibulocochlear nerve: The cochlear nerve conveys sensory information about sound from the cochlea. It joins the vestibular nerve to the vestibulocochlear nerve.

Cone of light: Light is reflected in the front, lower quadrant of the eardrum.

Eardrum (tympanic membrane): As seen with an otoscope, a healthy eardrum has a pearly, almost translucent appearance.

Lateral process of malleus

Handle of malleus

Cone of light

Round window

Vestibule

Antitragus: A small tubercle opposite the tragus.

Anterior semicircular canal: Positioned vertically, but at right angles to the plane of the posterior semicircular canal.

Pharyngotympanic tube: Passage connecting the middle ear to the back of the throat, and allowing air pressure either side of the eardrum to be equalized.
NERVOUS SYSTEM

**First cervical nerve (C1)**
The very first spinal nerve; its branches supply some muscles in the upper neck.

**Second cervical nerve (C2)**
Along with C3 and C4, this nerve supplies sensation to the skin of the neck as well as supplying a range of muscles in the neck.

**Third cervical nerve (C3)**

**Accessory nerve (CN XI)**
Originates outside the skull but enters it and then comes back out; part of it joins the vagus, the remaining fibers continue into the neck to supply trapezius and sternocleidomastoid muscles.

**Fourth cervical nerve (C4)**

**Fifth cervical nerve (C5)**
Together with C6, C7, C8 and T1, part of this nerve will form the brachial plexus—the network of nerves supplying the arm.

**Sixth cervical nerve (C6)**

**Seventh cervical nerve (C7)**

**Eighth cervical nerve (C8)**

**First thoracic nerve (T1)**

**Mandibular division of trigeminal nerve (CN V)**

**Facial nerve (CN VII)**
Difficult to read the full text; appears to be describing the facial nerve's branches.

**Glossopharyngeal nerve (CN IX)**
Supplies sensation to the back of the tongue and to the pharynx.

**Hypoglossal nerve (CN XII)**
Supplies the muscles of the tongue.

**Vagus nerve (CN X)**
Supplies muscles of the pharynx and larynx, and continues down to supply organs in the thorax and abdomen.
The last four cranial nerves all appear in the neck. The glossopharyngeal nerve supplies the parotid gland and the back of the tongue, then runs down to the pharynx. The vagus nerve is sandwiched between the common carotid artery and the internal jugular vein, and it gives branches to the pharynx and larynx before continuing down into the thorax. The accessory nerve supplies the sternocleidomastoid and trapezius muscles in the neck, while the last cranial nerve, the hypoglossal, dips down below the mandible, then curves back up to supply the muscles of the tongue. We can also see spinal nerves in the neck. The upper four cervical nerves supply neck muscles and skin, while the lower four contribute to the brachial plexus and are destined for the arm.
Pairs of spinal nerves emerge via the intervertebral foramina (openings) between the vertebrae. Each nerve splits into an anterior and a posterior branch. The posterior branch supplies the muscles and skin of the back. The anterior branches of the upper 11 thoracic spinal nerves run, one under each rib, as intercostal nerves, supplying the intercostal muscles and overlying skin. The anterior branch of the last thoracic spinal nerve runs under the twelfth rib as the subcostal nerve. In addition to motor and sensory fibers, thoracic spinal nerves contain sympathetic nerve fibers that are linked by tiny connecting branches to the sympathetic chain or trunk (see pp. 108–109). This allows sympathetic nerves originating from one level of the spinal cord to travel up and down, and spread out to several body segments.

**Vagus nerve**
The tenth cranial nerve strays a long way beyond the neck to supply structures in the thorax and abdomen as well, its name means wandering or straying.

**Phrenic nerve**
Comes from the third, fourth, and fifth cervical nerves; supplies the muscle of the diaphragm and the membranes lining either side of it—the pleura on the thoracic side and peritoneum on the abdominal side.

**First intercostal nerve**
Anterior branch of T1 (first thoracic) spinal nerve

**Eighth intercostal nerve**
Like each intercostal nerve, this supplies the muscles lying in the same intercostal space, and also supplies sensation to a strip of skin around the thorax.

**Subcostal nerve**
Anterior branch of T12 nerve, in series with the intercostal nerves; named subcostal as it lies under the last rib.
T1 spinal nerve
Emerges from the intervertebral foramen between T1 and T2 vertebrae

Fifth intercostal nerve
Anterior branch of T5 spinal nerve; lies in the gap between the fifth and sixth ribs

Eleventh intercostal nerve
Lying between the eleventh and twelfth ribs, this is the last intercostal nerve

SECTION THROUGH RIBS
ABDOMEN AND PELVIS

The lower intercostal nerves continue past the lower edges of the ribcage at the front to supply the muscles and skin of the abdominal wall. The lower parts of the abdomen are supplied by the subcostal and iliohypogastric nerves. The abdominal portion of the sympathetic trunk receives nerves from the thoracic and first two lumbar spinal nerves, and sends nerves back to all the spinal nerves. The lumbar spinal nerves emerge from the spine and run into the psoas major muscle at the back of the abdomen. Inside the muscle, the nerves join up and swap fibers to form a network, or plexus. Branches of this lumbar plexus emerge around and through the psoas muscle and make their way into the thigh. Lower down, branches of the sacral plexus supply pelvic organs and enter the buttock. One of these branches, the sciatic nerve, is the largest nerve in the entire body. It supplies the back of the thigh, as well as the rest of the leg and foot.
The walls of the abdomen and pelvis are supplied by nerves emerging from the spinal cord. Like the brain, the spinal cord contains gray matter (mostly neuron cell bodies) and white matter (axons), and is covered in the same three layers of meninges: dura mater, arachnoid, and pia mater (see p.119).
The upper limb (shoulder to hand) is supplied by five thick nerve roots that branch from the last four cervical and first thoracic spinal nerves. Emerging between the scalene muscles of the neck, they link up to form a complex skein (network) called the brachial plexus that dives under the clavicle to enter the axilla—the space between the upper arm and the chest. At this point, the plexus comprises three cords lying around the axillary artery. The network’s five major nerves—musculocutaneous, median, ulnar, axillary, and radial—provide sensation to the upper limb and supply its muscles. The musculocutaneous nerve supplies the muscles in the front of the arm: the biceps, brachialis, and coracobrachialis.
Ulnar nerve
Runs down the medial (inner) side of the upper arm then passes behind the medial epicondyle to help supply the forearm and hand muscles, as well as sensation to the hand.

Medial epicondyle of humerus

Median nerve
Pulls in nerve fibers from both the medial and lateral cords of the brachial plexus; lies close to the brachial artery as it runs down the upper arm, on its way to supply the forearm and hand.

Radial nerve
Largest branch of the brachial plexus; wraps all the way around the back of the humerus, then comes to lie in front of the lateral epicondyle; supplies muscles and sensation on the back of the arm.

Shaft of humerus

Lateral epicondyle of humerus

Ulnar nerve
Runs down the medial (inner) side of the upper arm then passes behind the medial epicondyle to help supply the forearm and hand muscles, as well as sensation to the hand.
The axillary and radial nerves emerge from the back of the brachial plexus and run behind the humerus. The axillary nerve wraps around the neck of the humerus, just underneath the shoulder joint, and supplies the deltoid muscle. The radial nerve—the largest branch of the brachial plexus—supplies all the extensor muscles in the upper arm and in the forearm. It spirals around the back of the humerus, lying right against the bone, and sends branches to supply the heads of the triceps. The radial nerve then continues in its spiral, running forward to lie just in front of the medial epicondyle of the humerus at the elbow.
Lateral epicondyle of humerus

Radial nerve
Wraps around the back of the humerus, supplying triceps muscle and skin over the back of the upper arm; it lies close to the bone, and is liable to be damaged if the shaft of the humerus is fractured.

Shaft of humerus

Median nerve

Radial nerve

Ulnar nerve
Passes behind the medial epicondyle of the humerus where it can cause a painful tingling if it is knocked—the so-called "funny bone" is actually a nerve.

Medial epicondyle of humerus

Lateral epicondyle of humerus
Ulnar nerve
- Passes into the hand, close to the pisiform bone, where it can get compressed—for example, when using vibrating machinery or when holding a motorbike handlebar.
- Supplies most of the small muscles in the hand.

Median nerve
- Supplies most of the flexor muscles in the front of the forearm.
- Passes through a triangular area on the inside of the elbow known as the cubital fossa.

Radial nerve
- Branches at the elbow.
- Supplies flexor carpi ulnaris and some of flexor digitorum profundus muscles in the forearm.

Superficial radial nerve
- Branch of the radial nerve that runs down to the wrist, just tucked underneath brachioradialis muscle on the outer (radial) side of the forearm.

Ulnar nerve
- Supplies flexor carpi ulnaris and some of flexor digitorum profundus muscles in the forearm.
- Supplies two small muscles in the hand, the small muscles in the ball of the thumb, and sensation to the thumb, index, middle, and half of the ring finger.

Median nerve
- Passes under the flexor retinaculum—through the carpal tunnel—into the wrist; it may become compressed here, producing carpal tunnel syndrome.
- Supplies two small muscles in the hand, the small muscles in the ball of the thumb, and sensation to the thumb, index, middle, and half of the ring finger.

Digital branches of the median nerve
- This nerve branches across the dorsum of the hand, supplying sensation to the back of the hand and fingers; it can become painfully compressed at the wrist—for example, by tight bracelets or handcuffs.

Branches of the superficial radial nerve
- Passes under the flexor retinaculum—through the carpal tunnel—into the wrist; it may become compressed here, producing carpal tunnel syndrome.
The front of the forearm is supplied by the musculocutaneous, median, and ulnar nerves. The musculocutaneous nerve supplies sensation to the lateral side of the forearm. The median nerve runs down the middle of the forearm, supplying most of the flexor muscles. It then travels over the wrist and into the hand to supply some of the thumb muscles, as well as sensation to the palm, thumb, and some fingers. The ulnar nerve courses down the inner side of the forearm, where it supplies just two muscles. It continues on to supply most of the small muscles in the hand and provide sensation to the inner side of the ring finger, and also the little finger. On the back of the forearm, the radial nerve and its branches supply all the extensor muscles. Branches of the radial nerve fan out over the back of the hand, where they provide sensation.
Shaft of femur

Sciatic nerve

Saphenous nerve

Branch of the femoral nerve that continues past the knee to supply sensation in the lower leg

Obturator nerve

Supplies the hip joint, the adductor and gracilis muscles, and the skin of the inner (medial) thigh

Femoral nerve

Largest branch of the lumbar plexus; runs under the inguinal ligament into the front of the thigh; supplies the quadriceps and sartorius muscles, as well as the skin of the front of the thigh

Femoral artery

Greater trochanter of femur

Femoral nerve

Femoral artery

Obturator foramen

Pudendal nerve

Neck of femur

Posterior cutaneous nerve of the thigh

Saphenous nerve

Branch of the femoral nerve that continues past the knee to supply sensation in the lower leg

Sciatic nerve

Shaft of femur
The lower limb (hip, thigh, leg, and foot) receives nerves from the lumbar and sacral plexuses. Three main nerves supply the thigh muscles: the femoral, obturator, and sciatic nerves (the last in the back). The femoral nerve runs over the pubic bone to supply the quadriceps and sartorius muscles in the front. The saphenous nerve, a slender branch of the femoral, continues past the knee and supplies skin on the inside of the lower leg and the inner side of the foot. The obturator nerve passes through the obturator foramen in the pelvic bone to supply the adductor muscles of the inner thigh and provide sensation to the skin there. Some smaller nerves just supply skin, such as the femoral cutaneous nerves.
Posterior cutaneous nerve of the thigh
Lies on the sciatic nerve; supplies skin of the back of the thigh and knee

Sciatic nerve
Largest nerve in the body; passes into the thigh midway between the greater trochanter and the ischial tuberosity; supplies the hip joint and hamstring muscles in the back of the thigh

Obturator nerve
Supplies skin and muscles in the inner thigh, as well as some sensation in the pelvis; problems with an ovary are sometimes first noticed as a painful sensation in the inner thigh

Pudendal nerve
Supplies the perineum

Neck of femur
Greater trochanter of femur
Femoral nerve
As well as supplying muscles on the front of the thigh, this nerve has branches supplying sensation to the hip and knee

Obturator foramen
Ischial tuberosity

Obturator nerve
Supplies skin and muscles in the inner thigh, as well as some sensation in the pelvis; problems with an ovary are sometimes first noticed as a painful sensation in the inner thigh

Medial femoral cutaneous nerve
Intermediate femoral cutaneous nerve
Saphenous nerve

Sciatic nerve
Largest nerve in the body; passes into the thigh midway between the greater trochanter and the ischial tuberosity; supplies the hip joint and hamstring muscles in the back of the thigh

Posterior cutaneous nerve of the thigh
Lies on the sciatic nerve; supplies skin of the back of the thigh and knee

Shaft of femur
Gluteal nerves from the sacral plexus emerge via the greater sciatic foramen, at the back of the pelvis, to supply the muscles and skin of the buttock. The sciatic nerve also emerges through the greater sciatic foramen into the buttock. The gluteus maximus is a good site for injections into a muscle, but these should always be given in the upper, outer part of the buttock to make sure the needle is well away from the sciatic nerve.

The sciatic nerve runs down the back of the thigh, supplying the hamstrings. In most people, the sciatic nerve runs halfway down the thigh then splits into two branches, the tibial and common peroneal nerves. These continue into the popliteal fossa (back of the knee) and on into the lower leg.
Tibial nerve

Passes under the soleus muscle and down the calf, supplying the deep and superficial muscles there.

Common peroneal (fibular) nerve

Lies just under the skin and next to bone here; can be damaged when a car hits a pedestrian, since the bumper may be level with the nerve at the head of the fibula.

Sural nerve

Cutaneous branch of the tibial nerve that supplies sensation to the outer side of the calf, foot, and little toe.

Saphenous nerve

This cutaneous nerve runs with the great saphenous vein down the inner (medial) side of the lower leg.

Deep peroneal (fibular) nerve

Lies on the front of the interosseous membrane between the tibia and fibula.
LOWER LEG AND FOOT

The common peroneal nerve runs past the knee and wraps around the neck of the fibula. Then it splits into the deep and superficial peroneal nerves. The deep peroneal nerve supplies the extensor muscles of the shin, then fans out to provide sensation to the skin at the back of the foot. The superficial peroneal nerve stays on the side of the leg and supplies the peroneal muscles. The tibial nerve runs through the popliteal fossa (back of the knee), under the soleus muscle, and between the deep and superficial calf muscles, which it supplies. It continues behind the medial malleolus and under the foot, then splits into two plantar nerves that supply the small muscles of the foot and the skin of the sole.
RESPIRATORY SYSTEM

Right lung
Possesses three lobes

Larynx
The larynx, or voicebox, is made of cartilages, held together with fibrous membranes and muscles; it forms part of the tract through which air passes on its way to and from the lungs, as well as being the organ of the voice

Nasal cavity
Air is warmed, cleaned, and moistened as it passes over the richly vascular lining of the nasal cavity before entering the pharynx

Naris (nostril)

Epiglottis

Pharynx
A passageway that connects the nasal cavities to the larynx, as well as the oral cavity to the esophagus

Esophagus

Intercostal muscle

Apex of left lung
Rib

Left lung
Has two lobes, and a concavity on its inner surface to accommodate the heart
Every cell in the human body needs to get oxygen, and to get rid of carbon dioxide. These gases are transported around the body in the blood, but the actual transfer of gases between the air and the blood occurs in the lungs. The lungs have extremely thin membranes that allow the gases to pass across easily. But air also needs to be regularly drawn in and out of the lungs, to expel the building carbon dioxide and to bring in fresh oxygen, and this is brought about by respiration—commonly called breathing. The respiratory system includes the airways on the way to the lungs: the nasal cavities, parts of the pharynx, the larynx, the trachea, and the bronchi (see p.149).
When we take a breath, air is pulled in through our nostrils, into the nasal cavities. Here the air is cleaned, warmed, and moistened before its onward journey. The nasal cavities are divided by the thin partition of the nasal septum, which is composed of plates of cartilage and bone. The lateral walls of the nasal cavity are more elaborate, with bony curls (conchae) that increase the surface area over which the air flows. The nasal cavity is lined with mucosa, which produces mucus. This often undervalued substance does an important job of trapping particles and moistening the air. The nasal sinuses, also lined with mucosa, open via tiny orifices into the nasal cavity. Below and in front of the pharynx is the larynx—the organ of speech. The way that air passes through this can be modulated to produce sound.

**LARYNX**

- **Epiglottis**: Elastic piece of cartilage named after the Greek for upon the tongue; it sits behind the tongue, and helps to protect the airway during swallowing.
- **Thyroid prominence**: Forms the “Adam’s apple” at the front of the neck, and is more prominent in men than in women; the vocal cords attach to its inner surface.
- **Thyroid cartilage**: The word thyroid means shield shaped in Greek.
- **Cricoid cartilage**: Shaped like a signet ring; the word cricoid comes from the Greek for ring shaped.
- **False vocal cord**: Vocal ligament or cord.
- **Vocal ligament or cord**: Artyenoid cartilage—“Funnel shaped” in Greek; there is a mobile joint between this small pyramidal cartilage and the cricoid cartilage; small muscles attach to the arytenoid, which works as a lever to open and close the vocal cords.

**HEAD AND NECK**
The trachea, commonly known as the windpipe, passes from the neck into the thorax, where it divides into two airways called bronchi—each supplying one lung. The trachea is supported and held open by 15–20 C-shaped pieces of cartilage, and there is smooth muscle in its wall that can alter the width of the trachea. Cartilage in the walls of the bronchi prevents them from collapsing when air enters the lungs under low pressure. Inside the lungs, the bronchi branch and branch again, forming smaller airways called bronchioles; the bronchioles are just muscular tubes, completely lacking in cartilage. The smallest bronchioles end in a cluster of alveoli, these are air sacs surrounded by capillaries, where oxygen passes from the air into the blood, and carbon dioxide passes in the opposite direction.
**Bronchus of left lung**
Bronchi are lined with epithelium, which produces mucus to trap particles, and carpeted with tiny hairlike projections called cilia that waft mucus up and out of the lungs.

**Superior lobe of left lung**

**Apex of left lung**
The apex, or topmost point, of each lung projects some 1/2 in (2 cm) above the clavicle.

**Cardiac notch of left lung**
Anterior edge of the left lung that curves inward slightly to accommodate the heart.

**Oblique fissure of left lung**
Divides the superior and inferior lobes of the left lung.

**Left clavicle**
(Cut away to show lung behind)

**Inferior lobe of left lung**

**Inferior margin of left lung**

**Lingula**
Slight projection of the front edge of the left lung; name originates from the Latin for little tongue.

**Anterior margin of left lung**

**Pulmonary arteriole**
Brings used deoxygenated blood to the alveoli.

**Pulmonary venule**
Takes away fresh, oxygenated blood.

**Bronchiole**

**Capillary network**

**Alveolar sac**

**ALVEOLAR CLUSTER**
Apex

Superior lobe

Costal surface

Oblique fissure

Inferior lobe

Cardiac notch

Left superior pulmonary vein
   Pulmonary means of the lungs in Latin

Left inferior pulmonary vein
   Even though pulmonary veins are colored blue, these veins carry oxygenated (not deoxygenated) blood back to the heart

Pulmonary ligament

Left main bronchus
   Just before it divides into the superior and the inferior lobar bronchi

Pleura
   The membrane lining the lungs; pleura comes from the Greek for rib or side of the body

Hilum

Cardiac impression

Pulmonary ligament

Costal surface of lung

Inferior lobe

Groove for left subclavian artery

LEFT LUNG (LATERAL VIEW)

LEFT LUNG (MEDIAL VIEW)

Inferior margin
   This sharp lower edge of the lung fits down into the cleft between the edge of the dome of the diaphragm and the chest wall; the bottom of the pleural cavity extends a couple more inches below the edge of the lung

Diaphragmatic surface of lung

Oblique fissure

Cardiac notch

Lingula

Anterior margin
Each lung fits snugly inside its half of the thoracic cavity. The surface of each lung is covered with a thin pleural membrane (visceral pleura), and the inside of the chest wall is also lined with pleura (parietal pleura). Between the two pleural layers lies a thin film of lubricating fluid that allows the lungs to slide against the chest wall during breathing movements, but it also creates a fluid seal, effectively sticking the lungs to the ribs and the diaphragm. Because of this seal, when you inhale, the lungs are pulled outward in all directions, and air rushes into them. The bronchi and blood vessels enter each lung at the hilum on its inner or medial surface. Although the two lungs may appear to be similar at first glance, there is some asymmetry. The left lung is concave to fit around the heart and has only two lobes, whereas the right lung has three lobes, marked out by two deep fissures.
The cardiovascular system consists of the heart, blood, and blood vessels. The heart—a muscular pump—contracts to push blood through the body’s network of vessels in order to deliver oxygen, nutrients, white blood cells, and hormones to the tissues of the body. The blood also removes waste products and takes them to other organs—mainly the liver and kidneys—for excretion. The circulatory system can be divided in two: pulmonary circulation carries blood pumped by the right side of the heart to the lungs, and systemic circulation carries blood pumped by the more powerful left side of the heart to the rest of the body. Pressure in the pulmonary circulation is relatively low, to prevent fluid being forced out of capillaries into the alveoli of the lungs. Pressure in the systemic circulation is much higher, to push blood up to the brain, into all other organs, and out into the fingers and toes.
The main vessels supplying oxygenated blood to the head and neck are the common carotid and vertebral arteries. The vertebral artery runs up through holes in the cervical vertebrae and eventually enters the skull through the foramen magnum. The common carotid artery runs up the neck and divides in two—the internal carotid artery supplies the brain, and the external carotid artery gives rise to a profusion of branches, some of which supply the thyroid gland, the mouth, tongue, and nasal cavity. Veins of the head and neck come together like river tributaries, draining into the large internal jugular vein, behind the sternocleidomastoid muscle, and into the subclavian vein, low in the neck.
Submental vein
Maxillary vein
Drains the pterygoid venous network
Angular vein
Infraorbital vein
Pterygoid venous network
A network of veins lying under the ramus of the mandible
Maxillary vein
Drains the pterygoid venous network
Superior labial vein
Drains from the upper lip into the facial vein
Inferior labial vein
Drains the lower lip
Mental vein
Submental vein
Facial vein
Superior thyroid vein
Superficial temporal vein
Drains a network of veins in the scalp and ends by joining the maxillary vein to form the retromandibular vein
Posterior auricular vein
Drains the scalp behind the ear, joins the retromandibular vein to form the external jugular vein
Occipital vein
Drains the back of the scalp and runs deep to join other veins
Retromandibular vein
Travels down behind the mandible, through the parotid gland alongside the external carotid artery
External jugular vein
Drains the face and scalp
Internal jugular vein
The largest vein in the neck, lies close to the common carotid artery

EXTERNAL VEINS OF THE HEAD
The brain has a rich blood supply, which arrives via the internal carotid and vertebral arteries. The vertebral arteries join together to form the basilar artery. The internal carotid arteries and basilar artery join up on the undersurface of the brain to form the Circle of Willis. From there, three pairs of cerebral arteries make their way into the brain. The veins of the brain and the skull drain into venous sinuses, which are enclosed within the dura mater (the outermost layer of the meninges) and form grooves on the inner surface of the skull. The sinuses join up and eventually drain out of the base of the skull, into the internal jugular vein.
VEINS AROUND THE BRAIN

Cavernous sinus
A network of veins lying on the base of the skull

Superior ophthalmic vein
Drains into the cavernous sinus

Inferior ophthalmic vein
Connects with the pterygoid venous plexus through the inferior orbital fissure

Pterygoid venous plexus

Internal jugular vein

DURAL VENOUS SINUSES

Sphenoparietal sinus

Cavernous sinus

Inferior petrosal sinus
Connects the cavernous sinus to the internal jugular vein

Superior petrosal sinus
Connects the cavernous to the transverse sinus

Marginal sinus

Confluence of sinuses

Superior sagittal sinus

Sigmoid sinus
Gets its name from the Greek for S-shaped

Confluence of the sinuses
Lies to one side of the internal occipital protuberance

Straight sinus
Drains the inferior sagittal sinus and the great cerebral vein

Inferior petrosal sinus
Connects the cavernous sinus to the internal jugular vein

Transverse sinus
Lies in the margin of the cerebellar tentorium, separating the cerebral hemispheres from the cerebellum

Great cerebral vein
Drains out of the brain into the straight sinus

Inferior sagittal sinus
Lies in the lower edge of the falx cerebri, a fold of dura mater that lies between the cerebral hemispheres

Superior sagittal sinus
Runs in the upper edge of the falx cerebri

Sigmoid sinus
Forms the continuation of the transverse sinus and passes through the jugular foramen to become the internal jugular vein

Superior petrosal sinus
Connects the cavernous to the transverse sinus

Transverse sinus
Lies in the margin of the cerebellar tentorium, separating the cerebral hemispheres from the cerebellum
The heart sits centrally in the chest, but skewed and twisted to the left, so that the frontal view of the heart is formed mainly by the right ventricle, and the apex of the heart reaches as far as a line dropped down from the midpoint of the left clavicle. The chest walls, including the skin on the chest, are supplied with blood vessels—intercostal arteries and veins—that run with the nerves in the gaps between the ribs. Intercostal arteries branch from the aorta at the back and from the two internal thoracic arteries at the front (which lie vertically along either edge of the sternum, behind the ribs). Intercostal veins drain into similar veins alongside the sternum at the front, and into the large azygos vein at the back, on the right side. If a physician needs to drain fluid from the pleural cavity (the space between the lungs and the chest wall), the needle is inserted along the top of a rib, to avoid the main intercostal nerve and vessels running below it.
Right ventricle
Left common carotid artery
On the left side of the body this branches directly from the arch of the aorta (compare with right)
Left internal jugular vein
Left subclavian artery
Left subclavian vein
Left brachiocephalic vein
Arch of aorta
The main artery of the body exits the heart and arches over it
Left pulmonary artery
Ascending aorta
Pulmonary trunk
Branches into the right and left pulmonary arteries, under the arch of the aorta
Left auricle
Right ventricle
Trachea
Ascending aorta
Passes down through the thorax, into the abdomen
Arch of aorta
Bifurcation of trachea
Azygos vein
Drains into the superior vena cava
Descending aorta
Posterior intercostal artery
Most of these arteries branch directly from the thoracic part of the descending aorta
Posterior intercostal vein
Paired veins drain into the azygos vein
Anterior (Front)
Back of thoracic cavity (heart removed)
The heart is encased in the pericardium. This has a tough outer layer that is fused to the diaphragm below and to the connective tissue around the large blood vessels above the heart. Lining the inside of this cylinder (and the outer surface of the heart) is a thin membrane called the serous pericardium. Between these two layers is a thin film of fluid that lubricates the movement of the heart as it beats. Inflammation of this membrane, known as pericarditis, can be extremely painful. Branches of the right and left coronary arteries, which spring from the ascending aorta, supply the heart muscle itself. The heart is drained by cardiac veins, most of which drain into the coronary sinus.
**Coronary sinus**
This large vein receives many of the cardiac veins and empties into the right atrium.

**Left auricle**

**Arch of aorta**

**Left pulmonary artery**

**Left pulmonary veins**

**Left atrium**

**Left pulmonary veins**

**Left subclavian artery**

**Left common carotid artery**

**Brachiocephalic trunk**

**Arch of aorta**

**Superior vena cava**

**Right pulmonary veins**

**Right atrium**

**Right coronary artery**
Wraps around to the back of the heart, lying in the groove between the right atrium and right ventricle.

**Posterior interventricular artery**
This large branch of the right coronary artery runs down between the two ventricles on the underside of the heart.

**Superior vena cava**

**Small cardiac vein**

**Inferior vena cava**

**Middle cardiac vein**
Drains into the coronary sinus.

**Coronary sinus**
Drains into the right atrium.

**Right pulmonary veins**

**Right atrium**

**Right ventricle**

**Brachiocephalic trunk**

**Anterior interventricular artery**
This branch of the left coronary artery wraps around the left side of the heart, lying in the groove between the left atrium and left ventricle.
HEART

The heart receives blood from veins and pumps it out through arteries. It has four chambers: two atria and two ventricles. The heart's left and right sides are separate. The right side receives deoxygenated blood from the body via the superior and inferior venae cavae, and pumps it to the lungs through the pulmonary trunk. The left gets oxygenated blood from the lungs via the pulmonary veins, and pumps it into the aorta for distribution. Each atrium opens into its corresponding ventricle via a valve (on the right, the tricuspid valve, and the bicuspid valve on the left), which shuts when the ventricle contracts, to stop blood flowing back into the atrium. The aorta and pulmonary trunk also have valves.
Cardiac muscle (myocardium) is essential to the heart’s function as a pump. When the myocardium contracts, blood is squeezed out of the heart. The myocardium is a network of interconnected fibers, which contract rhythmically and spontaneously. Autonomic nerves can adjust the rate of contraction, matching the heart’s output to the body’s need.

Cardiac muscle cells are packed with energy-producing mitochondria. The myofibrils of cardiac muscle are organized in a similar way to those in skeletal muscle, giving a striated appearance under a light microscope. These elaborate junctions firmly bind cardiac muscle cells together.
The aorta passes behind the diaphragm, level with the twelfth thoracic vertebra, and enters the abdomen. Pairs of arteries branch from the sides of the aorta to supply the walls of the abdomen, the kidneys, suprarenal glands, and the testes or ovaries with oxygenated blood. A series of branches emerge from the front of the abdominal aorta to supply the abdominal organs: the celiac trunk gives branches to the liver, stomach, pancreas, and spleen, and the mesenteric arteries provide blood to the gut. The abdominal aorta ends by splitting into two, forming the common iliac arteries. Each of these then divides, in turn, forming an internal iliac artery (which supplies the pelvic organs) and an external iliac artery (which continues into the thigh, becoming the femoral artery). Lying to the right of the aorta is the major vein of the abdomen: the inferior vena cava.
**Splenic vein**
Drains the spleen and receives other veins from the stomach and pancreas, as well as the inferior mesenteric vein

**Inferior mesenteric vein**
Drains blood from the colon and rectum and ends by emptying into the splenic vein

**Superior mesenteric artery**
Branches within the mesentery to supply a great length of intestine, including all of the jejunum and ileum and half of the colon

**Abdominal aorta**
The thoracic aorta becomes the abdominal aorta as it passes behind the diaphragm, level with the twelfth thoracic vertebra

**Left common iliac artery**
Path as a continuation of the femoral artery

**Left external iliac vein**
The continuation of the femoral vein, after it has passed into the pelvis

**Left internal iliac vein**
Drains the pelvic organs, perineum, and buttock

**Left gonadal artery**
Gonadal arteries branch from the aorta just below the renal arteries

**Left gonadal vein**
Drains the ovary or testis, and empties into the left renal vein

**Left renal artery**
Shorter than the right renal artery, this supplies the left kidney

**Left renal vein**
Longer than its counterpart on the right, this drains the left kidney and receives the left gonadal vein

**Superior rectal artery**
The last branch of the inferior mesenteric artery passes down into the pelvis to supply the rectum

**Left femoral artery**
The main vein from the leg; becomes the external iliac vein

**Left femoral vein**
The subclavian artery is the main arterial supply to the upper limb. When this artery passes under the clavicle and into the axilla (armpit), it becomes the axillary artery. Several branches spring off in this region, running backward toward the scapula, up to the shoulder, and around the humerus. Beyond the armpit, the name of the axillary artery changes to the brachial artery, which runs down the front of the arm, usually accompanied by a pair of companion veins. Two superficial veins that drain blood from the back of the hand end in the arm by draining into deep veins: the basilic vein drains into brachial veins; the cephalic vein runs up to the shoulder, then plunges deeper to join the axillary vein.
Ulnar recurrent artery

Ulnar artery

Inferior ulnar collateral artery

Superior ulnar collateral artery

ANTERIOR (FRONT)

Median cubital vein

Radial artery

Radial recurrent artery

Radial collateral artery

Brachial veins

A pair of deep veins often accompany the brachial artery

Deep brachial artery

Supplies the humerus and triceps muscle; often called by its Latin name, profunda brachii

Brachial artery

Supplies the coracobrachialis, biceps, and brachialis muscles in the front of the upper arm. The pulse of the brachial artery can be felt all the way down the upper arm, on the inner side; it is the artery used to measure blood pressure

Deep brachial artery

Supplies the humerus and triceps muscle; often called by its Latin name, profunda brachii

Basilic vein

Superficial vein that pierces the deep fascia (connective tissue) about halfway up the upper arm, and then plunges deep to join up with the brachial vein that runs with the brachial artery

Brachial veins

A pair of deep veins often accompany the brachial artery

Radial artery

Median cubital vein

Ulnar artery

Ulnar recurrent artery
Various branches from the axillary and brachial arteries supply the back of the shoulder and upper arm. The posterior circumflex humeral artery, which runs with the axillary nerve, curls around the upper end of the humerus. The deep brachial artery runs with the radial nerve, spiraling around the back of the bone. From this artery, and from the brachial artery itself, collateral branches run down the arm and join up, or anastomose, with recurrent branches running back up from the ulnar and radial arteries of the forearm. There are also anastomoses (links) between branches of the subclavian and axillary arteries around the shoulder. Anastomoses like this, where branches from different regions join up, can provide alternative routes through which blood can flow if the main vessel becomes squashed or blocked.
Deep brachial artery

Basilic vein

Brachial veins

POSTERIOR (BACK)

Superior ulnar collateral artery

Runs with the ulnar nerve, and joins up with the inferior ulnar collateral and ulnar recurrent arteries

Inferior ulnar collateral artery

Another branch of the brachial artery; joins up with the recurrent ulnar arteries, which run back up the arm from the ulnar artery

Ulnar recurrent artery

Branch of the ulnar artery, running back up past the elbow, into the upper arm

Ulnar artery

Radial collateral artery

Continuation of the deep brachial artery, running down the side of the arm, with the radial nerve, to join up with the radial recurrent artery

Radial recurrent artery

Branch of the radial artery, running back up past the elbow, into the upper arm

Radial artery

Median cubital vein
Dorsal digital vein
Drains blood from the sides of the fingers

Dorsal venous network
A plexus of veins visible under the skin that drains blood into the cephalic, accessory cephalic, and basilic veins

Cephalic vein
Drains blood from the radial side of the back of the hand and forearm

Accessory cephalic vein

Cephalic vein
Drains blood from the radial side of the back of the hand and forearm

Radial vein
Runs with the radial artery; drains the superficial palmar venous arch

Radial artery
Supplies the radial side of the forearm, and feeds into the deep palmar arch of the hand

Ulnar vein
Runs with the ulnar artery; drains the deep palmar venous arch

Ulnar artery
Supplies the ulnar side of the forearm; feeds into the superficial palmar arch

Median vein of the forearm
Drains the superficial venous plexus of the palm

Median cubital vein
Connects the cephalic and basilic veins; is a preferred site for taking blood

Brachial artery

Interosseous artery

Basilic vein
Drains blood from the ulnar side of the back of the hand and forearm

Basilic vein
The name of this vein means royal and comes from its historical importance in blood-letting

Radius

Ulna

Cephalic vein
The name of this vein comes from the Greek for head, because of the historical belief that blood-letting from it could cure headaches
The brachial artery divides into two arteries, which take their names from the bones of the forearm: the radial and ulnar arteries. The radial artery can be felt at the wrist, and this is the most common place for taking a pulse as the strong pulsations are easy to feel when the artery is pressed against the bone beneath it. Furthermore, taking a pulse here doesn’t even require any undressing. The radial and ulnar arteries end by joining up to form arterial arches in the wrist and palm. Digital arteries, destined for the fingers, spring off from the palmar arch. Superficial veins are concentrated on the back of the hand, rather than on the palm—otherwise those thin-walled vessels would be compressed every time a person gripped something. The dorsal venous network of the hand drains into two main vessels: the basilic and cephalic veins.
Deep femoral artery
Branches of this artery link up with branches of the external iliac and popliteal arteries

Descending branch of the lateral circumflex femoral artery
Links up with the lateral superior genicular artery, a branch of the popliteal artery

Femoral artery
This is the continuation of the external iliac artery

Medial circumflex femoral artery

Lateral circumflex femoral artery
Winds around the neck of the femur, linking up with the medial circumflex femoral artery

Femoral artery
The pulsation of this large artery may be easily felt in the groin, halfway between the anterior superior iliac spine of the pelvis and the pubic symphysis

Femur

Deep femoral artery
Branches of this artery link up with branches of the external iliac and popliteal arteries
As the external iliac artery runs over the pubic bone and underneath the inguinal ligament, it changes its name to the femoral artery—the main vessel carrying blood to the lower limb. The femoral artery lies exactly halfway along a line between the anterior superior iliac spine of the pelvis and the pubic symphysis. It has a large branch, the deep femoral artery, that supplies the muscles of the thigh. The femoral artery then runs toward the inner thigh, passing through the hole in the adductor magnus tendon, where its name changes to the popliteal artery. Deep veins run with the arteries, but—just as in the arm—there are also superficial veins. The great (or long) saphenous vein drains up the inner side of the leg and thigh, and ends by joining the femoral vein near the hip.
Accessory saphenous vein

Femoral vein

Femoral artery

Femur

Deep femoral artery

Descending branch of the lateral circumflex femoral artery

Lateral circumflex femoral artery

Branch of internal iliac artery

Perforating artery

Medial circumflex femoral artery

Femoral artery

Femoral artery

Branch of internal iliac artery

Femoral artery
In this back view, gluteal branches of the internal iliac artery can be clearly seen, emerging through the greater sciatic foramen to supply the buttock. The muscles and skin of the inner part and back of the thigh are supplied by branches of the deep femoral artery. These are known as the perforating arteries because they pierce through the adductor magnus muscle. Higher up, the circumflex femoral arteries encircle the femur. The popliteal artery, formed after the femoral artery passes through the hiatus (gap) in adductor magnus, lies on the back of the femur, deep to the popliteal vein.
Posterior tibial artery
Medial inferior genicular artery
Genicular arteries branch from the popliteal artery and form an anastomosis (network) around the knee

Medial inferior genicular artery
Popliteal artery
Anterior tibial artery
Passes forward above the interosseous membrane to supply the muscles of the shin

Anterior tibial vein
Peroneal artery
Also called the fibular artery
Posterior tibial veins
Deep veins of the leg run with the arteries, often as a pair of vena comitantes (companion veins)

Great (long) saphenous vein
This, and the small saphenous vein, may become dilated, tortuous, and easily visible (varicose veins)
The popliteal artery runs deep across the back of the knee, dividing into two branches: the anterior and posterior tibial arteries. The former runs forward, piercing the interosseous membrane between the tibia and fibula, to supply the extensor muscles of the shin. It runs down past the ankle, onto the top of the foot, as the dorsalis pedis artery. The latter gives off a peroneal branch, supplying the muscles and skin on the leg’s outer side. The posterior tibial artery itself continues in the calf, running with the tibial nerve and, like the nerve, divides into plantar branches to supply the sole of the foot. A network of superficial veins on the back of the foot is drained by the saphenous veins.
Prelaryngeal nodes
Preauricular nodes
Parotid nodes
Prelaryngeal nodes
Deep cervical nodes
Jugular veins
Right subclavian vein
Lymph from right arm, and right side of head and chest enters bloodstream here
Superior vena cava
Axillary nodes
Drain upper trunk and arm
Parasternal nodes
Supratrochlear nodes
Lymph from the hand and forearm drains to nodes at the elbow
Cisterna chyli
Lateral aortic nodes
External iliac nodes
Inguinal nodes
Popliteal nodes
A group of around six nodes sit within the popliteal fossa, at the back of the knee joint
Superficial cervical nodes
Pretracheal nodes
Left subclavian vein
Lymph from the thoracic duct enters bloodstream here
Spleen
Contains lymphocytes and filters blood; the largest organ in the lymphatic system
Pre- and para-aortic nodes
Internal iliac nodes
Lymphatics
Valved vessels transport lymph fluid around the body in a way similar to veins transporting blood
ANTERIOR (FRONT)
The lymphatic system consists of a network of lymphatic vessels that collect tissue fluid from the spaces between cells. Before this fluid is carried back to veins, it is delivered to lymph nodes to check for potential invaders. These nodes, like the tonsils, spleen, and thymus, are “lymphoid tissues”, meaning that they contain immune cells known as lymphocytes. The nodes are therefore part of the immune system, the body’s defense mechanism. There are also patches of lymphoid tissue in the walls of the bronchi and the gut. The spleen, which lies tucked under the ribs on the left side of the abdomen, has two important roles: it is a lymphoid organ, and it also removes old red blood cells from circulation.

Skin is also part of the immune system as it forms a physical and chemical barrier against infections. The formation of some important immune molecules, including antibodies, and a range of immune cells, including lymphocytes, happens in the bone marrow. Some lymphocytes mature in the bone marrow, whereas others move to the thymus to develop. Mature lymphocytes stay in the lymph nodes, where they perform their function.
A ring of lymph nodes lies close to the skin where the head meets the neck, from the occipital nodes (against the skull at the back) to the submandibular and submental nodes (which are tucked under the jaw). Superficial nodes lie along the sides and front of the neck, and deep nodes are clustered around the internal jugular vein, under cover of sternocleidomastoid muscle. Lymph from all other nodes passes to these deep ones, then into the jugular lymphatic trunk before draining back into veins in the base of the neck. Lymphoid tissue, in the form of the palatine, pharyngeal, and lingual tonsils, forms a protective ring around the upper parts of the respiratory and digestive tracts.
Pharyngeal tonsil
This lymphoid tissue is prominent in children and is referred to as the adenoid.

Opening of pharyngotympanic (Eustachian) tube

Pharynx
Runs from the area behind the nasal cavity to behind the larynx and consists of three areas, from top to bottom: nasopharynx, oropharynx, and laryngopharynx.

Lymphoid tissue

LOCATION OF TONSILS

Nasal cavity

Palatine tonsil
Lies under the mucous membrane or mucosa of the oropharynx; the two are often just called the tonsils.

Tongue

Lingual tonsil
Lymphoid tissue under the mucosa of the back of the tongue

Epiglottis

Larynx

Soft palate

Pharyngeal tonsil
This lymphoid tissue is prominent in children and is referred to as the adenoid.
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LYMPHATIC AND IMMUNE SYSTEM

Supraclavicular nodes

Parasternal nodes
Also called internal thoracic nodes; these lie in the gaps between the ribs, either side of the sternum on the inside of the ribcage; they drain some of the lymph from the front of the thorax – including from the breast in a woman

Axillary nodes
Receive lymph from superficial tissues of the thorax, upper limb, and breast

Intercostal nodes
Sitting in the intercostal spaces between the ribs at the back of the ribcage, these drain lymph from the deeper tissues at the sides and back of the thorax

Right lymphatic duct
Lymph from the right arm and the right side of the neck and thorax drains into the junction of the right internal jugular and subclavian veins

Parasternal nodes

Axillary nodes

Intercostal nodes

Supraclavicular nodes

Parasternal nodes

Axillary nodes

Thoracic duct

Paramammary node

ANTERIOR (FRONT) / FEMALE

ANTERIOR (FRONT) / MALE
**THORAX**

Most of the tissue fluid, or lymph, from the superficial tissues of the chest drains to axillary nodes, high in the armpits. The complex drainage of the female breast passes to these and to the parasternal, supraclavicular, and abdominal nodes. Lymph from deeper tissues drains to nodes in the thorax, some nestled between the ribs or on the diaphragm, others tucked behind the heart or grouped around the bronchi and trachea. Tissue fluid from the thorax’s left side ultimately drains into the thoracic duct, a large lymphatic vessel at the back of the thorax. Fluid from the right side drains into the right lymphatic duct. Both ducts empty into veins at the base of the neck. The thymus, a vital immune-system organ that lies behind the sternum, is largest during childhood. T lymphocytes mature in the thymus before leaving to populate lymph nodes.
The deep lymph nodes of the abdomen are clustered around arteries. Nodes lying along each side of the aorta receive lymph from paired structures, such as the muscles of the abdominal wall, the kidneys and adrenal glands, and the testes or ovaries. Iliac nodes collect lymph returning from the legs and pelvis. Nodes clustered around the branches on the front of the aorta collect lymph from the gut and abdominal organs. Eventually, all this lymph from the legs, pelvis, and abdomen passes into a swollen lymphatic vessel called the cisterna chyli; this narrows down to become the thoracic duct, which runs up into the chest. Most lymph nodes are small, bean-sized structures, but the abdomen also contains a large and important organ of the immune system—the spleen.
Spleen
Contains red pulp, into which old, tired red blood cells are removed from circulation, and also white pulp, which is full of lymphocytes, making it much like a massive lymph node.

Celiac nodes
Drain lymph from the organs supplied by the celiac artery, including the liver, pancreas, and stomach.

Cisterna chyli
Formed by the confluence of the main lymph trunks—the lumbar and intestinal trunks—in the abdomen. This leads into the thoracic duct. In Greek, the name means juice reservoir.

Mesenteric nodes
Nestled around the origins of the superior and inferior mesenteric arteries from the aorta, these drain most of the lymph from the intestines.

Common iliac nodes
Receive lymph from the external and internal iliac nodes and drain up to the lateral aortic nodes.

Internal iliac nodes
Drain lymph from the organs of the pelvis.

Thoracic duct
ANTERIOR (FRONT)
Ultimately, all the lymph from the hand, forearm, and arm drains to the axillary nodes in the armpit. But there are a few nodes, lower in the arm, that lymph may pass through on its way to the axilla. The supratrochlear nodes lie in the subcutaneous fat on the inner arm, above the elbow. They collect lymph that has drained from the medial side of the hand and forearm. The infraclavicular nodes, lying along the cephalic vein, below the clavicle, receive lymphatics draining from the thumb and the lateral side of the forearm and arm. Axillary nodes drain lymph from the arm and receive it from the chest wall. They may become infiltrated with cancerous cells spreading from a tumor in the breast.
Supratrochlear nodes
Drain superficial tissues on the inner (medial) side of the hand and forearm.

Anterior axillary nodes
Drain lymph from the trunk above the umbilicus, including the front of the chest and breast.
Distal superficial inguinal nodes
The lower nodes in the groin drain most of the superficial lymphatics of the thigh and leg.

Deep inguinal nodes
Drain deep tissues of the thigh and leg.

Proximal superficial inguinal nodes

Distal superficial inguinal nodes
The lower nodes in the groin drain most of the superficial lymphatics of the thigh and leg.

Presymphyseal node

Great saphenous vein
Most lymph from the thigh, leg, and foot passes through the inguinal group of lymph nodes, which are in the groin. But lymph from the deep tissues of the buttock passes straight to nodes inside the pelvis (see pp.184–85), along the internal and common iliac arteries. Eventually, all the lymph from the leg reaches the lateral aortic nodes, on the back wall of the abdomen. As in the arm, there are groups of nodes clustered around points at which superficial veins drain into deep veins. Popliteal nodes are close to the drainage of the small saphenous vein into the popliteal vein, while the superficial inguinal nodes lie close to the great saphenous vein, just before it empties into the femoral vein.
The digestive system comprises the organs that enable us to take in food, break it down physically and chemically, extract its useful nutrients, and excrete what we don’t need. This process begins in the mouth, where the teeth, tongue, and saliva work together to form food into a moist ball that can be swallowed. The mouth, pharynx, stomach, intestines, rectum, and anal canal form a long tube that is referred to as the digestive tract. It usually takes between one and two days for ingested food to travel all the way from the mouth to the anus. Other organs—including the salivary glands, liver, gallbladder, and pancreas—complete the digestive system.
OVERVIEW

Rectum
This is a holding station for the waste products of digestion, which are known as feces.

Small intestine
Comprising the duodenum, jejunum, and ileum, the small intestine is where food is digested and nutrients are absorbed.

Large intestine
This comprises the cecum and the colon. The large intestine is where water is absorbed from digested food.

Stomach
An expandable bag, the stomach holds food and releases it bit by bit into the small intestine. It also secretes hydrochloric acid, which kills dangerous ingested bacteria.

Liver
The largest organ in the human body, the liver produces bile and receives all the nutrients absorbed from the gut.

Gallbladder
This baglike organ stores bile until it is needed in the small intestine.

Pancreas
Partially hidden behind the stomach, the pancreas produces hormones (including insulin), and makes enzymes that aid digestion, which it secretes into the small intestine.

Appendix
Dead-end tube attached to the last part of the large intestine, with no function in modern humans.

Anal canal
The last few inches of the digestive tract carry feces (waste food) from the rectum to the anus, from where they are expelled from the body.

Pancreas
Partially hidden behind the stomach, the pancreas produces hormones (including insulin), and makes enzymes that aid digestion, which it secretes into the small intestine.

Gallbladder
This baglike organ stores bile until it is needed in the small intestine.

Liver
The largest organ in the human body, the liver produces bile and receives all the nutrients absorbed from the gut.
DIGESTIVE SYSTEM

Nasopharynx

Oropharynx

Epiglottis
Helps close the opening to the larynx during swallowing

Laryngopharynx
Lowest part of the pharynx; lies behind the larynx, and continues below into the esophagus

Esophagus
The pharynx becomes the esophagus level with the sixth cervical vertebra

Hard palate
The mucosa here is firmly bound to the periosteum (membrane covering the bone), ensuring that this lining is not moved and damaged during chewing

Tongue
Manipulates food in the mouth, bears taste buds, and forms sounds

Larynx

Mylohyoid
Sheet of muscle that forms the floor of the mouth; contracts to raise the hyoid bone and push the tongue up against the roof of the mouth during swallowing

Parotid gland

Oral cavity

Hard palate

Sublingual gland

Submandibular duct

Submandibular gland

Upper lip

Upper incisor

Lower incisor

Lower lip

Sublingual gland

Geniohyoid
This muscle raises the hyoid during swallowing

Hyoid bone

Larynx
The mouth is the first part of the digestive tract, and it is here that the processes of mechanical and chemical digestion get underway. Your teeth grind each mouthful, and you have three pairs of major salivary glands—parotid, submandibular, and sublingual—that secrete saliva through ducts into the mouth. Saliva contains digestive enzymes that begin to chemically break down the food in your mouth. The tongue manipulates the food, and also has taste buds that allow you to quickly make the important distinction between delicious food and potentially harmful toxins. As you swallow, the tongue pushes up against the hard palate, the soft palate seals off the airway, and the muscular tube of the pharynx contracts in a wave to push the ball of food down into the esophagus, ready for the next stage of its journey.
DIGESTIVE SYSTEM

- **Aorta**
  Passes behind the diaphragm, in front of the twelfth thoracic vertebra

- **Median arcuate ligament**
  Formed by fibers from both crura

- **Esophagus**
  In the neck, the esophagus lies behind the trachea

  - **Thoracic part of the esophagus**
    The esophagus is slightly constricted here by the left main bronchus, which crosses in front of it

- **Inferior vena cava**
  Passes through the diaphragm level with the tenth thoracic vertebra

- **Liver**
  Lies under the right dome of the diaphragm, and largely under cover of the ribs

- **Iliac arcuate ligament**
  Lateral arcuate ligament
  A thickening of the fascia covering the psoas muscle that forms an attachment for the muscle fibers of the diaphragm

- **Muscular part of diaphragm**
  Sternal part of diaphragm
  Xiphoid process
  Central tendon of diaphragm

- **Sternal part of diaphragm**
  Right crus of diaphragm
  Left crus of diaphragm

- **Medial arcuate ligament**
  Formed by fibers from both crura

- **Aorta**
  Passes behind the diaphragm, in front of the twelfth thoracic vertebra

- **DIAPHRAGM FROM BELOW**
The upper part of the stomach lies below the left dome of the diaphragm, under the ribs.

ANTERIOR (FRONT)

There are several large tubes crammed into the space behind the heart. These include the descending aorta, the azygos vein, and the lymphatic duct, but also a part of the digestive tract—the esophagus. This tube of smooth muscle starts in the neck as a continuation of the pharynx. It runs down through the thorax, slightly to the left of center, and pierces through the diaphragm level with the tenth thoracic vertebra. A couple of centimeters below this, it empties into the stomach and ends. The esophagus, like much of the digestive tract, has an outer layer of longitudinal muscle and an inner layer of circular muscle within its wall. During swallowing, a wave of constriction passes downward to push food or fluid down into the stomach.
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DIGESTIVE SYSTEM

Right lobe of liver

Fundus of gallbladder
Bottom of the baglike gallbladder, which just sticks out under the liver

Transverse colon
Hanging down below the liver and stomach, this part of the colon has a mesentery (fold of the peritoneum that connects the intestines to the dorsal abdominal wall) through which its blood vessels and nerves travel

Hepatic flexure of colon
Junction between the ascending and transverse colon, tucked under the liver

Ascending colon
This part of the large intestine is firmly bound to the back wall of the abdomen

Ileum
Lying mainly in the suprapubic region of the abdomen, this part of the small intestine is about 3.3 ft (1m) long; ileum simply means entrails in Latin

Cecum
First part of the large intestine, lying in the right iliac fossa of the abdomen

Appendix
Properly known as the vermiform (wormlike) appendix; usually a few centimeters long, it is full of lymphoid tissue, and thus forms part of the gut’s immune system

Rectum
About 4½ in (12cm) long, this penultimate part of the gut is stretchy; it can expand to store faeces, until a convenient time for emptying presents itself

Anal canal
Muscular sphincters in and around the anal canal keep it closed; the sphincters relax during defecation, as the diaphragm and abdominal wall muscles contract to raise pressure in the abdomen and force the feces out
With the organs in situ, it is clear how much the abdominal cavity extends up under the ribs. The upper abdominal organs—the liver, stomach, and spleen—are largely under cover of the ribcage. This gives them some protection, but it also means that they are vulnerable to injury if a lower rib is fractured. The large intestine forms an M shape in the abdomen, starting with the cecum low down on the right, and the ascending colon running up the right flank and tucking under the liver. The transverse colon hangs down below the liver and stomach, and the descending colon runs down the left side of the abdomen. This becomes the S-shaped sigmoid colon, which runs down into the pelvis to become the rectum. The coils of the small intestine occupy the middle of the abdomen.
During embryological development, the stomach starts as a simple tube, which expands to form a baglike structure.

Rugae
The lining of the stomach is folded into rugae (from the Latin for wrinkles) which smooth out as the stomach fills.

Greater curvature
A fold of peritoneum called the greater omentum hangs down from this.

Lesser curvature
This is connected to the liver by a fold of peritoneum (the membrane lining the abdominal cavity) called the lesser omentum.

Pylorus
From the Greek for gatekeeper, this is the last part of the stomach, where its contents are slowly released into the first part of the small intestine—the duodenum.

Pyloric sphincter
The muscle around the end of the pylorus is thickened to make a sphincter—this comes from the Greek word meaning to draw tight.

Fundus of stomach
The uppermost part of the stomach in someone standing or sitting upright; normally contains air.

Body of stomach
During embryological development, the stomach starts as a simple tube, which expands to form a baglike structure.

Greater curvature
The main blood vessels of the stomach run along the greater and lesser curvatures.

Body of stomach

Duodenum

Duodenum
The stomach is a muscular bag, where food is held before moving on to the intestines. Inside the stomach, food is exposed to a cocktail of hydrochloric acid, which kills off bacteria, and protein-digesting enzymes. The layered muscle of the stomach wall contracts to churn up its contents. Semidigested food is released from the stomach into the first part of the small intestine, the duodenum, where bile and pancreatic juices are added. Contractions in the intestine wall then push the liquid food into the jejunum and ileum, where digestion continues. What is left passes into the cecum, the beginning of the large intestine. In the colon, the next part of the large intestine, water is absorbed so that the gut contents become more solid. The resulting feces pass into the rectum, where they are stored until excretion.

Haustra
This is the name given to the sacculations (pouches) of the large intestine; it comes from the Latin for scoop.

Taenia coli
The longitudinal muscle coat is condensed into three bands, or taeniae; the name comes from the Greek for ribbon.

SMALL INTESTINE

LARGE INTESTINE

SMOOTH MUSCLE STRUTURE

Functions of the gut, blood vessels, and respiratory tract are carried out involuntarily, at a subconscious level, with the help of a special type of muscle called smooth muscle. This is supplied by autonomic motor nerves.

SMOOTH MUSCLE STRUCTURE

- Smooth muscle cell: These spindle-shaped cells contain actin and myosin; unlike in skeletal and cardiac muscle, the proteins are not lined up, so smooth muscle does not appear striated.
- Mitochondrion
- Intermediate filament
- Dense body
- Cell nucleus
- Myosin filament
- Actin filament
- Intermediate filament
- Dense body
- Cell nucleus

- Attachment of mesentery
- Serous lining of the small intestine: This is formed by the mesentery (membranous folds) enveloping the gut tube.

- Mucosa
  - The epithelium lining is packed with mucus-producing glands.

- Muscular layer
  - These ridges help to increase the surface area available for absorption of nutrients.

- Circular folds

- Attachment of mesentery

- Serous lining of the small intestine

- Taenia coli

- Haustra
  - This is the name given to the sacculations (pouches) of the large intestine; it comes from the Latin for scoop.

- SMALL INTESTINE

- LARGE INTESTINE

- CECUM WITH APPENDIX

- Ileum

- Mesoappendix

- Appendix
  - Usually 2-3½in (6–9cm) long and opening into the back wall of the cecum.

- Ascending colon

- Taenia coli
  - These ribbonlike bands of longitudinal muscle converge on the base of the appendix.
The liver, the largest internal organ, can weigh up to 6lb (3kg). It does hundreds of jobs simultaneously, many of them related to digestion. It produces bile, which is stored in the gallbladder and helps to digest fats. It also receives nutrients from the gut via the portal vein and processes them. It breaks down or builds up proteins, carbohydrates, and fats according to need; detoxifies or deactivates substances such as alcohol and drugs; and plays a role in the immune system. The pancreas, a long, thin, leaf-shaped gland lying under the liver and behind the stomach, produces hormones that are secreted into the blood, and makes pancreatic juice, full of digestive enzymes, which it empties into the duodenum.
This is about 3 in (8 cm) long and is where veins from every part of the digestive tract converge and enter the liver.
The urinary system comprises the kidneys, ureters, bladder, and urethra. The kidneys lie high up in the abdomen, on its back wall. The upper part of both kidneys is tucked under the twelfth rib. The kidneys filter the blood and ensure that it stays at exactly the right volume and concentration to keep all the cells in the body working properly. They also get rid of unwanted substances from the blood, playing an important role in excreting nitrogen-containing urea, for example. The urine made by the kidneys is carried by the ureters down to the bladder, which lies in the pelvis. The urethra runs from the bottom of the bladder and opens to the outside world. In a woman, the urethra is short—only a few inches long—and opens at the perineum, between the legs. The urethra of a man is longer, running through the length of the penis to open on the tip.
The female urethra is around 1 \( \frac{1}{2} \) in (4cm) long. It passes through the muscle of the pelvic floor and a muscular sphincter, before opening between the clitoris and vagina.

The male urethra is about 8 in (20cm) long. The prostate gland surrounds the commencement of the male urethra. The female urethra is short and directed from the bladder towards the vaginal vault, passing through the muscular floor of the pelvis. It is located posterior to the bladder and anterior to the vagina. The male urethra is longer and passes through the prostate gland before opening at the penis.
The kidneys lie high up on the back wall of the abdomen, tucked up under the twelfth ribs. A thick layer of perinephric fat surrounds and protects each kidney. The kidneys filter the blood, which is carried to them via the renal arteries. They remove waste from the blood, and keep a tight check on blood volume and concentration. The urine they produce collects first in cup-shaped calyces, which join to form the renal pelvis. The urine then flows out of the kidneys and down narrow, muscular tubes called ureters to the bladder in the pelvis. The bladder is a muscular bag that can expand to hold up to about 1 pint (0.5 litres) of urine, and empties itself when the individual decides it is convenient. Urine travels through the urethra before leaving the body.
Abdominal aorta

Left ureter

Detrusor muscle

Urethra

External urethral orifice

Urethra

From the Greek for urinate; this tube carries urine from the bladder to the outside world, a distance of around 1 1/2 in (4 cm) in women, and about 8 in (20 cm) in men (as it travels the length of the penis)

External urethral orifice

The male urethra opens at the tip of the glans penis

Renal cortex

Cortex means rind or bark; this is the outer tissue of the kidney

Renal medullary pyramid

Medulla means marrow or pith; this core tissue of the kidney is arranged as pyramids, which look triangular in cross section

Left kidney

Renal pelvis

Collects all urine from the kidney, and empties into the ureter; pelvis means basin in Latin, and the renal pelvis should not be confused with the bony pelvis—also shaped like a large basin

Left renal artery

Major calyx

The major calyces collect urine from the minor calyces, then themselves join together to form the renal pelvis

Minor calyx

Calyx originally meant flower covering in Greek, but because it is similar to the Latin word for cup it is used to describe cup-shaped structures in biology; urine from the microscopic collecting tubules of the kidney flows out into the minor calyces

Left renal vein

Abdominal aorta

Left common iliac artery

Bladder

The empty bladder lies low down, in the true pelvis, behind the pubic symphysis; as the bladder fills, it expands up into the abdomen

Trigone

The three-cornered region of the back wall of the bladder, between the ureteric orifices and the internal urethral orifice

Internal urethral orifice

Ureteric orifice

Internal urethral orifice
REPRODUCTIVE SYSTEM
OVERVIEW

Most organs in the body are similar in men and women. However, when it comes to the reproductive organs, there is a world of difference. In a woman, the ovaries, which produce eggs and female sex hormones, are tucked away, deep inside the pelvis. Also located within the pelvis are the vagina, uterus, and paired oviducts, or fallopian tubes, in which eggs are conveyed from the ovaries to the uterus. The woman's reproductive system also includes the mammary glands, which are important in providing milk for the newborn.

In a man, the testes, which produce sperm and sex hormones, hang well outside the pelvis, in the scrotum. The rest of the male reproductive system consists of a pair of tubes called the vasa deferentia (singular, vas deferens), the accessory sex glands (the seminal vesicles and the prostate), and the urethra.
Oviduct
Also known as fallopian tubes, oviducts collect eggs produced at ovulation and transport them to the uterus; oviducts are also the place where fertilization normally occurs.

Fimbriae
Fingerlike projections that form a feathery end to each oviduct.

Vas deferens

Ovary
Female gonad; is hidden away, deep within the pelvis.

Fundus of uterus
The uterus is angled forward, so the fundus—the farthest point from the opening—lies toward the front.

Cervix of uterus
The cervix, or neck of the uterus, projects down into the vagina.

Body of uterus

Seminal vesicle
Contributes fluid to semen.

Prostate gland
Accessory gland located at the base of the bladder; contributes some fluid to semen.

Shaft of penis
Formed by masses of erectile tissue, which become engorged with blood during erection.

Urethra
Conveys sperm and urine through penis.

Epididymis
A tightly-coiled tube on the back of the testis; sperm are stored and mature here.

Glans penis

Testis
Male gonad; hangs outside body cavity, in the scrotum.

Scrotum
Pouch of skin and muscle that encases testis.

Vagina
Flexible muscular tube that accommodates the male penis during coitus; during childbirth, it expands to allow the fetus to pass through.
**Axillary tail**
This part of the illustration shows the extent of the breast; breast tissue continues upward and outward on the chest wall—right up into the axilla (armpit).

**Nipple**

**Areola**
Means small area in Latin

**Superficial fascia**
Breast tissue lies within this layer

**Secretory lobule**

**Lung**

**Rib**

**Pectoralis minor**

**Pectoralis major**

**Intercostal muscle**

**Stroma**
Fibrous and fatty tissue that surrounds glandular tissue of the breast; from the Greek for spread or bed covering

**Areola**
This area of skin surrounding the nipple becomes darker during pregnancy

**Nipple**
Lactiferous ducts convey milk to tip of nipple

**Lactiferous sinus**
Just before they enter the nipple, the lactiferous ducts expand slightly in a lactating breast

**Lactiferous duct**
Each lactiferous duct drains one lobe of the breast; each lobe contains several lobules

**CROSS SECTION OF BREAST**
The breasts, or mammary glands, are an important part of the reproductive system in women. Like all other mammals, human females have mammary glands to provide the newborn with milk. But while many mammals have multiple mammary glands, humans (and other apes) have just two, on the front of the chest. The breasts develop at puberty, when they grow due to the increased production of glandular tissue and fat. The breasts lie on the pectoralis major muscle on each side. Each breast contains 15 to 20 lobes, which are connected to the nipple by lactiferous ducts. There seems to be a basic plan in the developing embryo, so that male nipples appear, although the breast does not form.
The male and female reproductive systems are both comprised of a series of internal and external organs, although structurally these are very different. It is true that both sexes possess gonads (ovaries in women and testes in men) and a tract, or set of tubes, but the similarity ends there. When we look in detail at the anatomy of the pelvis in each sex, the differences are obvious. The pelvis of a man contains only part of the reproductive tract, as well as the lower parts of the digestive and urinary tracts, including the rectum and bladder. Beneath the bladder is the prostate gland; this is where the vasa deferentia, which bring sperm from the testis, empty into the urethra. A woman’s pelvic cavity contains more of the reproductive tract than a man’s. The vagina and uterus are situated between the bladder and rectum in the pelvis.
**SAGITTAL SECTION / FEMALE**

**Myometrium**
Thick, smooth muscle layer of uterus

**Fundus of uterus**
The top portion of the uterus, farthest from the cervix

**Uterus**
The uterus is shaped like a flattened pear, and normally lies in the position shown here—bent forward over an empty bladder

**Vesicouterine pouch**
A pocket of peritoneal cavity between the bladder and the uterus. The peritoneal cavity is a potential space between the peritoneum lining the abdominal walls, and the abdominal and pelvic organs

**Bladder**

**Pubic symphysis**
Cartilage joint at front of pelvis; softens during pregnancy then widens slightly during childbirth

**Endometrium**
Lining of the uterus; innermost layer of endometrium is shed during menstruation. From the Greek for within the womb

**Suspensory ligament of ovary**
Carries ovarian arteries and veins to and from the ovary

**Oviduct**
Literally, egg-duct; each one is about 4 in (10cm) long

**Ovary**
Means egg place in Latin; each of the two ovaries lies on the pelvic side wall, in the angle between the internal and external iliac arteries

**Perimetrium**
The peritoneum (serous membrane lining the abdominal cavity) lies over the uterus

**Rectouterine pouch**
A pocket of peritoneal cavity between the rectum and the uterus

**Body of uterus**

**Cavity of uterus**

**Posterior fornix of vagina**

**Rectum**

**Coccyx**

**Cervix of uterus**
Literally, the neck of the uterus

**Anterior fornix of vagina**
Fornices are gutter-like areas that form as the cervix projects down into the vagina, known as anterior, lateral, and posterior fornices; fornix means arch or vault in Latin

**Rectovaginal septum**

**Anal canal**

**External anal sphincter**

**Bladder**

**Pubic symphysis**
Cartilage joint at front of pelvis; softens during pregnancy then widens slightly during childbirth

**Clitoris**
Contains spongy, erectile tissue similar to that in the penis

**Urethra**

**External urethral sphincter**

**Vagina**
Tube, around 3 1/2 in (9cm) long, with walls of fibrous and muscular tissue

**Oviduct**
Literally, egg-duct; each one is about 4 in (10cm) long

**Ovary**
Means egg place in Latin; each of the two ovaries lies on the pelvic side wall, in the angle between the internal and external iliac arteries

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The peritoneum (serous membrane lining the abdominal cavity) lies over the uterus

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**REPRODUCTIVE SYSTEM**

**Epididymis**
- Can be felt through the scrotum as a long lump on the back of the testis

**Efferent ductules**
- 10–20 ductules carry seminal fluid from the testes to the epididymis

**Vas deferens**
- Muscular tube; carries sperm from the testes into the pelvis, via the abdominal cavity. It leads into the prostate and joins the duct of the seminal vesicle before entering the urethra

**Prostate gland**
- Accessory reproductive gland; contributes about a third of all seminal fluid

**Cowper’s gland**
- One of two pea-sized glands, also known as bulbourethral glands; secretes a tiny portion of seminal fluid

**Bulb of penis**
- Part of the root of the penis; attaches to the perineal membrane, which stretches between the ischiopubic rami of the pelvis (see p.44)

**Crus of penis**
- One of two crura that are attached to the ischiopubic rami and make up part of the root of the penis

**Gland of the penis**
- Expanded part of the corpus spongiosum

**Seminal vesicle**
- One of a pair of accessory reproductive glands; contributes to seminal fluid

**Dorsal artery**
- A branch of the internal pudendal artery, which is itself a branch of the internal iliac artery

**Dorsal veins**
- These drain up to the venous plexus around the prostate and, ultimately, to the internal iliac veins

**Ureter**

**Bladder**

**Rete testis**
- Literally meaning the network of testis; these interconnecting tubes link the seminiferous tubules with the efferent ductules

**Lobule of testis**
- 200–300 lobules lie in each testis; each contains 1–3 tightly-packed seminiferous tubules, in which sperm are made

**Corpus spongiosum**
- The bulb of the penis continues on to form spongy erectile tissue called the corpus spongiosum, or spongy body

**Corpora cavernosa**
- One of two columns of tissue, formed where the crura join at the shaft of the penis, known together as corpora cavernosa

**Corpora albuginea**
- Fibrous division between the corpora cavernosa

**Tunica albuginea**
- Fibrous envelope around the components of the penis

**Septum**
- Fibrous division between the corpora cavernosa

**Urethra**

**Prostate gland**
- Accessory reproductive gland; contributes about a third of all seminal fluid

**CROSS SECTION OF PENIS**

**Ureters**

**Bladder**

**Tunica albuginea**
- Literally meaning egg-white-like coat; the outer covering of the testis

**Corpora cavernosa**

**Corpus spongiosum**

**Dorsal veins**
- These drain up to the venous plexus around the prostate and, ultimately, to the internal iliac veins

**Dorsal artery**
- A branch of the internal pudendal artery, which is itself a branch of the internal iliac artery
At a very fundamental level, the reproductive systems of man and woman must work together to allow eggs and sperm to meet. These views of the isolated organs and reproductive tracts show clearly how the anatomy is arranged to achieve this. The ovaries, where eggs (or ova) are produced, are deep inside the female pelvis. The eggs are collected from the ovaries by a pair of tubes, the oviducts, and it is usually here that fertilization takes place. The fertilized egg then moves along the oviduct, dividing into a ball of cells. The embryo eventually reaches the uterus, which is designed to accommodate and support the growing fetus. The vagina provides both a way for sperm to get in, and the route for the baby to get out at birth.
The body’s internal environment is controlled and regulated by nerves and hormones. The autonomic nervous system uses nerve impulses and neurotransmitters to send information in a swift and localized way. The glands of the endocrine system produce hormones—chemical messengers, often carried in the blood—which act in a slower, more prolonged, and more generalized way. Both the autonomic nervous system and the endocrine system are governed by the hypothalamus in the brain. The pituitary gland produces hormones that affect other endocrine glands, which sometimes form discrete organs. There are also hormone-producing cells in the tissues of many other organs.
Suprarenal gland
A pair of glands, also known as adrenal glands, that produce epinephrine, also called adrenaline.

Pancreas
Has cells that produce hormones controlling glucose metabolism: insulin and glucagon; also produces digestive enzymes.

Ovary
Ovaries produce sex hormones as well as gametes (reproductive cells) called ova.

Testis
Testes produce sex hormones as well as gametes (reproductive cells) called sperm.
The insides of our bodies are regulated by the autonomic nervous and endocrine systems. There is overlap between these two systems, and their functions are integrated and controlled within the hypothalamus of the brain. The pituitary gland has two lobes; its posterior lobe develops as a direct extension of the hypothalamus. Both lobes of the pituitary gland secrete hormones into the bloodstream, in response to nerve signals or blood-borne releasing factors from the hypothalamus. Many of the pituitary hormones act on other endocrine glands, including the thyroid gland in the neck, the suprarenal glands on top of the kidneys, and the ovaries or testes.
Thyroid gland
The name of this gland comes from the term for shield-shaped in Greek (as does the name of the thyroid cartilage of the larynx, which is coincidentally—a similar shape) also butterfly-shaped (below)

Left lobe of thyroid gland
Right lobe of thyroid gland
Isthmus of thyroid gland
Right superior parathyroid gland
Four pea-sized glands sit at the back of the thyroid
Right inferior parathyroid gland
The human body is a “living machine” with many complex working parts. To understand how the body functions, and to cure the various ailments that afflict it, it is crucial for medical professionals to examine it in detail. Advances in technology have made it possible to view human anatomy without dissecting the body. Techniques such as magnetic resonance imaging (MRI) reveal the inside of the body with great accuracy and allow us to build up a complete picture of our anatomy from every possible angle.
IMAGING TECHNIQUES

Imaging is vital to diagnose illness, unravel disease processes, and evaluate treatments. Modern techniques provide detailed information with minimum discomfort to the patient and have largely replaced surgery in establishing the presence and extent of disease. Imaging has also helped advance biological research.

The invention of the X-ray in 1895 made the development of noninvasive medicine possible. Without the ability to see inside the body, many internal disorders could only be found after major surgery. Computerized imaging now helps doctors make early diagnoses, which at times greatly increase the likelihood of recovery. Computers process and enhance raw data to aid our visual ability. However, sometimes direct observation is essential. Viewing techniques have also become less invasive with the development of instruments such as the endoscope (see opposite).

MICROSCOPY

Light microscopy (LM) uses magnifying lenses to focus light rays. The light passes through a thin section of material and enlarges it up to 2,000 times. Higher magnifications are achieved with beams of electrons (subatomic particles). In scanning electron microscopy (SEM), the beam runs across a specimen coated with gold film and bounces off the surface to create a three-dimensional image.

X-RAY

Like light rays, X-rays are electromagnetic energy, but of short wavelength. When passed through the body to strike photographic film, they create shadow images (radiographs). Dense structures, such as bone, absorb more X-rays and show up as white, while soft tissues, such as muscle, appear gray. Air-filled spaces, such as the lungs, appear black. The spaces inside the digestive tract, or within blood vessels, may be visualized by filling them with a contrast medium—such as iodine or barium—that absorbs X-rays. A contrast X-ray image of blood vessels is known as an angiogram.
RADIONUCLIDE AND PET SCANNING
In radionuclide imaging, a radioactive substance is injected into the body and is absorbed by the area to be imaged. As the substance decays, it emits gamma rays, which a computer forms into an image. Positron emission tomography (PET) is a type of radionuclide scanning where the injected chemical emits radioactive particles called positrons. PET gives data about how the brain functions rather than anatomy.

PET brain scan
This scan of the brain shows that the organ is active even in sleep mode. Areas in red, orange, and yellow represent high levels of activity.

ULTRASOUND
In ultrasound, a device called a transducer emits very high-frequency sound waves as it is passed over the body part being examined. The sound waves echo back to the device based on the density of the tissues they encounter. A computer analyses the reflected waves and creates an image.

Fetal ultrasound
Low-intensity ultrasound is a safe way to monitor fetal development. In this scan the fetus’s head can be seen clearly in profile on the right.

MRI AND CT SCANNING
Computerized tomography (CT) and magnetic resonance imaging (MRI) detail various tissue types. In CT, a scanner using X-rays rotates around the patient as a computer records the levels of electromagnetic energy passing through tissues of different densities. A cross section is built from layers of data. In MRI, a person lies in a magnetic chamber that causes hydrogen atoms in the body to align. A pulse of radiowaves is released, throwing the atoms out of alignment. As they realign, the atoms emit radio signals that are used to create an image.

MRI scan of head
A digitally enhanced MRI scan of the head shows tissues of the brain and spinal cord in orange and red.

CT scan of lungs
In a horizontal slice through the chest, the spongy tissues and airways of the healthy lungs (oranges and yellows) show up clearly. The heart and major blood vessels between the lungs are mid-blue; the vertebrae, ribs, and sternum are dark blue.

ENDOSCOPY
Telescopelike endoscopes are inserted through natural orifices or incisions to image the body’s interior. They can be bent and controlled, and may carry instruments for other purposes as well, such as surgery and biopsy. Endoscopes have been designed to fit various body parts—bronchoscope for airways, gastroscope for the stomach, laparoscope for abdomen, and proctoscope for lower bowel.

Endoscopic view of stomach
The gastric mucosa (inner lining) of a healthy stomach as seen through an endoscope. This procedure may be performed to investigate upper digestive tract disorders.

ELECTRICAL ACTIVITY
Monitoring electrical activity in the body can reveal whether it is functioning normally. Signals coming from muscles and nerves are detected by applying sensor pads to the skin. The signals are sent to a computer that coordinates, amplifies, and displays them as a real-time trace—usually a spiked or wavy line. Examples of this technique include electrocardiography (ECG) of the heart, electromyography (EMG) of skeletal muscles, and electroencephalography (EEG) of the brain’s nerve activity.
HEAD AND NECK

The discovery of X-rays at the end of the 19th century suddenly created the possibility of looking inside the human body—without having to physically cut it open. Medical imaging is now an important diagnostic tool, as well as being used for the study of normal anatomy and physiology. In computed tomography (CT), X-rays are used to produce virtual sections or slices through the body. Another form of sectional imaging, using magnetic fields rather than X-rays to create images, is magnetic resonance imaging (MRI), as shown here. MRI is very useful for looking in detail at soft tissue, for instance, muscle, tendons, and the brain. Also seen clearly in these sections are the eyes (1 and 3), the tongue (1 and 2), the larynx, vertebrae, and spinal cord (2 and 5).
The axial, or transverse, sections through the chest (sections 1–4) show the heart and large blood vessels lying centrally within the thorax, flanked by the lungs, and all set within the protective, bony casing of the ribcage. Section 1 shows the clavicles, or collarbones, joining the sternum at the front, the apex (top) of the lungs, and the great vessels passing between the neck and the thorax. Section 2 is lower down in the chest, just above the heart, while section 3 shows the heart with detail of its different chambers. The aorta appears to be to the right of the spine in this image, rather than to the left, but this is the usual way in which scans are viewed. You need to imagine yourself standing at the foot of the bed, looking down at the patient. This means that the left side of the body appears on the right side of the image as you view it. Section 4 shows the very bottom of the heart, and the inferior lobes of the lungs.
MRI is a useful way of looking at soft tissues—and for visualizing the organs of the abdomen and pelvis, which only appear as subtle shadows on a standard X-ray. In the series of axial or transverse sections through the abdomen and pelvis, we can clearly see the dense liver, and blood vessels branching within it (section 1); the right kidney lying close to the liver, and the left kidney close to the spleen (section 2); the kidneys at the level where the renal arteries enter them (section 3), with the stomach and pancreas lying in front; coils of small intestine, the ileum, resting in the lower part of the abdomen, cradled by the iliac bones (section 4); and the organs of the pelvis at the level of the hip joints (section 5). The sagittal view (section 6) shows how surprisingly shallow the abdominal cavity is, in front of the lumbar spine. In a slim person, it is possible to press down on the lower abdomen and feel the pulsations of the descending aorta—right at the back of the abdomen.
LOWER ARM AND HAND

These scans of the arm, forearm, and hand show how tightly packed the structures are. Section 1 reveals the bones of the wrist—the carpals—interlocking like a jigsaw. The wrist joint itself is the articulation between the radius and the scaphoid and lunate bones. In section 2, part of the elbow joint is visible, with the bowl-shaped head of the radius cupping the rounded end of the humerus. Muscles in the forearm are grouped into two sets, flexors on the front and extensors behind the forearm bones and interosseous membrane. Compare sections 3–8 with sections through the leg (see pp. 234–35)—both limbs have a single bone (humerus or femur) in the upper part, two bones in the lower part (radius and ulna in the forearm; tibia and fibula in the lower leg), a set of bones in the wrist and ankle (carpals and tarsals), fanning out to five digits at the end of the limb. Evolutionarily, these elements developed from the rays of a fish fin.
The sequence of axial and transverse sections through the thigh and lower leg show how the muscles are arranged around the bones. Groups of muscles are bound together with fascia—fibrous packing tissue—forming three compartments in the thigh (the flexor, extensor, and adductor muscles), and three in the lower leg (flexor, extensor, and peroneal or fibular muscles). Nerves and deep blood vessels are also packaged together in sheaths of fascia, forming “neurovascular bundles”. Section 2 shows the bones of the forefoot, while the tightly packed muscles surrounding the tibia and fibula in the lower leg are visible in section 3. At the knee joint, shown in section 4, the patella can be seen to fit neatly against the reciprocal shape of the femoral condyles. The neurovascular bundle is clearly visible here, at the back of the knee, in a space known as the popliteal fossa—with the hamstring muscles on either side. Sections 5 and 6, through the middle and upper thigh, show the powerful quadriceps and hamstring muscles surrounding the thigh bone, or femur.
Glossary

Terms defined elsewhere in the glossary are in italics. All distinct terms are in bold.

abduction
The action of moving a limb further from the midline of the body. In muscle names, abductor indicates a muscle that has this action. See also adduction.

adduction
The action of moving a limb closer to the midline of the body. In muscle names, adductor indicates a muscle that has this action. See also abduction.

adipose tissue
Fat-storage tissue.

adrenal glands
Also called suprarenal glands. A pair of glands found one on top of each kidney. Each gland consists of an outer adrenal cortex, which secretes corticosteroid hormones, and an inner adrenal medulla, which secretes epinephrine. See also corticosteroid.

adrenaline
See epinephrine.

afferent
In the case of blood vessels, carrying blood towards an organ, and in nerves, conducting impulses towards the central nervous system. See also efferent.

alveolus (pl. alveoli)
A small cavity, specifically, one of the millions of tiny air sacs in the lungs where exchange of gases with the blood takes place, also the technical term for a tooth socket.

amino acid
Proteins are made from up to 20 different types of these small, nitrogen-containing molecules; amino acids also play various other roles in the body. See also peptide.

amnion
The membrane that encloses the developing fetus within the uterus (womb). The fluid inside it (amniotic fluid) helps to cushion and protect the fetus.

anastomosis
An interconnection between two otherwise separate blood vessels (e.g. two arteries, or an artery and a vein).

angio-
A prefix relating to blood vessels.

angiography
In medical imaging: any technique for obtaining images of blood vessels in the living body.

anterior
Toward the front of the body, when considered in a standing position. Anterior to means in front of. See also posterior.

antibiotic
Any of various chemical compounds, natural or synthetic, that destroy or prevent the growth of microorganisms (e.g. bacteria, yeasts, and fungi).

antibody
Defensive proteins produced by white blood cells that recognize and attach to particular “foreign” chemical components (antigens), such as the surface of an invading bacterium or virus. The body is able to produce thousands of different antibodies targeted at different invaders and toxins.

articular fat pad
In a joint bone, such as the knee, the fatty tissue within the synovial membrane.

articular surface
The part of the long bone where the epiphysis forms the joint surface of the bone, which is covered in articular cartilage.

articulation
A joint, especially but not necessarily one allowing movement; also, a location within a joint where two bones meet in close proximity. A bone in a joint is said to articulate with the other bone(s) forming the joint.

ATP
Short for adenosine triphosphate, an energy-storing molecule used by all living cells.

atrium (pl. atria)
Either of the two smaller chambers of the heart that receive blood from the veins and pass it on to the corresponding ventricle.

autonomic nervous system
The part of the nervous system that controls unconscious processes such as the activity of the body’s glands and the muscles of the gut. It is divided into the sympathetic nervous system, the roles of which include preparing the body for “fight or flight”, and the parasympathetic nervous system, which stimulates movement and secretions in the gut, produces erection of the penis during coitus, and empties the bladder.

axon
A wirelike extension of a nerve cell (neuron) along which electrical signals are transmitted away from the cell.

bacteria
Single-celled living organisms, some of which are dangerous pathogens. Bacterial cells are much smaller than animal and plant cells, and lack nuclei.

bile
A yellow-green fluid produced by the liver, stored in the gallbladder, and discharged into the intestine via the bile duct. It contains excretory products together with bile acids that help with fat digestion.

biopsy
A sample taken from a living body to test for infection, cancerous growth, etc; also the sampling process.

brachial
Relating to the arm.

brainstem
The lowest part of the brain, leading down from the rest of the brain to the spinal cord. In descending order, it consists of the midbrain, pons, and medulla oblongata.

bronchus (pl. bronchi)
The air tubes branching from the trachea and leading into the lungs; right and left main bronchi enter each lung respectively and divide into lobar bronchi, and eventually into much smaller tubes called bronchioles.

bursa
A pocket of synovial fluid that may lubricate the movement of tendons around joints, such as in the suprapatellar region of the knee joint.

carcinoma
An uncontrolled growth of cells with the potential to spread and form colonies elsewhere in the body. Cancer cells typically look different from their noncancerous equivalents under the microscope. Cancers can arise in many different tissues.
capillaries
The smallest blood vessels, with a wall only one cell thick, supplied by arterioles and draining into veins. Capillaries form networks, and are the sites where nutrients, gases, and waste products are exchanged between body tissue and blood.

carbohydrates
Naturally occurring chemical substances containing carbon, hydrogen, and oxygen atoms, e.g. sugars, starch, cellulose, and glycogen.

cardiac
Relating to the heart.

carpal
Relating to the wrist.

cartilage
A rubbery or tough supportive tissue (colloquially “gristle”) found in various forms around the body.

cell
A tiny structure containing genes, a surrounding fluid (cytoplasm) that carries out chemical reactions, organelles, and an enclosing membrane. See also nucleus.

central nervous system
The brain and spinal cord, as distinct from the nerves that run throughout the rest of the body (the peripheral nervous system).

central osteonal canal
Also known as the Haversian canal, it is a channel in the center of each osteon in a compact bone, containing blood and lymphatic vessels.

cerebellum
An anatomically distinct region of the brain below the back of the cerebrum, responsible for coordinating the details of complex bodily movements, and managing balance and posture.

cerebrospinal fluid
The clear fluid that fills the ventricles of the brain and surrounds the brain and spinal cord, helping to provide a constant environment and acting as a shock absorber.

cerebrum
The largest part of the brain and the locus of most “higher” mental activities; part of the forebrain in evolutionary terms. It is divided into two halves called cerebral hemispheres.

cervical
1. Relating to the neck.
2. Relating to the cervix (neck) of the uterus.

cervix
The narrow “neck” of the uterus, opening into the upper end of the vagina; widens during childbirth.

cholesterol
A natural chemical that is an essential constituent of the body’s cell membranes and is an intermediate molecule in the production of steroid hormones. It is a constituent of the plaques that cause the arteries to narrow in atherosclerosis.

chromosomes
The microscopic packages in the nucleus of a cell that contain genetic information in the form of DNA. Humans have 23 pairs of chromosomes, with a complete set present in nearly every cell of the body. Each chromosome consists of a single DNA molecule combined with various proteins.

ciliary
(pl. cilia)
A microscopic, beating, hairlike structure found in large numbers on the surfaces of some cells—for example in the air tubes of the lungs, where they help to remove foreign particles.

circadian rhythm
An internal, daily body rhythm. It is kept accurate by reference to external light and dark.

CNS
Short for central nervous system.

cochlea
The complex spiral structure in the inner ear that translates sound vibrations in the fluid it contains into electrical impulses to be sent to the brain.

collagen
A tough fibrous, structural protein that is widespread in the body (particularly in bone, cartilage, blood-vessel walls, and skin).

colon
The main part of the large intestine, comprises the ascending, transverse, and descending colon.

commissure
A link between two structures, especially any of several nerve tracts in the brain and spinal cord that crosses the midline of the body.

compartment (as in anatomical grouping or area)
In the case of muscles, used to define an anatomically and functionally discrete group of muscles, e.g. flexor compartment of the forearm.

condyle
A rounded, knucklelike projection on a bone that forms part of a joint.

connective tissue
Any tissue comprising cells embedded in an acellular matrix; includes cartilage, bone, tendon, ligament, and blood.

cornea
The tough, transparent, protective layer at the front of the eye; helps focus light on the retina.

coronary section
A real or imagined section down the body that divides it from side to side; it is perpendicular to a sagittal section.

corpus callosum
A large tract of nerve fibers (commissure) that links the brain’s two cerebral hemispheres.

cortex
The Latin word for bark, used for the outer parts of some organs, especially:
1. The cerebral or cerebellar cortex – the surface layers of cells (the “gray matter”) of these parts of the brain.
2. The adrenal cortex – the outer part of the adrenal glands.

corticosteroid
Any of several steroid hormones produced by the adrenal cortex. Examples include cortisol and cortisone, which have many effects on the body’s metabolism and also suppress inflammation. The mineral-regulating hormone aldosterone is also a corticosteroid.

cranial
1. Relating to the cranium.
2. Toward the head.

cranial nerves
Pairs of nerves that lead directly from the brain rather than from the spinal cord. They mainly supply structures in the head and neck.

cranium
Together with the mandible (jaw), forms the skull.

CSF
Short for cerebrospinal fluid.

CT
Short for computed tomography, a sophisticated X-ray technique that produces images in the form of “slices” through the patient’s body.

cutaneous
Relating to the skin.

cyst
A fluid-filled cavity in the body. Also, an old term for the bladder; hence cystitis.

dendrite
A branchlike outgrowth of a nerve cell (neuron) that carries incoming electrical signals to that cell. A neuron usually has many dendrites.

depressor
Term used in names of several muscles that act to pull down, e.g. depressor anguli oris (pulls down the angle of the mouth). See also levator.

diaphragm
A sheet of muscle that separates the thorax from the abdomen. When relaxed it is domed upward; it flattens when contracted, to
increase thoracic volume and draw air into the lungs. It is the most important muscle used in breathing.

diaphysis
A cylinder of compact bone around a central marrow cavity in a long bone.

diffusion
The net movement of molecules in a fluid (gas or liquid) from regions of high to lower concentration.

dilated
Opened or stretched wider.

distal
Relatively further away from the center of the body or from the point of origin. See also proximal.

DNA
Short for deoxyribonucleic acid, a very long molecule made up of small individual units or nucleotides, containing one of four bases. DNA is found in the chromosomes of living cells; the order of the bases “spells out” the genetic instructions of the animal. See also gene.

dorsal
Relating to the back or back surface of the body, or to the top of the brain; also, relating to the back (dorsum) of the hand or the upper surface of the foot.

dorsal (sensory) root ganglion
Part of the spinal cord where cell bodies of sensory nerves cluster.

duodenum
The first part of the small intestine, leading out of the stomach.

efferent
In the case of blood vessels, carrying blood away from an organ, in the case of nerves, conducting impulses away from the central nervous system. See also afferent.

electrocardiography
Recording the electrical activity produced by the heart muscle, using electrodes applied to the patient’s skin.

embryo
The earliest stage of a developing unborn individual in the uterus.

erythrocyte
A red blood cell.

extension
The movement that increases the angle of, or straightens, a joint. The name extensor indicates a muscle that has this action, e.g. extensor digitorum extends the fingers. See also flexion.

external
In anatomy: closer to the outer surface.

extracellular
Outside the cell; often used in reference to the fluid or matrix between cells of a connective tissue.

Fallopian tube
Another name for the oviduct or uterine tube; two oviducts attach to the uterus, extending to the ovary on each side; the ovum travels down this tube after ovulation.

fascia (pl. fasciae)
Layers of fibrous tissue between and around muscles, vessels, and organs.

fascicle
A bundle of muscle fibers, packed in connective tissue called endomysium and contained in a sheath of perimysium.

fertilization
The union of a sperm with an unfertilized egg (ovum), the first step in the creation of a new individual. See also zygote.

fetus
The unborn individual in the uterus, from 8 weeks after fertilization, when it begins to show a recognizable human appearance. See also embryo.

flexion
The bending movement at a joint. The name flexor indicates a muscle that has this action, e.g. flexor carpi ulnaris bends the wrist. See also extension.

follicle
A small cavity or sac-like structure: e.g. the hair follicle from which a hair grows.

foramen
An opening, hole, or connecting passage.

fossa
A shallow depression or cavity.

frontal
Relating to or in the region of the forehead; frontal bone, the skull bone of the forehead; frontal lobe, the foremost lobe of each cerebral hemisphere, lying behind the forehead.

gallbladder
The hollow organ into which bile (formerly known as gall) secreted by the liver is stored and concentrated before being transferred to the intestine.

gamete
A sperm or an ovum (egg). Gametes contain just one set of 23 chromosomes, whereas normal body cells have two sets (46 chromosomes). When sperm and egg combine during fertilization, the two-set condition is restored. See also zygote.

ganglion
1. A concentration of nerve cell bodies, especially one outside the central nervous system. 2. A swelling on a tendon sheath.

gastric
Relating to the stomach.

gene
A length of a DNA molecule that contains a particular genetic instruction. Many genes are blueprints for making particular protein molecules, while some have a role in controlling other genes. Between them, the thousands of different genes in the body provide the instructions for a fertilized egg to grow into an adult, and for all essential activities of the body to be carried out. Nearly every cell in the body contains an identical set of genes, although different genes are “switched on” in different cells.

genome
The complete set of genes found in a human or other living species. The human genome is thought to contain about 20,000–25,000 different genes.
gland
A structure in the body, the main purpose of which is to secrete particular chemical substances or fluids. Glands are either exocrine, releasing their secretions through a duct onto an external or internal surface, such as the salivary glands, or endocrine, releasing hormones into the bloodstream. See also endocrine system.

glial cells
Cells in the nervous system that are not neurons but play various supportive and protective roles within the nervous system.

gloss-, glosso-
Prefixes relating to the tongue.

glucagon
A hormone produced by the pancreatic islets (see pancreas) that increases glucose levels in the blood; its effect is opposite to that of insulin.

glucose
A simple sugar that is the main energy source used by the body’s cells.

glycogen
A carbohydrate made up of long, branched chains of connected glucose molecules. The body stores glycogen in the form of glycogen, especially in the muscles and liver; also called animal starch.

gonad
An organ that produces sex cells (gametes) – i.e. an ovary or a testis. A gonadotropin is a hormone that specifically affects the gonads.

gray matter
Part of the brain that contains cell bodies of neurons. See also white matter.

gyrus (pl. gyri)
One of the folds on the outer surface of the brain. See also sulcus.

hemoglobin
The red pigment within erythrocytes that gives blood its color and carries oxygen to the tissues.

head (of a muscle)
Where a muscle has several origins or proximal attachments, these may be referred to as “heads”, as in the long and short heads of biceps brachii.

hepatic
Relating to the liver.

homeostasis
The maintenance of stable conditions in the body, e.g. in terms of chemical balance or temperature.

hormone
A chemical messenger produced by one part of the body that affects other organs or parts. There also exist local hormones that affect only nearby cells and tissues. Chemically, most hormones are either steroids, peptides, or small molecules related to amino acids. See also neurotransmitter.

hypothalamus
A small but vital region at the base of the brain, which is the control center for the autonomic nervous system, regulating processes such as body temperature and appetite. Also controls the secretion of hormones from the pituitary gland.

ileum
The last part of the small intestine, ending at the junction with the large intestine (colon). N.B. Not the same as ilium, one of the bones of the hip.

immune system
The molecules, cells, organs, and processes involved in defending the body against disease.

immunity
Resistance to attack by a pathogen (disease-causing organism); specific immunity develops as a result of the body’s immune system being primed to resist a particular pathogen.

immunotherapy
Any of various treatments involving either the stimulation or suppression of the activity of the immune system.

inflammation
An immediate reaction of body tissue to damage, in which the affected area becomes red, hot, swollen, and painful, as white blood cells (see leukocyte) accumulate at the site to attack potential invaders.

inguinal
Relating to, or in the region of, the groin.

insertion
The point of attachment of a muscle to the structure that typically moves when the muscle is contracted. See also origin.

insulin
A hormone produced by the pancreatic islets (see pancreas) that promotes the uptake of glucose from the blood, and the conversion of glucose to the storage molecule, glycogen.

integument
The external protective covering of the body.

internal
In anatomy: inside the body, distant from the surface. See also external.

internal elastic media
The layer between the tunica media and tunica intima that is prominent in large arteries, including the aorta and its main branches. This layer is absent from some veins, including those around the brain.

intra-
Prefix meaning within, as in intracellular or intramuscular.

islets of Langerhans
See pancreas.

-itis
Suffix meaning “inflammation”, used in words such as tonsillitis and laryngitis.

joint
Any junction between two or more bones, whether or not movement is possible between them. See also articulation, suture, synovial joint.

keratin
A tough protein that forms the substance of hair and nails, gives strength to the skin, etc.

labia (sing. labium)
Either of the two paired folds that form part of the vulva in females: the outer labia majora and the more delicate inner labia minora.

labial
Relating to the lips, or to the labia of the female genitals.

lactation
Secretion of milk by the breasts.

larynx
The voicebox: a complex structure situated at the top of the trachea (windpipe). It includes the vocal cords, structures that function to seal off the trachea when necessary, as well as creating sound when their edges are made to vibrate during breathing.

lateral
Relating to or toward the sides of the body. See also medial.

leukocyte
A white blood cell. There are several types, acting in different ways to protect the body against disease as part of its immune response. Leukocytes are found in lymph nodes and other tissues generally, as well as in the blood.

levator
Term used in the names of several muscles whose action is to lift up, such as the levator scapula (lifts the shoulder blade). See also depressor.

ligament
A tough fibrous band that holds two bones together. Many ligaments are flexible, but they cannot be stretched. The term
is also used for bands of tissue connecting or supporting some internal organs.

**limbic system**
Several connected regions at the base of the brain, involved in memory, behavior, and emotion.

**line of fusion**
A line in the bone that shows the area of fusion of the cartilage growth plate with a long bone. The cartilage plate allows long bones to grow quickly in length during childhood and fuses by adulthood, but the line of fusion may still be evident for a few years.

**lingual**
Relating to the tongue.

**lipid**
Any of a large variety of fatty or fatlike substances that are found naturally in living things and are relatively insoluble in water.

**lumbar**
Relating to the lower back and sides of the body between the lowest ribs and the top of the hip bone. The lumbar vertebrae are the vertebrae that lie within this region.

**lumen**
The space inside a tubular structure, such as a blood vessel or glandular duct.

**lymph node**
A small lymphoid organ; lymph nodes serve to filter out and dispose of bacteria and debris, such as cell fragments.

**lymphocyte**
A specialized leukocyte that produces antibodies including natural killer cells, T cells, and B cells.

**lymphoid tissue**
The tissue of the lymphatic system, which has an immune function, including lymph nodes, the thymus, and the spleen.

**M line**
A fine line present in skeletal muscle, which connects the thick myosin filaments and holds them in place. See also Z disc.

**macromolecule**
A large molecule, especially one that consists of a chain of small similar “building blocks” joined together. Proteins, DNA, and starch are examples of macromolecules.

**mammary**
Of, or relating to, the breasts.

**marrow**
In anatomical contexts, usually short for bone marrow, the soft material located in the cavities of bones; in some areas this tissue is mainly fat; in others, it is blood-forming tissue.

**matrix**
The extracellular material in which the cells of connective tissues are embedded. It may be hard, as in bone; tough, as in cartilage; or fluid, as in blood.

**medullary (marrow) cavity**
Cavities of long bones that are filled with blood-forming red marrow at birth, but this is replaced with fat-rich yellow marrow by adulthood. Red marrow persists in other parts such as the skull, spine, ribs, and pelvis.

**medulla**
1. Short for medulla oblongata, the elongated lower part of the brain that connects with the spinal cord. 2. The central part or core of some organs such as the kidneys and adrenal glands.

**melanin**
A dark brown naturally occurring pigment molecule, which occurs in greater amounts in tanned or darker skin, and protects deeper tissues from ultraviolet radiation.

**melatonin**
A hormone secreted by the pineal gland in the brain, which plays a role in the body’s sleep–wake cycle (see circadian rhythm).

**membrane**
1. A thin sheet of tissue covering an organ, or separating one part of the body from another. 2. The outer covering of a cell (and similar structures within the cell). A cell membrane is composed of a double layer of phospholipid molecules with other molecules such as proteins embedded in it.

**meninges**
Membranes that enclose the outside of the brain and spinal cord. Meningitis is inflammation of the meninges, usually resulting from infection.

**meniscus (pl. menisci)**
Crescent-shaped articular disc made of fibrocartilage present in the knee joint. A pair of menisci facilitates the complex movements of this joint.

**menstrual cycle**
The monthly cycle that takes place in the uterus of a non-pregnant woman of reproductive age. The endometrium (lining of the uterus) grows thicker in preparation for possible pregnancy; an egg is released from the ovary (ovulation); then, if the egg is not fertilized, the endometrium breaks down and is discharged through the vagina in a process known as menstruation.

**mental**

**mesentery**
A folded sheet of peritoneum (the membrane lining the abdominal cavity and organs), forming a connection between the intestines and the back of the abdominal cavity.

**metabolism**
The chemical reactions taking place inside the body. The metabolic rate is the overall rate at which these reactions are occurring.

**metaphysis**
Neck of a long bone where spongy bone starts to encroach on marrow cavity. See also epiphysis.

**midbrain**
The upper part of the brainstem.

**middle ear**
The air-filled middle chamber of the ear, between the inner surface of the eardrum and the inner ear. See also ossicles.

**molecule**
The smallest unit of a chemical compound that can exist, consisting of two or more atoms joined together by chemical bonds. The water molecule is a simple example, consisting of two hydrogen atoms joined to one oxygen atom. See also macromolecule.

**motor**
Adjective relating to the control of muscle movements, as in motor neuron, motor function, etc. See also sensory.

**MRI scan**
Short for magnetic resonance imaging scan, a medical imaging technique based on the energy released when magnetic fields are applied then removed from the body; it can produce very detailed images of the soft tissues of the body.

**mucosa (pl. mucosae)**
A membrane that secretes mucus.

**mucus**
A thick fluid produced by some membranes of the body for protection, lubrication, etc. (Adjective mucous.)

**muscle fiber**
Cylindrical units in a skeletal muscle that range from a few millimeters to several centimeters in length. They are formed by the merging of many cells, and therefore contain many nuclei.

**myelin**
Fatty substance forming a layer around some nerve axons, called myelinated axons, insulating them and speeding their nerve impulses.

**myel-**
1. Prefix relating to the spinal cord. 2. Prefix relating to bone marrow.
myo-
Prefix relating to muscle.

myofibril
Fibers in skeletal muscle that contain filaments made of contractile proteins, mainly actin and myosin. The way these filaments are organized gives skeletal muscle a striped or striated appearance under a light microscope.

natural killer (NK) cell
A type of lymphocyte that can attack and kill cancer cells and virus-infected cells.

neocortex
All the cortex of the cerebrum except the region concerned with smell and the hippocampal formation.

nerve
A cablelike structure transmitting information and control instructions in the body. A typical nerve consists of axons of many separate nerve cells (neurons) running parallel to, but insulated from, each other; the nerve itself is surrounded by an overall protective sheath of fibrous tissue. Nerves may contain nerve fibers controlling muscles or glands (effector fibers), while others contain fibers carrying sensory information back to the brain (afferent fibers); some nerves carry both types of nerve fiber.

neuron
A nerve cell. A typical neuron consists of a rounded cell body, branchlike outgrowths called dendrites that carry incoming electrical signals to the neuron; and a single, long, wirylike extension, called an axon, which transmits outgoing messages. There are many variations on this basic pattern, however.

neurotransmitter
Any of various chemical substances released at synapses by the ends of nerve cells, where they function to pass a signal on to another nerve cell or muscle. Some neurotransmitters act mainly to stimulate the action of other cells, others to inhibit them.

nucleus (pl. nuclei)
1. The structure within a cell that contains the chromosomes.

2. Any of various concentrations of nerve cells within the central nervous system.

3. The central part of an atom.

ocellar
Relating to the back of the head. The occipital bone is the skull bone forming the back of the head.

occipital bone
The skull bone forming the back of the head. The occipital lobe is the most posterior lobe of each cerebral hemisphere, lying below the occipital bone.

esophagus
The gullet: the tubular part of the alimentary canal between the pharynx and the stomach.

estrogens
Steroid hormones produced predominantly by the ovary, and which regulate female sexual development and physiology. Artificial estrogens are used in oral contraceptives and hormone replacement therapy.

olfactory
Relating to the sense of smell.

oligodendrocyte
A structure in nerve cell that manufactures the myelin sheath along the axons in the central nervous system.

optic nerve
The nerve that transmits visual information from the retina of the eye to the brain.

oral
Relating to the mouth.

orbit
The bony hollow in the skull within which the eye is contained.

pancreas
A large, elongated gland lying behind the stomach, with a dual role in the body. The bulk of its tissue secretes digestive enzymes into the duodenum, but it also contains scattered groups of cells called pancreatic islets or islets of Langerhans that produce important hormones, including insulin and glucagon.

parasympathetic nervous system
See autonomic nervous system.

parathyroid glands
Four small glands that are often embedded in but are separate from the thyroid gland. They produce parathyroid hormone, which regulates calcium metabolism in the body.

parietal
A term (derived from the Latin word for “wall”) with various applications in anatomy. The parietal bones form the side walls of the skull, and the parietal lobes of the brain lie beneath these bones. Membranes (such as the pleura and peritoneum) are described as parietal where they are attached to the body wall.

pathogen
Any disease-causing agent, including bacteria and viruses.

pathology
The study of disease; also, the physical manifestations of a disease.

pelvic girdle
The hip bones attach to the sacrum to form the pelvic girdle, linking the leg bones to the spine.

pelvis
1. The cavity enclosed by the pelvic girdle, or the area of the body containing the pelvic girdle.

2. The renal pelvis is the cavity in the kidney where the urine collects before passing down the ureter.

peptide
Any molecule consisting of two or more amino acids joined together, usually in a short chain. There are many types, some of which are important hormones. Proteins are polypeptides: long chains of amino acids.

peri-
Prefix meaning round or surrounding.

periosteal blood vessels
The blood vessels that run around the outside of the compact bone. See also endosteal blood vessels.

periosteum
The outer lining of bones; contains cells that can lay down or remove bone tissue.

peripheral
Toward the outside of the body or to the extremities of the body. The term peripheral nervous system refers to the entire nervous system except for the brain and spinal cord. See also central nervous system.
peritoneum  
A thin, lubricated sheet of tissue that enfolds and protects most of the organs of the abdomen.

pharynx  
The muscular tube behind the nose, mouth, and larynx, leading into the esophagus.

phospholipid  
A type of lipid molecule with a phosphate (phosphorus plus oxygen) group at one end. The phosphate group is attracted to water while the rest of the molecule is not. This property makes phospholipids ideal for forming cell membranes if two layers of molecules are situated back-to-back.

physiology  
The study of the normal functioning of body processes; also, the body processes themselves.

pituitary gland  
Also called the hypophysis, a complex pea-sized structure at the base of the brain, sometimes described as the body’s “master gland”. It produces various hormones, some affecting the body directly and others controlling the release of hormones by other glands.

placenta  
The organ that develops on the inner wall of the uterus during pregnancy, allowing the transfer of substances, including nutrients and oxygen, between maternal and fetal blood. See also umbilical cord.

plasma  
Blood minus its cellular components (red and white blood cells, and platelets).

platelets  
Specialized fragments of cells that circulate in the blood and are involved in blood clotting.

pleura (pl. pleurae)  
The lubricated membrane that lines the inside of the thoracic cavity and the outside of the lungs.

plexus  
A network, usually in reference to nerves or blood vessels.

pneum-, pneumo-  
1. Prefix relating to air. 2. Prefix relating to the lungs.

portal vein  
The large vein carrying blood from the intestines to the liver, previously known as the hepatic portal vein.

posterior  
Toward the back of the body, when considered in a standing position. Posterior to, behind. See also anterior.

process  
In anatomy, a projection or extended part of a bone, cell, etc.

progesterone  
A steroid hormone produced by the ovaries and placenta, which plays a role in the menstrual cycle and in the maintenance and regulation of pregnancy.

pronation  
The rotation of the radius around the ulna in the forearm, turning the palms of the hand to face downward or backward. In muscle names, pronator indicates a muscle that has this action, e.g. pronator teres. See also supination.

prostate gland  
A gland located below the male bladder; its secretions contribute to semen.

rectum  
The short final portion of the large intestine, connecting it to the anal canal.

rectus  
In muscle names, a straight muscle.

reflex  
An involuntary response in the nervous system to certain stimuli, for example the “knee-jerk” response. Some reflexes, called conditioned reflexes, can be modified by learning.

renal  
Relating to the kidneys.

respiration  
1. Breathing. 2. Also called cellular respiration, the biochemical processes within cells that break down fuel molecules to provide energy, usually in the presence of oxygen.

retina  
The light-sensitive layer that lines the inside of the eye. Light falling onto cells in the retina stimulates the production of electrical signals, which are transmitted to the brain via the optic nerve.

ribosomes  
Particles within cells involved in protein synthesis.

RNA  
Short for ribonucleic acid, a long molecule similar to DNA, but usually single- rather than double-stranded.

sacral  
Relating to or in the region of the sacrum, the bony structure made up of fused vertebrae at the base of the spine that forms part of the pelvic girdle.

sagittal section  
A real or imagined section down the body, or part of the body, that divides it into right and left sides.

sarcoplasm  
The cytoplasm of muscle cell, contains many nuclei.

scrotum  
The loose pouch of skin holding the testes in males.

sebum  
An oily, lubricating substance secreted by sebaceous glands in the skin.

semen  
The fluid released through the penis when the male ejaculates; it contains sperm and a mixture of nutrients and salts. Also called seminal fluid.

sensory  
Concerned with transmitting information coming from the sense organs of the body.

serous membrane  
A type of body membrane that secretes lubricating fluid and envelops various internal organs and body cavities. The pericardium, pleura, and peritoneum are all serous membranes.

sinus  
A cavity, especially: 1. One of the air-filled cavities in the bones of the face that connect to the nasal cavity. 2. An expanded portion of a blood vessel, for example the carotid sinus and coronary sinus.

skeletal muscle  
A type of muscle also known as voluntary or striated muscle, usually under voluntary control. Appears striped under the microscope. Many—but not all—skeletal muscles attach
to the skeleton, and are important in movement of the body. See also smooth muscle.

smooth muscle
Muscle tissue that lacks stripes when viewed under a microscope, in contrast to striated muscle. Smooth muscle is found in the walls of internal organs and structures, including blood vessels, the intestines, and the bladder. It is not under conscious control, but controlled by the autonomic nervous system.

somatic
1. Of or relating to the body, e.g. somatic cells.
2. Relating to the body wall.
3. Relating to the part of the nervous system involved in voluntary movement and sensing the outside world.

somatosensory
Related to sensations received from the skin and internal organs, including senses such as touch, temperature, pain, and awareness of joint position, or proprioception.

sperm
A male sex cell (gamete), equipped with a long moving “tail” (flagellum) to allow it to swim toward and fertilize an egg in the body of the female. Colloquially the word is also used to mean semen.

sphincter
A ring of muscle that allows a hollow or tubular structure in the body to be drawn closed (e.g. the pyloric sphincter and anal sphincter).

spinal cord
The part of the central nervous system that extends down from the bottom of the brain through the vertebral column, which protects it. Most nerves that supply the body originate in the spinal cord.

spinal nerve
A nerve in the central nervous system that is formed by the merging of the sensory and motor nerve rootlets.

tongue
A muscular organ attached to the floor of the mouth and protruding through the mouth.

spleen
A structure in the abdomen composed of lymphoid tissue. It has various roles, including blood storage.

starch
A plant carbohydrate made up of long, branched chains of glucose molecules linked together.

stem cell
A cell in the body that can divide to give rise to more cells. This could be either more stem cells, or a range of more specialized types of cell. Stem cells contrast with highly specialized cells, which play specific roles in the body, and which may have lost the ability to divide completely – such as nerve cells.

steroids
Substances that share a basic molecular structure, consisting of four rings of carbon atoms fused together. Steroids, which may be naturally occurring or synthetic, are classified as lipids. Many of the body’s hormones are steroids, including estrogen, progesterone, testosterone, and cortisol.

striated muscle
A muscle with tissue that presents a striped appearance under a microscope. Striated muscle includes skeletal muscles and cardiac (heart) muscle. See also smooth muscle.

sucrose
See sugar.

sugar
1. Commonly used foodstuff, also called sucrose.
2. Any of a number of naturally occurring substances that are similar to sucrose. They are all carbohydrates with relatively small molecules, in contrast to other carbohydrates that are macromolecules, such as starch.

sulcus (pl. sulci)
One of the grooves on the folded outer surface of the brain. See also gyrus.

superior
Higher up the body, when considered in a standing position. See also inferior.

supination
The rotation of the radius around the ulna in the forearm, turning the palms of the hand to face upward or forward. The opposite to pronation. In muscle names, supinator indicates a muscle having this action, e.g. the supinator of the forearm.

suprarenal gland
See adrenal glands.

suture
1. A stitched repair to a wound.
2. A rigid joint between two bones, as between the bones of the skull.

sympathetic nervous system
See autonomic nervous system.

symphysis
A cartilaginous joint between two bones, containing fibrocartilage.

synapse
A close contact between two nerve cells (neurons) allowing signals to be passed from the end of the first neuron on to the next. Synapses can either be electrical (where the information is transmitted electrically) or chemical (where neurotransmitters are released from one neuron to stimulate the next one). Synapses also exist between nerves and muscles.

synovial cavity
Cavity in a joint that is filled with a thin film of lubricating synovial fluid.

synovial joint
A lubricated, movable joint, such as the knee, elbow, or shoulder. In synovial joints the ends of the bones are covered with smooth cartilage and lubricated by a slippery liquid known as synovial fluid.

systemic
Relating to or affecting the body as a whole, not just one part of it. The systemic circulation is the blood circulation supplying all of the body apart from the lungs.

GLOSSARY
active in childhood, its roles include the maturation of T-lymphocytes.

**thyroid gland**
An endocrine gland located at the front of the throat, close to the larynx (voicebox). Thyroid hormones such as thyroxin are involved in controlling metabolism, including regulating overall metabolic rate. The hormone calcitonin, which helps regulate the body's calcium, is also secreted by the thyroid.

**tissue**
Any type of living material in the body that contains distinctive types of cells, usually together with extracellular material, performing a specific function. Examples of tissues include bone, muscle, nerve, and connective tissue.

**trachea**
The windpipe: the tube leading between the larynx and the bronchi. It is reinforced by rings of cartilage to keep it from collapsing.

**tract**
An elongated structure or connection that runs through a certain part of the body. In the central nervous system, the term is used instead of nerve for bundles of nerve fibers that connect different body regions.

**transmitter**
See neurotransmitter.

**tropomyosin**
Actin-bonding protein that is present in the thin filament of skeletal muscle.

**tunica adventitia**
The outermost coat of a blood vessel, which is composed of connective tissue and elastic fibers. See also tunica intima and tunica media.

**tunica intima**
The innermost lining of an artery; made up of a single layer of flattened cells, also known as the endothelium. Also present in veins. See also tunica media and tunica adventitia.

**tunica media**
Middle layer of muscle cells that is thinner in veins than in arteries.

See also tunica intima and tunica adventitia.

**umbilical cord**
The cord that attaches the developing fetus to the placenta of the mother, within the uterus. Blood from the fetus passes through blood vessels inside the cord, transporting nutrients, dissolved gases, and waste products between the placenta and the fetus.

**urea**
A small nitrogen-containing molecule formed in the body as a convenient way of getting rid of other nitrogen-containing waste products. It is excreted in the urine.

**ureter**
Either of two tubes that convey urine from the kidneys to the bladder.

**urethra**
The tube that conveys urine from the bladder to the outside of the body; in men it also conveys semen during ejaculation.

**uterus**
The womb, in which the fetus develops during pregnancy.

**valve**
In a vein, a pocketlike structure that allows deoxygenated blood to flow only toward the heart and prevents its backflow into cells. In the heart, it is present in each of the two atria and helps to direct the flow of blood in the chambers.

**ventricle**
1. Either of the two larger muscular chambers of the heart. The right ventricle pumps blood to the lungs to be oxygenated, while the stronger-muscled left ventricle pumps oxygenated blood to the rest of the body. See also atrium.
2. One of the four cavities in the brain that contain cerebrospinal fluid.

**venule**
A very small vein, carrying blood away from capillaries.

**vertebra (pl. vertebrae)**
Any of the individual bones forming the vertebral column or spine.

**villi (sing. villus)**
Small, closely packed, fingerlike protrusions on the lining of the small intestine, giving the surface a velvety appearance and providing a large surface area, which is essential for the absorption of nutrients.

**vitamin**
Any of a variety of naturally occurring substances that are essential to the body in small amounts, but which the body cannot make itself and so must obtain from the diet.

**white matter**
Present in the brain and spinal cord, and made up of the axons of neurons. See also gray matter.

**whole muscle**
Part of the skeletal muscle that is made up of fasciculi and covered in a layer of fascia (fibrous tissue) called epimysium.

**Z disc**
Present in the center of the isotropic or I band in skeletal muscle; it anchors the thin filaments. See also M line.

**zygote**
A cell formed by the union of two gametes at fertilization.
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