<u>Anatomy & Physiology entrance test for Laboratory Animal course</u>

Participants of a Laboratory Animal Science basic course in the Netherlands must give proof of their knowledge on basic vertebrate Anatomy/Zoology and Physiology (equal to 200 study hours or 7.5 ECTS for each subject). The knowledge will be judged by means of a test (50 questions multiple-choice ± 1,5 h in English) passed before entering the course. Those participants that don't pass can retest.

The Location : Usually in the CDP, the secretary will inform you by mail about the location.

Dates anatomy and physiology test: individually scheduled. Please mail Juliëtte Jonkers for an appointment via cdp-cursus@umcg.nl

The test encompasses the basic anatomy and physiology of vertebrates. The knowledge of the following 12 subjects will be tested.
The terms and principles in the descriptive text should be familiar; for self-test the links can be used. The text underneath is not meant for studying. For study material we would like to refer you to books or courses on vertebrate anatomy/physiology or on human anatomy and physiology.

Suggested books for preparing the A&P test:
Any comprehensive book on physiology/ comparative anatomy can be used and there are some learning tools available on internet. If you find it difficult to choose the following books might be useful:

Physiology:

Randall, D. et al, Eckert Animal Physiology
Berne, R.M. et al, Physiology
Ganong, W.F. Review of Medical Physiology
Moyes C.D. et al., Principles of Animal Physiology

Anatomy:
Liem, K.F. et al, Functional Anatomy of the Vertebrates
Kardong, K.V., Vertebrates: Comparative Anatomy, Function, Evolution
Romer, A.S. et al, The Vertebrate Body
Hildebrandt M. et al., Analysis of vertebrate structure

Anatomy and Physiology
Essentials of Anatomy & Physiology; Martini and Bartholomew, Pearson
Anatomie en fysiologie van de mens; Grégoire, Thiememeulenhoff

1. Organization of the Body

You should know what the anatomical position of the body is and in what direction the transverse, sagittal & coronal planes of the body lie.
Directional terms such as: proximal/distal; deep/superficial; superior/inferior; lateral/medial; anterior/posterior; caudal/ cranial (also called rostra or cephalic) dorsal/ventral; central/peripheral allow the location of one anatomical feature to be placed relative to another.
You should know the difference between physiology and anatomy and the definitions of metabolism, anabolism and catabolism.
Self-test:
https://wikieducator.org/Directional_Terms_Worksheet_1
https://wikieducator.org/Tissues_Worksheet

2. Skin (Integument)

The skin covers the body with the superficial epidermis, made of epithelial tissue, and the deeper dermis, containing much connective tissue. Under the dermis is the superficial fascia (also called the hypodermis despite NOT being part of the skin). Associated with these layers are hairs, feathers, claws, hoofs, glands and sense organs of the skin.

The most superficial layer of the epidermis is the waterproof stratum corneum. It is not comprised of living cells, hence affords the body great protection against dehydration and from bacteria in the same way that the peel of (say) an apple protects its contents.

The deepest layer of the epidermis is the stratum germinativum. Here keratinocytes are actively dividing. Melanocytes also inhabit this layer and produce melanin. Dendrocytes migrate to the skin from the bone marrow and become macrophages there. Merkel cells are one of the many sensory receptors found in the skin.

The dermis contains blood capillaries, hair roots, and several types of sensory receptors which may be free nerve endings or encapsulated. The dermis also contains the exocrine sweat and oil glands.

Self-test:

https://wikieducator.org/Skin_Worksheet

3. Motor system (skeleton, muscles)

The skeletal system can be divided into the bones of the skeleton and the joints where the bones move over each other. Each bone is an organ. They are classified as part of either the axial skeleton or the appendicular skeleton. In mammals bone may be termed compact (dense) or spongy (cancellous).

Compact bone is found in the shaft (the diaphysis) of long bones and is composed of microscopic cylindrical structures called osteons. These are lamellar structures with osteocytes within lacunae that surround a central canal that contains blood vessels. The central canal can exchange material with the lacunae via little channels called canaliculi.

Spongy bone is found in the ends (the epiphyses) of long bones and is composed of bony trabeculae. Marrow is found in the shaft of long bones and between the trabeculae of spongy bone. Active marrow produces red and white blood cells by haemopoiesis. Yellow marrow is inactive.

Bone is a storage place for calcium and is continually being remodeled by osteoclasts (which remove bone) and osteoblasts (which deposit bone). In the process, Ca is released or stored.

A bone is connected to an adjacent bone at an articulation (a joint) and they are bound to each other by ligaments. All the joints in the appendicular skeleton are freely moveable (synovial) joints and stabilized by tendons. Their free movement is produced when the muscles attached to them contract and is ensured by the smooth hyaline cartilage that covers the articulating bone surfaces and the lubricating synovial fluid within the joint capsule.

https://wikieducator.org/Skeleton_Worksheet

The muscles, in conjunction with the skeleton and joints, give the body the ability to move.

Skeletal muscle is attached to the skeleton, is voluntarily controlled, has cells that are very long “fibers” that are multinucleate and striated.

Skeletal muscle cells are distinctly different from cardiac and smooth muscle cells. The cells are called fibers, their plasma membrane is called sarcolemma, the cytoplasm is called sarcoplasm, the endoplasmic reticulum is called sarcoplasmic reticulum and the contracting structures within a myofibril of a muscle cell are called sarcomeres. Within a sarcomere are bundles of thick and thin myofilaments. The sarcolemma bundles many myofibrils together into a cell somewhat like a packet of spaghetti. Sarcomeres are joined end to end to form a long strand called a myofibril. The thick myofilaments are composed of the protein myosin. The thin myofilaments are composed of the protein actin, while the proteins, troponin and tropomyosin along with calcium ions and ATP participate in the physiology of contraction of a sarcomere.

Each cell/fiber is surrounded by a membrane called the endomysium which overlies the sarcolemma.

The endomysium and contains nerve axons and capillaries. A bundle of muscle fibers is called a fascicle and is surrounded by a connective tissue membrane called the perimysium. A muscle is a bundle of fascicles and the membrane surrounding a muscle is called the epimysium.

https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Muscles#Test_Yourself

4. Respiratory system

This is the system involved with bringing oxygen in the air into the body and getting rid of carbon dioxide, which is a waste product of processes that occur in the cell. It is made up of the trachea, bronchi, bronchioles, lungs, diaphragm, ribs and muscles that move the ribs in breathing.

Air passes through the nostrils the nasal cavity, the pharynx, the larynx, the glottis, the trachea, the bronchi into the bronchioles to finally reach the alveoli. Here oxygen diffuses through the membrane from the alveoli to the blood and carbon dioxide diffuses from the blood to the alveoli. The walls of the alveoli are part of the respiratory membrane that separates the air in the alveoli from the blood in the alveolar capillaries.

At the end of an inhalation, the volume of air that is within the respiratory tree but that has not reached the alveoli, is not in contact with the respiratory membrane and so does not participate in gas exchange. This volume of "fresh" air is called the anatomical dead space and is then exhaled. At the end of an exhalation, there is a volume of "stale" air within the bronchial tree that has yet to pass out of the body. Instead this stale air re-enters the alveoli, pushed in by the fresh air of the next inhalation.

The anatomy of the respiratory system in birds differs slightly, the main differences being the presence of air sacs and the absence of the diaphragm.

Respiration in fish makes use of direct diffusion between the gills and their huge surface and the surrounding water.

Carbon dioxide produced in the tissues dissolves in water to form carbonic acid ($CO_2 + H_2O \rightleftharpoons H_2CO_3$) Then the carbonic acid molecule disassociates to form the hydronium and bicarbonate ions ($H_2CO_3 \rightleftharpoons HCO_3^- + H^+$). The hydronium ions are buffered by hemoglobin in the red blood cells while the bicarbonate ions move into the blood plasma. When blood reaches the lungs, carbon dioxide moves from the blood to the alveoli and the two previous equations proceed from right to left. Hence, breathing out carbon dioxide causes acid (hydronium ions) to be converted to water. If the ability to breathe out is impaired, then acid is not excreted, so blood pH will fall and the body may be in respiratory acidosis.

Pressure Applied to the Respiratory System in Mammals

In mammals pressure differences are created in the pleural cavity by contraction of the diaphragm and the movement of the chest wall (see also Boyle's law). This provides the pressure gradients for inhalation and exhalation.

At the end of an inhalation, the air pressure in the alveoli is about 101 kPa (that is, equal to atmospheric pressure). The concentration of dissolved gases and their partial pressure in the alveolar fluid is similar to that in the alveoli. The solution concentration of these same gases in venous blood entering the alveolar capillaries is slightly lower than the atmospheric pressure. The partial pressure of O_2 being lower and of CO_2 being higher. Hence O_2 will diffuse down its concentration gradient from alveolar fluid across the respiratory membrane into the capillary blood. Similarly, CO_2 , will diffuse down its concentration gradient from the venous blood through the respiratory membrane into the alveoli.

Each lung is surrounded and enclosed by a two-layer membrane called the pleura.

The parietal pleura is attached to the inside of the chest wall, while the visceral pleura is attached to the surface of the lungs. The "space" between the two layers of the pleura is occupied by a few milliliters of lubricating pleural fluid which is at a negative pressure (i.e. a pressure less than atmospheric pressure) which is always less than the pressure within the alveoli. This ensures that as the chest expands during inhalation, the lungs are pushed outwards by the air pressure within them and inflate.

https://wikieducator.org/Respiratory_System_Worksheet

5. Circulation

Cardiovascular System This is also known as the circulatory system. It consists of the heart, the blood vessels and the blood. It transports substances around the body.

Blood

Blood is comprised of plasma which is an aqueous solution of proteins, blood clotting factors, dissolved ions, wastes, dissolved gases, glucose and cholesterol.

It also contains red blood cells (erythrocytes), platelets and white blood cells (leucocytes).

In addition blood has three buffer systems: the phosphate; the carbonic acid/bicarbonate system and the protein buffer which maintains blood pH between 7.35 and 7.45.

Blood transports: O_2 from the lungs to the body's cells by binding O_2 to hemoglobin; CO_2 from cells to the lungs; nitrogenous waste from cells (to kidneys and (sweat) glands or to the gills (fish)); absorbed nutrients from the small intestine to the liver and to cells; and hormones from endocrine system to target cells. Blood also transfers heat around the body. Blood is able to coagulate to minimize blood loss when a vessel is damaged and contains antibodies and complement proteins to defend against bacteria.

Blood cells are made in the active (red) bone marrow from stem cells called hemocytoblasts by the process known as hemopoiesis. The sequence of events that lead to of blood clotting is known as hemostasis, while bleeding is known as a hemorrhage. Oxygen is transported attached to hemoglobin within the red blood cells.

Blood coagulation occurs when a clot of insoluble fibrin is formed from fibrinogen. The transformation of fibrinogen is produced by the enzyme thrombin.

Heart

In fish with their single loop circulation, the heart only has one atrium and one ventricle. The oxygen-depleted blood that returns from the body enters the atrium, and then the ventricle, and is then pumped out to the gills where the blood is oxygenated, and then it continues through the rest of the body. In contrast to that, sustaining a double loop circulation amphibians and reptiles show various degrees of heart chamber formation. In birds and mammals the two loops are completely separated by the chamber formation.

In a four chambered heart the left ventricle contracts to pump blood through the aortic valve into the aorta from where it flows throughout the systemic circulation. Simultaneously, the right ventricle pumps the same volume of blood through the pulmonary valve into the pulmonary trunk from where it flows into the lungs. As the combined length of the blood vessels in the rest of the body is much greater than the combined length of the blood vessels in the lungs, the left ventricle has to contract with greater force than does the right ventricle. Consequently the muscle of the LV is much stronger (thicker) than that of the RV. As the ventricles begin to contract, the mitral (bicuspid) valve closes to prevent blood "regurgitating" from the LV into the left atrium. Simultaneously the tricuspid valve on the right, closes to prevent retrograde blood flow from the RV into the right atrium.

The student should be able to name the four main blood vessels that enter or leave the heart, the four chambers of the heart and the order of in which the blood it passes through them.

The myocardium is a tireless muscle in that it performs its cycle of contraction (systole) and relaxation (diastole) ceaselessly for the duration of a lifespan.

To perform this feat it must be well supplied with energy and oxygen. Twenty five percent of the volume of a cardiac muscle cell may be taken up by mitochondria which produce the required ATP. In turn the coronary arteries supply the cells with the oxygen that the mitochondria need to produce ATP.

Blood Vessels

Blood vessels that carry blood away from the heart are called arteries. The largest is the aorta. Additional arteries arise as the branches of the arterial tree divide and divide again to reach every part of the body. Eventually their diameter is small enough for the vessels to be called arterioles and they direct blood into a capillary bed. Artery walls are elastic and expand in diameter when the heart pumps blood into them and recoil to a smaller diameter during diastole as blood continues its flow towards the capillaries. This expansion and contraction may be felt as the "pulse" by palpating a superficial artery.

Blood vessels that carry blood towards the heart are called veins and have thinner walls but larger diameters than arteries. Venules drain blood away from capillary beds and join with each other to form larger veins and eventually become the inferior vena cava, if from that part of the body inferior to the diaphragm, or the superior vena cava if coming from the head, neck, arms and chest. Veins have valves which allow blood to flow towards the heart but not away from the heart. Furthermore, veins are compressed when the skeletal muscles that they pass by contract and this compression propels the contained blood through the valves. By this means, blood is lifted towards the heart against gravity

Both veins and arteries have smooth muscle within their vessel walls whose contraction produces vasoconstriction and whose relaxation produces vasodilation. In this way blood may be directed away from or towards a tissue as its requirements change.

Capillaries are the place at which nutrients and oxygen enter the blood (from the gills, gut and lungs). They are also the destination for the contents of blood. Capillaries in the muscles and other organs are the place to which oxygen, water, nutrients and electrolytes are delivered. From here they make their way by diffusion to the cells. From here also, wastes from the cells are collected to be in turn delivered to the capillaries of the gills, lungs, liver and kidneys. Consequently the structure of capillaries, facilitates exchanges between their lumen and the interstitial fluid.

Pressure: The Physics of Pressure

When fluids are flowing their behavior is complex but reasonably predictable. The rules or "laws" that allow us to predict such behavior are Boyle's law, Henry's law, Poiseuille's law, Pascal's principle, Bernoulli's theorem, Fick's law of diffusion, the law of partial pressures, and the ideal gas equation. Fluid flow in the body is complicated by the dilation and constriction of the airways and blood vessels; the ability of constituents in the gas or blood to move out of and into the tubes and vessels; and by the body altering the pressure differences generated by the muscular efforts of the heart and respiratory muscles, or by changing its posture.

Pressure Applied to the Cardiovascular System

Blood moves from the heart to the capillaries due to the pressure exerted by the heart muscle (and by gravity). The ventricles contract to force blood into the aorta and the pulmonary trunk and relax to allow blood from

the vena cava and pulmonary veins to enter them via the atria. The number of cycles per minute is called the heart rate. Aortic blood pressure oscillates between the systolic pressure (the maximum value) and the diastolic value (the minimum value). These values increase as the level of physical activity increases and return to their resting values after exercise. This constantly oscillating blood pressure causes the arteries to bulge and recoil and can be felt as "the pulse" in superficial arteries.
Blood moves from the capillaries to the heart due to gravity and when contracting muscles squash against veins which forces the contained blood through the venous valves. The valves ensure that blood can only flow towards the heart. In mammals the act of inhalation increases pressure in the abdomen and this also helps to push blood in the inferior vena cava towards the heart.

Blood Pressure and Its Control

The heart produces the pressure difference that is required to lift blood (with its contained oxygen) to the top of the head of a giraffe against gravity and to move blood through the other arteries despite blood's viscosity and the friction provided by the vessel walls. The body's need for oxygen changes as the level of bodily activity changes, so the movement of blood must change to match these requirements. That is, cardiac output must be sufficient to ensure that the demand for oxygen by the tissues is met. Cardiac output will increase if the heart rate increases and if the volume pumped by each stroke increases. These rates are set by the sino-atrial node and may be increased or decreased by stimulation from the "cardio-vascular center" of the medulla oblongata via the autonomic nervous system.
Blood experiences resistance to its flow which is overcome by the body's ability to adjust cardiac output, to dilate and constrict its blood vessels, and to some extent, to alter its blood volume.
Baroreceptors are located in the walls of arteries at strategic positions in the body . Over the short term, if BP falls, baroreceptor reflexes increase heart rate and force of contraction and promote vasoconstriction. The reverse happens if BP rises.
Chemoreceptors respond to an increase of CO_2, and to the decreased pH of blood that occurs as arterial pressure falls. They transmit signals to the vasomotor center which excites it to produce vasoconstriction. This increases blood pressure. They also signal the cardioaccelerator center which increases cardiac output. Hence more blood moves through the lungs and this allows the excretion of CO_2 and the intake of O_2 to increase.
In mammals long term control of blood pressure is achieved by the kidneys as they alter the amount of water that is filtered from blood and excreted in urine. Water loss in urine decreases the volume of blood and this in turn decreases blood pressure. Four hormones (angiotensin II, ADH, aldosterone, ANP) are associated with or act on the kidney to regulate urine volume and hence blood volume and BP.
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Cardiovascular_System/Blood#Test_Yourself
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Cardiovascular_System/The_Heart#Test_Yourself
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Cardiovascular_System/Blood_circulation#Test_Yourself

6. Digestive system

This is also known as the gastrointestinal system , alimentary system or gut . It consists of the digestive tube and glands like the liver and pancreas that produce digestive secretions. It is concerned with breaking down the large molecules in foods into smaller ones that can be absorbed into the blood and lymph. Waste material is also eliminated by the digestive system.
The contents of the gut are outside the body and are dangerous to the body. They include acid, protein digesting enzymes and bacteria. Vertebrates are protected from the gut contents by its mucosal lining and the cells of the lymphoid tissue (macrophages, dendritic cells, B-lymphocytes, and T-lymphocytes). The gut also contains ingested food molecules of protein, carbohydrate and triglyceride. Digestion (hydrolysis) is the disassembling of large food molecules and is necessary to reduce the very large polymer molecules in food to particles small enough to pass into the cells lining the gut. The products of hydrolysis of proteins are amino acids and di- and tripeptides. Carbohydrates are hydrolyzed into monosaccharides (glucose, fructose, galactose), while triglycerides are hydrolyzed into free fatty acids and monoglycerides. Nucleic acids (DNA & RNA) are hydrolyzed into nucleotides and then hydrolyzed by enzymes (nucleosidases & phosphatases) into their free bases, pentose sugars and phosphate ions.
Ingested food passes through the esophagus, stomach, small diameter intestine (duodenum, jejunum, ileum), large diameter intestine (caecum, colon, rectum), before the residue is eliminated. The movement is produced by peristalsis and is unidirectional, being controlled by deglutition-sphincters and valves.

Hydrolysis is achieved by enzymes in saliva and from glands in the stomach and duodenal mucosae and from the pancreas. The products of carbohydrate and protein digestion are absorbed by active transport (for glucose and amino acids), enter the blood capillaries and are transported to the liver by the hepatic portal vein. The products of triglyceride digestion diffuse through the plasma membranes of the cells lining the small intestine where they are reconstituted into triglycerides. They then combine with phospholipids and cholesterol, are coated with protein to form water-soluble chylomicrons. Chylomicrons enter the lymphatic vessels and eventually the blood stream.
https://wikieducator.org/Digestive_System_Worksheet
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/The_Gut_and_Digestion#Test_Yourself

7. Excretory system and osmoregulation

This is also known as the renal system. It removes waste products from the blood and is made up of the kidneys, ureters and bladder.
The kidneys are the major excretory organs of the body. They excrete the organic wastes urea, uric acid and creatinine. They regulate the volume of blood (and hence blood pressure) by increasing or decreasing the volume of urine produced to match the body's requirement for water. They help regulate blood pH by excreting hydronium ions and by reabsorbing and producing bicarbonate ions. They maintain blood osmolarity and individual ions (electrolytes) at their healthy concentrations.
The kidneys produce the enzyme renin, the hormone erythropoietin and the "vitamin" calcitriol. In turn the physiological functions of the kidney are influenced by ADH, aldosterone, parathyroid hormone, ANP, BNP and angiotensin II.
The nephron is the blood processing functional unit of kidney. The nephron consists of a glomerulus and a renal tubule. The renal tubule consists of the "Bowman's" capsule (which surrounds the glomerulus and receives the fluid filtered from the glomerulus) and the proximal
convoluted tubule, the descending and ascending limbs of the loop of Henle, and the distal convoluted tubule. A collecting duct receives filtrate from several nephrons.
Macroscopically the kidney consists of a superficial cortex (where all of the glomeruli are located) and the deeper medulla. The collection duct is called ureter that delivers urine to the storage bladder.
To understand the physiology of the kidney you must also understand how the
juxtaglomerular apparatus works and how the vasa recta and the loop of Henle operate within the osmotic gradient of the medulla. In addition it is useful to know how the cells of the renal tubules absorb or secrete Na^+, K^+, H_3O^+, Cl^-, Ca^{++}, NH_4^+ and HCO_3^- ions.
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Urinary_System#Test_Yourself
https://wikieducator.org/Excretory_System_Worksheet

8. Reproductive system

This is the system that keeps the species going by making new individuals. In mammals it is made up of the ovaries, uterus, vagina and fallopian tubes in the female and the testes with associated glands and ducts in the male.
In female mammals, the hypothalamus releases GnRH, which causes the anterior pituitary to release FSH (and LH). FSH acts on an ovary to stimulate development of some primordial follicles. They produce estrogens which cause the rate of production of GnRH to increase which in turn causes the anterior pituitary to release LH. LH promotes the development of one follicle and causes its ovum to be ovulated. This releases the ovum into the abdominal cavity from where it enters the Fallopian tube in which it may be fertilized. The remnant granulosa cells of the follicle develop into the corpus luteum which produces and releases progesterone. Progesterone prepares the uterus (its endometrium thickens) to receive a fertilized egg. The progesterone also decreases the rate of GnRH and FSH release so that additional primordial follicles aren't stimulated to continue their development. If pregnancy does not occur, the corpus luteum deteriorates and estrogen and progesterone levels drop. This drop allows the rate of GnRH release to increase and so the next cycle begins.
In male mammals, the hypothalamus releases GnRH, which causes the anterior pituitary to release FSH (and LH). LH stimulates the interstitial (Leydig) cells of testes to produce testosterone. FSH stimulates the nurse (sustentacular / Sertoli) cells in testes which, in the presence of testosterone, promotes spermiogenesis. Sperm are continually produced in the seminiferous tubules and stored in the epididymis. The vas (ductus) deferens transports sperm by peristaltic contractions to the ejaculatory ducts. Here the sperm mix with semen from the seminal vesicles (which capacitates them) and prostate fluid before being ejaculated through the urethra.
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Reproductive_System#Test_Yourself

9. Endocrine system

This is the system that produces chemical messengers or hormones. It consists of various endocrine glands (ductless glands) that include the pituitary, adrenal, thyroid and pineal glands as well as the testes and ovary.

Homeostasis

Homeostasis is the body's automatic tendency to maintain a relatively constant internal environment in terms of temperature, cardiac output, ion concentrations, blood pH, hydration, dissolved CO_2 concentration in blood, blood glucose concentration, concentrations of wastes etc.

Receptors monitor changes in these physiological variables, that is, they receive a stimulus. This stimulus is transmitted via an afferent pathway to an integrating center (e.g. the brain or a gland). The integrating center compares the stimulus to the normal level of the variable – the "set point". If a response is required a message is sent via an efferent pathway to the effector organ. The effector produces a response that moves the value of the variable back towards the set point

Thus using "negative feedback " the body is in a dynamic state of equilibrium because its internal conditions change and vary (oscillate) within relatively narrow limits.

Endocrine System

The organs of the endocrine system produce hormones. A hormone is a messenger molecule, made in small quantities by endocrine cells/glands and released into the blood circulation to coordinate cellular activities in distant tissues. Hormone molecules elicit a response in the target cells by attaching to a receptor on the cell's plasma membrane (or inside the cell) that is specific for that molecule.

The hypothalamus is a region of the brain that controls the endocrine system and integrates the activities of the nervous and endocrine systems in 3 ways.

(1) The hypothalamus produces and secretes regulatory hormones that control the secretion of different hormones from the endocrine cells in the anterior pituitary gland. In turn, the hormones released by the anterior pituitary, stimulate their target endocrine organs to produce and release hormones which go onto to influence the behavior of the body cells which have receptors for these hormones.

(2) The hypothalamus produces ADH and oxytocin which are transported to the posterior pituitary to be stored and released into the blood following appropriate stimuli.

(3) The hypothalamus contains "autonomic centers" that exert neural control over endocrine cells of the medullae of the adrenal glands. When activated, the adrenal medullae release hormones into the bloodstream.

Other important organs that participate in the production of hormones are:

The thyroid gland produces thyroxine and calcitonin. The latter decreases the concentration of Ca ions in the blood.

The parathyroid glands produce parathyroid hormone (PTH) which increases the concentration of Ca ions in the blood.

The adrenal glands produce many hormones. These include "mineralocorticoids" (e.g. aldosterone), "glucocorticoids" (e.g. cortisol, corticosterone) and "gonadocorticoids" (e.g. estradiol and the weak androgens androstenedione, dehydroepiandrosterone). The adrenal medullae produce epinephrine and norepinephrine.

The pancreas contains regions of cells (called Islets of Langerhans) that produce insulin (the beta cells), and glucagon (the alpha cells).

The testes produce testosterone and inhibin while the ovaries produce estrogens, inhibin and progesterone.

The pineal gland produces melatonin.

The kidneys produce erythropoietin,calcitriol ("vitamin D3") and the enzyme renin.

The liver (not regarded as an endocrine organ) produces the prohormone angiotensinogen which is converted by renin and then by "angiotensin converting enzyme" to the hormone angiotensin II.

The atria of the heart produce atrial natriuretic hormone (ANP) which blocks the secretion of renin.

https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Endocrine_System#Test_Yourself
https://wikieducator.org/Endocrine_System_Worksheet

10. Nervous system

Nervous System This system coordinates the activities of the body and responses to the environment. It consists of the sense organs, the nerves, brain and spinal cord.

Cells and Action Potential

Nerve cells are able to conduct an electrical impulse and are called neurons. Most neurons have an axon that carries an impulse away from the cell body and one, two or many dendrites that carry an impulse towards the cell body.

Other cells, collectively called neuroglia are support cells for neurons, but do not carry impulses. Within the CNS they are ependymal cells, astrocytes, microglia and oligodendrocytes, while in the PNS they are satellite cells and Schwann cells. Oligodendrocytes and Schwann cells form the myelin sheath around axons.
Within the neuron, the concentration of Na^+ ions is much less than their concentration in the interstitial fluid, while the concentration of K^+ ions is the reverse. This state- the resting potential is achieved through work of a Na/K exchange pump. The great difference in the distribution of these ions (and of other ions) results in the electrical potential on the inside of the neuron's membrane being negative with respect to the electrical potential on the outside of the plasma membrane. When an appropriate stimulus is received by a neuron, sodium channels open and Na^+ ions rush into the neuron (down their concentration gradient). Almost immediately, potassium channels open so that K^+ ions can rush out. This inflow of Na^+ ions followed by the outflow of K^+ ions is termed the "action potential" and propagates along the axon as the nerve impulse.
A nerve impulse will travel to the end of the axon where it reaches the axon terminals. These terminals will in turn stimulate the cell to which they are attached. This attachment is called a synapse. If the axon stimulates a muscle fiber, the meeting place is also called the neuro-muscular junction. The gap between the axon terminal and the adjoining cell is called the synaptic cleft and is crossed by a chemical (a neurotransmitter) released from the axon terminal. The neurotransmitter molecule binds to a receptor protein on the plasma membrane of the adjoining cell.
In this way, the neurotransmitter passes on the action potential to the next cell.

Brain and Spinal Cord Anatomy

The brain and spinal cord are enclosed by membranes called meninges: the dura mater, the arachnoid mater and the pia mater.
Together the brain and spinal cord are the "central nervous system" (CNS). The peripheral nervous system includes motor nerves that leave the CNS from the brain or the spinal cord and sensory nerves that bring information to the CNS. Sensory nerves are "afferent". That is, carry information from sensory organs to the brain – often via the spinal cord. Motor nerves are "efferent". That is, they carry commands from the brain (usually) to the muscles (usually). Motor and sensory nerve fibers attached to the brain are called cranial nerves and those attached to the spinal cord are called spinal nerves.
The brain consists of the cerebrum, diencephalon, brainstem and cerebellum while cerebrospinal fluid (CSF) rather than blood circulates through the ventricles within the brain, through the central canal of the spinal cord and between the arachnoid and pia maters.
A section through the brain displays gray-colored matter containing cell bodies and white-colored matter. The whiteness arises from the myelin that wraps around axons as, being a fat, myelin is white in appearance. The diencephalon includes the thalamus, the hypothalamus, and the pituitary and pineal glands. The brainstem comprises the midbrain, the pons, and the medulla oblongata.
In cross-section, the spinal cord displays its characteristic butterfly-shaped central gray matter region surrounded by the white matter of myelinated nerves. This white matter is either ascending tracts (carrying sensory information to the brain) or descending tracts (carrying motor instructions to muscles and glands). The axons of sensory neurons within a spinal nerve enter the spinal cord from the dorsal side, while the axons of motor neurons within a spinal nerve exit the spinal cord from the ventral side. This "dorsal root" and the "ventral root" meet and join.

Autonomic System, Neurotransmitters, Reflexes

The autonomic nervous system is not under our conscious control. It stimulates cardiac muscle, smooth muscle, the diaphragm and both exocrine and endocrine glands. Hence it controls heart rate, vasodilation, blood pressure, body temperature, respiration rate, digestive motility, and aspects of urinary function, reproductive function and endocrine function. The ANS has two divisions: the "sympathetic" division (SD) which mobilizes body during exercise, excitement, and emergency situations; and the "parasympathetic" division (PSD) which maintains body activities e.g. digestion, defecation, diuresis and conserves energy. Some organs are innervated by both divisions.
The vagus nerve (cranial nerve X) carries 90% of PSD impulses. Acetylcholine is a neurotransmitter released by the axon terminals of all PSD neurons.
Norepinephrine is a neurotransmitter released by the axon terminals of most SD post-ganglionic fibers. It is the type of receptor (not the neurotransmitter molecule) that determines whether the post-synaptic cell responds by being stimulated or being inhibited.
Reflexes are also not under our conscious control despite skeletal muscles being the source of many of the movements. This is because (for spinal reflexes) the sensory neuron carrying the afferent impulse synapses directly with a motor neuron(s) in the spinal cord that carries the efferent impulse to the responding muscles. An interpretation by the brain is not involved.

https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Nervous_System#Test_Yourself
https://wikieducator.org/Nervous_System_Worksheet

11. Sensory organs

A broadly acceptable definition of a sense would be "A system that consists of a group of sensory cell types that responds to a specific physical phenomenon, and that corresponds to a particular group of regions within the brain where the signals are received and interpreted." There is no firm agreement as to the number of senses because of differing definitions of what constitutes a sense.
The senses are frequently divided into exteroceptive and interoceptive:
Exteroceptive senses are senses that perceive the body's own position, motion, and state, known as proprioceptive senses. External senses include the traditional five: sight, hearing, touch, smell and taste, as well as thermoception (temperature differences) and possibly an additional weak magnetoception (direction).
Proprioceptive senses include nociception (pain); equilibrioception (balance); proprioception (a sense of the position and movement of the parts of one's own body).
Interoceptive senses are senses that perceive sensations in internal organs.
Non-human animals may possess senses that are absent in humans, such as electroreception and detection of polarized light.

Eye

Light that strikes the cone cells of the retina, first passes through the cornea, then the aqueous humor (in the anterior chamber of the eye , the pupil (the central opening in the iris), the lens and through the vitreous humor (in the posterior chamber). Both the cornea and the lens refract (bend) the light that passes through them. However it is the elasticity of the lens which allows its focal length to be changed, that brings light from any viewed object, regardless of its distance from the eye, to a focus on the retina. This focusing process is called accommodation. It is achieved by the donut shaped ciliary muscle surrounding the lens and attached to it by the ciliary fibers. By relaxing into a larger diameter hole the ciliary muscle pulls the ciliary fibers tight, which stretches the biconvex lens to a thinner shape. This thinner shape has a longer focal length which is suited to viewing objects that are distant from the eye.
Away from the *fovea centralis*, light striking the rod or cone cells of the retina must first pass through the layer of ganglion cells and bipolar cells that transmit the impulses generated by the rods and cones to the optic nerve. The axons of the ganglion and bipolar cells, as well as blood vessels gather together as the optic nerve (cranial nerve II) to pass out of the eyeball at the optic disc. This area (the blind spot) is insensitive to light as there are no rods or cones there. There are three types of cone cells that are maximally sensitive to one of either red, green or blue light (they are sensitive also to other wavelengths, just less so). Their combined effect allows us to perceive color. Rod cells are useful for seeing in conditions where the intensity of light is low such as at night, but are unable to distinguish color.

Ear

Sound is directed into the ear canal by the pinna (ear lobe) where the air pressure variations cause the tympanic membrane to bow in and out. Via ossicles in the middle ear the soundwaves are transformed into vibrations of the liquid (perilymph). This causes the basilar membrane of the cochlea and organ of Corti to “rise and fall” which in turn causes the hair cells of the organ of Corti to rub against the tectorial membrane that is located just overhead. The hair cells are stimulated by this contact and pass on the stimulus to a branch of the auditory nerve (cranial nerve VIII).
One decibel (dB) is a tenth of a bel. It is a unit of “level” and is the logarithm of the ratio of two sounds – one being the reference sound, which for the case of sound level measurement is “silence” (=0 dB). Silence does not mean that sound energy is absent, rather it means that the human ear cannot hear it.
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/The_Senses#Test_Yourself
https://wikieducator.org/Special_Senses_Worksheet

12. Lymphatic system

This system is responsible for collecting and “cleaning” the fluid that leaks out of the blood vessels. This fluid is then returned to the blood system. The lymphatic system also makes antibodies that protect the body from invasion by bacteria etc. It consists of lymphatic vessels, lymph nodes, the spleen and thymus glands.
https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Lymphatic_System#Test_Yourself

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