

# Glossary

- A-band** Region in a sarcomere that appears dark when viewed microscopically, corresponding to the location of the myosin filaments.
- Abiotic** Term referring to non-biological (physical and chemical) variables in the environment such as temperature, oxygen and availability of water.
- Absolute refractory period** Short period after an action potential is triggered when no further action potential can be triggered, regardless of stimulus intensity.
- Absolute zero (0 K or  $-273.15^{\circ}\text{C}$ )** The temperature at which substances have no thermal energy and their composite molecules do not move.
- Acclimation** The process in which an animal adjusts to an artificial change in its environment, usually of one variable, in a laboratory.
- Acclimatization** The process in which an animal adjusts to gradual changes in the natural environment, and which enable the animal to maintain or even enhance its performance.
- Acetylcholine** Major neurotransmitter at the chemical synapses of most animals.
- Acrosomal reaction** A series of events in the acrosome – the organelle that develops at the tip of the sperm's head – when it contacts an egg, which facilitates its penetration of the outer layer of the egg.
- Actin filaments** The thinnest filamentous structures of the cytoskeleton made of the protein actin; the actin filaments are involved in cell shape changes and various forms of cell motility, such as muscle contraction.
- Action potential** All or nothing electrical signal that propagates rapidly along axons without a decrease in amplitude.
- Activation energy** The minimum amount of energy reactant molecules must possess in order for the reaction to proceed.
- Active transport** The transport of a solute across a membrane using metabolic energy against a concentration difference if the solute is not electrically charged, or against an electrochemical potential difference if the solute is electrically charged.
- Adaptation** *Evolutionary adaptation:* changes within a population over many generations driven by natural selection in response to persistent changes in the environment. *Sensory receptor adaptation:* Gradual decrease of a sensory receptor response to a stimulus of constant intensity.
- Adipocytes** Cells that are specialized to store fat.
- Adrenal cortex** The outer part of the adrenal gland of mammals, which produces steroid hormones in response to adrenocorticotropic hormone (ACTH) and other controlling factors.
- Adrenal medulla** The inner part of the adrenal gland of mammals consisting of modified post-ganglionic neurons (chromaffin cells) that form an extension of the sympathetic nervous system and function as neuroendocrine cells, which release catecholamines into circulation.  
*See also chromaffin cells and catecholamines.*
- Adrenaline** The main hormone secreted by the adrenal medulla of most mammals, and contained in some neurons; also called epinephrine.
- Adrenoceptors (adrenoreceptors)** Class of G-protein coupled receptors that are activated by adrenaline and noradrenaline; the adrenoceptors are of two types:  $\alpha$ -receptors and  $\beta$ -receptors (and several subtypes), which determine the type of response elicited in the target tissue.
- Aerobic dive limit** The duration of a natural dive beyond which the concentration of lactic acid during recovery from the dive increases above the resting level.
- Aerobic pathway** Metabolic pathway requiring molecular oxygen.
- Aerobic metabolism (aerobic respiration)** Metabolic pathway consisting of four segments: aerobic glycolysis, oxidative decarboxylation of pyruvate, TCA (Krebs) cycle and oxidative phosphorylation, in which oxygen is used to transfer energy from molecules such as glucose and fatty acids to ATP with the formation of carbon dioxide and water as end products.
- Aerobic scope** The difference between the maximum sustainable rate of oxygen consumption by an animal and its resting rate of oxygen consumption.
- Aerofoil** Streamlined surface that generates lift when air flows over it; the aerofoil has a rounded leading edge, a sharp trailing edge and curved upper and lower surfaces.
- Aestivation** A prolonged dormancy characterized by inactivity, and low metabolic rate, in response to high temperatures and/or arid conditions.
- Afferent** A vessel or nerve going toward the organ supplied—for example, afferent neurons carrying signals from sensory structures to the central nervous system.
- Affinity** The strength of binding between two molecules e.g. oxygen binding to a blood pigment or hormone binding to specific receptors.
- Afterpotential** The short transitory phase immediately following the rapid repolarization of the membrane following an action potential before it returns to the resting level.
- Agonist** Compound that binds to and activates a specific type of receptor.
- Air sacs** Thin-walled sacs attached to the bronchi of the lungs of birds and some species of reptiles; the air sacs receive the inspired air after it has passed through the lungs. Thin-walled air sacs may also be part of the tracheal respiratory system in some species of insects.
- Albedo** The fraction of the incident light or radiation that is reflected by an object; a perfect reflector has an albedo of 1.0 and a perfect absorber has an albedo of 0.0.
- Aldosterone** A steroid hormone produced by the adrenocortical tissue of tetrapods, which stimulates potassium secretion and sodium conservation by the kidney of tetrapods, parts of the gastrointestinal tract, sweat glands of mammals, and the urinary bladder and skin of amphibians.
- Alimentary canal** *See gastrointestinal tract.*
- Alkaline tide** The tendency for plasma pH of terrestrial vertebrates to increase (become more alkaline) following a meal, usually consisting of other animals.

- Allele** A heritable genetic variant of a particular sequence in the genome.
- Allometric relationship** If  $y$  in the scaling equation ( $y = a x^b$ ) is a biological trait such as the metabolic rate that would be expected to vary in proportion to a body size attribute such as the body mass ( $x$ ) and the experimentally determined scaling factor  $b$  is different from the expected value (in this example if  $b$  is different from 1), then the observed relationship is said to be allometric.
- Allostasis** The ability of animals to regulate their internal environment to a range of stable conditions (rather than to one stable set of conditions, as in homeostasis) particularly in response to challenging environmental changes. A key aspect of the concept of allostasis is the proactive ability to change physiological variables in advance of demand.
- Altricial** A species in which the young hatch or are born at a relatively early stage in development, with their eyes closed and with them being incapable of coordinated movement.
- Alveoli** Sac-like endings to the smallest bronchioles in the lungs of mammals, where gas exchange occurs.
- Ammonotelic** Animals that excrete the majority of their nitrogenous waste as ammonia.
- Ampullae (semicircular canals)** Enlargements at the base of the semicircular canals in the inner ear.
- Anabolism** The set of metabolic pathways that lead to the synthesis of new, more complex molecules from simple precursor molecules.
- Anadromous** The migration of an aquatic animal from the seas and oceans up rivers to spawn.
- Anaerobic (or lactate) threshold** The transition between sustained and exhaustive exercise during progressively higher work rates, when lactate begins to accumulate in the blood.
- Anaerobic glycolysis** The occurrence of glycolysis under conditions of limited oxygen availability.
- Anaerobic metabolism (anaerobic respiration)** Metabolic pathway that occurs in the cytosol without use of oxygen. The amount of energy released that can be utilized by cells from the anaerobic metabolism of glucose, called anaerobic glycolysis, is only a small fraction of that obtained from the aerobic metabolism of glucose. The end product of anaerobic glycolysis in vertebrates is lactic acid, which must be removed at a later date.
- Anaphase** Fourth phase of mitosis during which sister chromatids become daughter chromosomes.
- Anatomical dead space** Region of a gas-exchange organ where there is little or no gas exchange, such as the trachea in vertebrate lungs.
- Androgens** Any steroid hormone that stimulates the development and maintenance of male characteristics, including testosterone in most vertebrates, 11-keto testosterone in fish, and synthetic compounds.
- Angiogenesis** The process of formation of new blood vessels, which involves the growth and differentiation of endothelial cells that line the inner wall of the blood vessels.
- Angiotensin II** An octapeptide hormone formed from the decapeptide angiotensin I; angiotensin II causes constriction of blood vessels and stimulates the release of steroid hormones from adrenocortical tissue/adrenal cortex.
- Anhydrobiosis** A state of almost complete dehydration and reduced metabolism survived by some animals e.g. water bears.
- Animalia** The animal kingdom.
- Annelids** Animals of the phylum Annelida; segmented worms and a few that have secondarily lost distinct segmentation.
- Anoxia** The state of a complete lack of oxygen in the environment or in the blood supplying the tissues. Environments or tissues in the body where there is a complete absence of oxygen are termed anoxic.
- Antagonist** Compound that binds to and prevents the activation of a specific type of receptor.
- Anterior pituitary** The pars tuberalis and non-neural lobe of the pituitary gland (= adenohypophysis), which synthesizes, stores and secretes the peptide hormones thyroid stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), growth hormone (GH), prolactin, the gonadotrophins (FSH and LH) and melanocyte stimulating hormone (MSH).
- Antidiuretic hormones** Hormones that reduce urine excretion, such as the neurohypophysial peptides: arginine vasopressin in mammals and arginine vasotocin in non-mammalian vertebrates.
- Antifreeze compounds** Synthesized substances that lower the freezing point of body fluids.
- Antioxidants** Molecules that act as scavengers of free radicals.
- Antiport carriers (exchangers)** Carriers that transport two coupled molecules in opposite directions.
- Apical membrane** The part of the plasma membrane of polarized cells that faces toward the external environment or the lumen of a cavity.
- Apnoea** An absence of ventilation.
- Apodeme** Ingrowth of the exoskeleton to which muscles are attached.
- Apoptosis** A process of programmed cell death during normal tissue growth or development and in response to DNA damage.
- Appendix (gastrointestinal tract)** A pouch-like sac that connects to the first part of the colon (caecum) in mammals.
- Aquaporins** Specific proteins that form channels in the membranes of cells that allow water to pass through the membrane (water channels).
- Arachnids** Animals in the Class Arachnida, which encompasses spiders, mites and scorpions. Arachnids are part of the subphylum Chelicerata (phylum Arthropoda).
- Arboreal** Animals that move about or live in trees.
- Archaeans** Micro-organisms similar to bacteria in size and their simple structure but radically different in molecular organization. Archaeans constitute one of the three domains of organisms.
- Arginine vasopressin (AVP)** A nonapeptide hormone synthesized by neurosecretory cells in the mammalian hypothalamus, which is stored in the axon terminals in the posterior lobe of the pituitary gland; AVP causes arteriolar vasoconstriction and has antidiuretic actions on the kidney.  
*See also Posterior pituitary.*
- Arousals (from torpor)** Periods between bouts of torpor when most species of hibernating animals increase their body temperature almost back to that at which it is regulated during the summer.
- Arthropods** The most diverse grouping of animals (phylum Arthropoda), which includes arachnids, hexapods (insects and springtails), crustaceans and myriapods (centipedes and millipedes), characterized by a segmented body, jointed appendages and a rigid waterproofed exoskeleton.
- Aspiration breathing** The sucking of air into an air bladder or lung by expanding the surrounding part of the body.
- Astrocytes** Most abundant type of glial cells of vertebrates; the astrocytes provide metabolic support to neurons.

**Asynchronous flight muscles** Flight muscles in most insect groups attached to an elastic thorax that flicks between two configurations at considerably higher rates than the rate of muscle stimulation by the nerves such that the wings do not move in synchrony with the nerve impulses.

**ATP (adenosine triphosphate)** Molecule acting as the common currency for energy transfer and utilization in animal cells.

**Atrial natriuretic peptides** Peptide hormones released from the atria of vertebrate hearts, mainly in response to stretching of the myocytes, whose actions include the stimulation of salt-excretion by the kidney (natriuresis) and other osmoregulatory organs, and dilation of the vasculature.

**Atrioventricular node** The subordinate pacemaker in the heart of vertebrates located in the wall of the right atrium of air breathers.

**Atrium (plural atria) (heart)** A chamber of the heart which receives the blood returning from the body.

**Auditory apparatus** Part of the auditory system where the mechano-electrical transduction of the sound waves into action potentials takes place.

**Autocrine secretions** Chemical secretions that usually act on the cells that produce them.

**Autonomic (visceral) nervous system** Part of the peripheral nervous system that connects the CNS with sensory structures and internal organs (viscera) and exerts involuntary control of bodily functions.

**Axon** The anatomical part of a neuron that carries signals away from the soma.

**Axon terminals** The endings of an axon that allow transmission of signals from one neuron to another or to an effector cell.

**Baroreceptors** Mechanosensory neurons that sense pressure, such as blood pressure in the circulatory system.

**Baroreflex** Fast negative feedback response, which helps regulate blood pressure on a short-term basis.

**Basal metabolic rate** The minimum amount of energy consumed (and heat produced) by an animal, in order to keep it alive. In endotherms, this is normally measured as the rate of oxygen consumption in animals that are in a non-reproductive state, post-absorptive, in the inactive part of their daily cycle and in their thermoneutral zone.

**Basement membrane** A thin extracellular matrix composed of glycoproteins and collagen that forms a sheet underlying a layer of epithelial cells (in gas-exchange organs, kidney tubules, or gastrointestinal tract), mesothelial cells (e.g. forming the sac around the heart) or endothelial cells (e.g. lining blood vessels or lymph vessels).

**Basilar membrane** Membrane that separates the cochlear duct from the tympanic duct in the inner ear.

**Basilar papilla** The hearing organ in birds, reptiles and some amphibians; it is a blind-ended tubular structure that is homologous to the organ of Corti in mammals.

**Basolateral membranes** The part of the plasma membrane of epithelial cells at the basal and lateral sides of the cell.

**Bathypelagic zone** An oceanic zone beneath the mesopelagic zone that extends from around 1000 m to around 4000 m in depth.

**Behavioural thermoregulation** The use of behaviours such as basking or sheltering by ectotherms to maintain a relatively constant body temperature. Endotherm behaviours also assist in their maintenance of relatively constant body temperature.

**Benthic** Animals that live and feed on the bottom of rivers, lakes and seas.

**Bimodal breathers** Animals which can use either air or water for gas exchange.

**Biodiversity** The number of different species and the variations within these species in a small area, ecoregion, biome or the entire planet.

**Biological clocks** Inbuilt, endogenous rhythms that allow organisms to coordinate their physiological functions and behaviour with predictable changes in their environments.

**Biomarkers** Naturally occurring markers or indicators of a biological state or condition.

**Biomes** Similar ecosystems found on different landmasses or in different oceans, which are characterized by their physical, chemical and climatic characteristics, and the interacting communities of animals and plants supported.

**Biomineralization** The process by which living organisms produce biominerals by incorporating minerals such as calcium into an organic matrix, to form exoskeletons, shells, internal calcareous plates, or internal skeletons.

**Blastocoel** The fluid-filled cavity that develops in the interior of the blastula/blastocyst (in mammals) early in the cleavage of the oocyte (ovum) after fertilization.

**Blastocyst** A sphere of cells formed by division of a fertilized ovum of mammals; it has an inner cell mass that develops into the embryo and outer layers of cells that form the embryonic part of the placenta.

**Blastopore** The first opening of the developing embryo.

**Blood pressure** The pressure generated in a circulatory system by the contraction of some part of that system, normally a discrete heart.

**Blood-brain barrier** Selective membrane interface that separates the blood plasma from the cerebrospinal fluid (CSF) allowing the CSF composition to differ from that of the blood plasma.

**Body and/or caudal fin swimming** Type of swimming in fish by lateral movements of the body and/or tail.

**Bohr effect** The inverse relationship between the affinity of a blood pigment for oxygen and both the acidity and concentration of carbon dioxide.

**Bony fish** A diverse taxonomic group of fish (Osteichthyes) which have a bony skeleton, and which form two sub-groups: lobe-finned fish (sarcopterygians) and the ray-finned fish (actinopterygians).

**Boundary layer** A thin layer of a fluid close to a solid surface in contact with a moving stream of that fluid in which flow velocity varies from zero at the solid surface to approximately free stream velocity at the boundary.

**Bowman's capsule** The cup-like beginning of the tubular part of a vertebrate nephron, which holds the glomerulus and collects the glomerular filtrate (primary urine).

**Boyle's Law** Describes how any change in the volume of a gas in a container held at constant temperature leads to an inverse change in the pressure of that gas.

**Brackish water** Water of intermediate salinities between that of seawater and fresh water.

**Bradycardia** A heart rate that is below the normal resting level.

**Bradykinin** A nine-amino acid peptide that causes blood vessels to dilate and blood pressure to fall; it is also a potent activator of nociceptors when produced by damaged cells.

**Brainstem** The midbrain together with the medulla and the pons.

**Brown adipose tissue** Very heavily vascularized adipose tissue packed with mitochondria and small fat droplets. Its function is to generate heat.

- Brush border** The collection of microvilli extending from the luminal membrane of some epithelia that increase the surface area for transport processes. Brush borders characterize the epithelial lining of the digestive tract and the luminal membrane of the proximal segment of the renal nephron.
- Buccal cavity** Mouth.
- Buccal force pump** An active part of the ventilatory cycle of fish and some amphibians caused by the closure of the mouth forcing water or air through the gill mesh or into the lungs.
- Buffer capacity** The ability of a solution to resist changes in pH.
- Buffer systems** Substances that help maintain the pH of body fluids within the normal range.
- Bundle of His** Specialized heart cells which conduct electrical impulses from the A-V node to the ventricles in mammals.
- Ca<sup>2+</sup>-pumps** ATP-dependent Ca<sup>2+</sup>-pump proteins, which occur in all cells, and are of two types: (i) Ca<sup>2+</sup> pumps on the surface membrane of the sarcoplasmic/endoplasmic reticulum and (ii) Ca<sup>2+</sup> pumps in the plasma membrane where they pump Ca<sup>2+</sup> out of the cell cytosol.
- Ca<sup>2+</sup>-transient** Dynamic change in cytosolic Ca<sup>2+</sup>-concentration in response to stimulation.
- Caecum** A pouch-like structure at the junction between the small and the large intestine in mammals.
- Calcium channels** Membrane channels that are selective to the passage of calcium ions (Ca<sup>2+</sup>) when open.
- Calmodulin** Highly-conserved cytosolic Ca<sup>2+</sup>-binding protein that binds to various molecules and regulates the function of many cellular processes.
- Calorimeter** Piece of equipment that measures the amount of heat produced by an animal at constant temperature and pressure.
- Capacitance (electrical)** An ability to store electrical charges (for instance, in cell membranes).
- Capacitation** Functional maturation of mammalian spermatazoa, which is necessary before they are able to penetrate and fertilize an ovum.
- Capillaries** Tubes of endothelial cells inside a delicate basement membrane, where the exchanges of gases, water, ions, metabolic substrates, metabolites and hormones take place between the organs/tissues (or respiratory fluid) and the circulating blood.
- Cardiac (heart) muscle** Muscle responsible for the pumping action of an animal's heart.
- Cardiac output** The volume of blood pumped from the heart per unit time.
- Cardiac stroke volume** The amount of blood ejected from the heart per beat.
- Carnivores** Animals that eat food items of animal origin.
- Carotid bodies** Major peripheral chemoreceptors involved in the control of ventilation in mammals, which are mainly sensitive to a decrease in the partial pressure of oxygen.
- Carrier proteins** Proteins that bind to specific molecules and transport them across cellular membranes.
- Catabolism** The set of metabolic processes whereby larger molecules such as food particles are broken down into simpler molecules.
- Catadromous** The migration of an aquatic animal moving down a river into the sea to spawn.
- Catalysis** The increase in the rate of a reaction as a result of the participation of an additional substance called a catalyst, which is not itself consumed in the reaction. Enzymes catalyse biochemical reactions.
- Catalytic rate constant (k<sub>cat</sub>)** A measure of the maximum number of substrate molecules converted to a product per unit time when an enzyme is saturated with substrate.
- Catch muscle** Smooth muscle that can develop a state of contraction (called catch), whereby large forces are maintained with little consumption of metabolic energy.
- Catecholamines** Molecules that contain the catechol group (benzene with two hydroxyl groups) such as noradrenaline, adrenaline and dopamine.
- Caudal nervous system** One of the three components of the autonomic nervous system in arthropods innervating the hindgut and the reproductive organs.
- C-cells** Clear cells which secrete calcitonin in mammals; these cells occur between the thyroid follicles.
- Central nervous system** The part of the nervous system that acts as the processing centre for the nervous system as a whole.
- Central pattern generators** Neural circuits capable of producing rhythmic motor patterns independent of sensory input such as the rhythmic pattern of action in breathing, walking and chewing.
- Centrioles** Two cylindrical structures in the centrosome, perpendicular to each other, which are involved in the formation of the mitotic spindle apparatus that segregates chromosomes during cell division.
- Centrosome** Organelle located close to the nucleus to which the microtubules present in the cell are attached.
- Cephalopods** A group of highly mobile molluscs (class Cephalopoda), such as octopuses and squid, with a well-developed brain and high mobility.
- Cerebellum** Part of the hindbrain located behind the top part of the brainstem. The cerebellum regulates motor movements.
- Cerebral cortex** The thin layer of the brain tissue that covers the outer portion of the cerebrum.
- Cerebral hemisphere** One of the two hemispheres of the cerebrum (telencephalon).
- Cerebrospinal fluid** Clear extracellular fluid that fills the space between central nervous system tissue and the meninges in vertebrates, as well as the cavities (ventricles) within the brain and the central canal of the spinal cord.
- Cerebrum** One of the two regions of the forebrain in vertebrates located in the upper part of the cranial cavity. Also called telencephalon.
- Channel proteins** Proteins that form pores through membranes to facilitate the passage of specific water-soluble molecules from one side of the membrane to the other.
- Chaperone proteins** A group of proteins, including heat shock proteins, which guide the folding and/or assembly of other proteins, including those damaged by cellular stress.
- Charles' Law** States that any change in the absolute temperature of a gas in a flexible-walled container causes a proportional change in the volume of that gas.
- Chemical synapse** Specialized communication sites between two excitable cells, where signal transmission occurs via chemical transmitter molecules.
- Chemo-mechanical cycle** Cyclic interaction between myosin heads and actin-filaments that produces force in muscle with consumption of MgATP.
- Chemoreceptors** Sensory receptors that are sensitive to the presence of specific molecules and ions.
- Chitin** A structural polysaccharide made of nitrogen modified glucose units, which forms a linear structure similar to that of cellulose. The exoskeleton of arthropods is made of chitin.



- Chloride cells** Specialized epithelial cells in the gills of marine teleosts that excrete sodium chloride.
- Chloride channels** A structurally and functionally diverse group of anion-selective channels involved in a variety of physiological processes e.g. volume regulation, fluid secretion, and regulation of the excitable tissues (neurones, and muscle cells).
- Chordates** Animals belonging to the phylum Chordata, which includes vertebrates, tunicates and cephalochordates, and which at least at some stage of development have a notochord, a dorsal nerve cord, repeated muscle blocks (myotomes) on either side of their body, and gill slits.
- Chordotontal organ** Internal mechanoreceptor organ in arthropods.
- Chorioallantoic membrane** A vascular membrane lining the inner shell membrane in the eggs of birds and mammals where gas exchange with the circulation occurs.
- Chorionic gonadotropin** A peptide hormone that maintains a functional corpus luteum in pregnant primates and horses after the blastocyst begins to implant and its outer layer, the chorion, begins to form the embryonic placenta.
- Choroid** A pigmented, highly-vascular membrane of the eye that lies behind the retina; its main functions are to nourish the retina and absorb scattered light.
- Chromaffin cells** Neuroendocrine cells in the medulla of mammalian adrenal glands, and more diffusely in other vertebrates, which release catecholamines.
- Chromatids** One half of two identical (sister) copies of a replicated chromosome linked at the centromere.
- Chronic response** A response that occurs after a persistent change in environmental conditions lasting days to months.
- Chronobiotic agent** Any agent, such as the hormone melatonin, that influences the biological clocks controlling body rhythms.
- Chylomicrons** Small droplets (<1  $\mu\text{m}$ ) of a mixture of lipids and proteins used to transport dietary lipids from the intestines to other locations in the body of mammals.
- Chyme** The semiliquid paste-like mass of partially digested food that passes from the stomach into the intestine.
- Circadian clocks (rhythms)** Endogenously generated, approximately 24 hour (daily) cycles in physiological processes.
- Circannual rhythms** Endogenously generated, approximately annual cycles in physiological processes, such as hormone secretion.
- Circulatory system** The system responsible for supplying cells with oxygen and metabolic substrates, facilitating communication between various tissues and organ systems, and removal of waste products and heat produced by cells. (i) In a **closed** circulatory system, blood is pumped around the body within closed tubes (arteries, arterioles and capillaries, venules, veins) which are lined with endothelium or endothelium-like cells. (ii) In an **open** circulatory system, blood (haemolymph) is pumped into a branching system of arteries and finer vessels, which are not lined by endothelium or endothelium-like cells, from which it enters a system of sinuses or smaller spaces, collectively known as a haemocoel.
- Circumventricular organs (CVOs)** Specialized vascularized areas of the brain, around the margins of the ventricles, which have an incomplete blood-brain barrier, and which allow sensory functions by some CVOs, such as detection of plasma osmolality, and secretory function by other CVOs, such as the pineal gland and pituitary gland.
- Clade** A grouping of organisms that includes a common ancestor and all its living and extinct descendants.
- Cladogram** Branching diagram showing the phylogenetic relationship between organisms.
- Claudins** A family of membrane proteins that are important components of tight junctions between epithelial cells where they control the movement of molecules between the cells.
- Clearance (renal clearance)** The volume of blood plasma that would need to be completely cleared of a solute per unit time to account for the amount of the solute excreted per unit time.
- Cleidoic eggs** Self-contained encased eggs, which occur in all birds and reptiles, a few mammals (monotremes) and terrestrial insects, and which provide all the nutrients needed by the developing embryo as yolk and albumen.
- Cloaca** The common chamber at the end of the digestive tract in vertebrates (except most mammals) and certain invertebrates into which intestinal, genital and urinary products are released.
- Cochlea** Bony structure resembling a snail's shell, which forms part of the inner ear, and in which the auditory apparatus is located in mammals.
- Cochlear duct** The central compartment in the cochlea filled with endolymph, which is separated by Reissner's membrane from the vestibular duct and by the basilar membrane from the tympanic duct.
- Coelom** The main body cavity in most animals.
- Cold receptors** Sensory nerve cells that respond to the cold. In mammals, cold receptors are located in or immediately below the epidermis and have a rather flat response curve, slightly increasing their firing rate as skin temperature falls below its normal level, and more dramatically decreasing the rate as skin temperature increases above its normal level.
- Coleopterans** The largest and most diverse order (Coleoptera) of insects, including beetles, weevils and fireflies.
- Collagen** Main protein component of connective tissue in vertebrates; the basic unit of collagen consists of three polypeptide chains coiled around each other in a triple helix, which confers strength to the connective tissue.
- Colligative properties** Properties of solutions that depend on the total number of particles dissolved in a volume of solvent, rather than the chemical nature of the particles. Important colligative properties in animal physiology are osmotic pressure due to osmolarity, freezing point depression, and vapour pressure lowering.
- Colloid osmotic pressure** Osmotic pressure resulting from the unequal distribution of non-permeating protein solutes (colloids) across the wall of blood vessels, which draws water into the capillary.
- Columella** Small, single bone that transmits vibrations of the tympanum through the middle ear space to the oval window in birds, reptiles and amphibians.
- Commissurae** Transverse connections between two parallel net cords.
- Compatible solutes (osmolytes)** Solutes that even at high concentrations do not affect the functioning of macromolecules (such as enzymes) in cells.
- Compound eye** Type of convex eye found in arthropods consisting of many individual units called ommatidia, which are arranged in a dome-like structure.
- Conduction** The process in which ions, heat, electric currents or respiratory fluids are transmitted through a medium when there is an electrochemical difference or a difference of temperature, electrical potential, or pressures, respectively.
- Cones (visual system)** One of the two types of ciliary photoreceptors where the outer segment is in the shape of a cone.

- Connective tissue** Tissue that connects, supports, binds, or separates other tissues or organs and has the ability to stretch and contract passively.
- Contact-rehydration** The process by which some animals rehydrate by taking up water across their integument.
- Contractile apparatus** Structure consisting of actin- and myosin-filaments capable of producing force and movement.
- Convection** Physical process during which a bulk flow of a fluid (gas or liquid) accompanies the transfer of heat or matter.
- Convergent evolution** The process whereby unrelated organisms independently evolve similar features.
- Convex eyes** Type of eyes occurring in arthropods, annelids and molluscs where the photoreceptor cells form a convex photoreceptive surface.
- Coprophagy** Behaviour practiced by hindgut fermenters involving the re-ingestion of faeces.
- Cornea** The transparent, convex layer forming the front of the eye.
- Coronary blood vessels** Special vessels which transport arterial, oxygen-rich, blood to the muscles of the heart in birds and mammals and to the compact region of the ventricle in other vertebrates.
- Corpora allata** Paired organs behind the brain of insects that synthesize and secrete juvenile hormone, which controls development and metamorphosis, and, in some species, acts as a neurohaemal area for storage of prothoracicotrophic hormone.
- Corpus callosum** Nerve tract that appeared during the evolution of placental mammals, which connects the two hemispheres of the cerebrum.
- Corpus luteum** Body in the vertebrate ovary which develops from the remnants of the ruptured follicle(s) after ovulation, and which secretes mainly progesterone and small amounts of oestradiol.
- Cortex** The external or surface layer of an organ.
- Corticosterone** A steroid hormone secreted by the adrenocortical tissue of many vertebrates which has actions on carbohydrate, fat and protein metabolism and in responding to stress.
- Cortisol** A steroid hormone secreted by the adrenal cortex of mammals and adrenocortical tissue of other vertebrates, which has multiple actions, including effects on salt balance, carbohydrate, fat and protein metabolism, and immune function. *See also steroid hormones.*
- Coulomb's law** Describes the interactions between electrically charged particles by stating that charges of opposite sign attract each other, while charges of the same sign repel each other with a force that is proportional to the product of the charges carried by the particles and inversely proportional to the square of the distance between particles.
- Countercurrent exchange** The process of exchange of heat or matter (e.g. O<sub>2</sub>, water or ions) by passive processes (diffusion and/or osmosis) between two fluids running in parallel to each other but in opposite directions.
- Countercurrent multiplication** A process which uses energy to create large concentration differences in a fluid that flows in opposite directions through the arms of a hairpin structure between the hairpin bend and the entry or exit of the hairpin structure.
- Cranial nerves** Nerves that emerge in pairs from the brain of vertebrates; cranial nerves are numbered in order from the front of the brain using Roman numerals, except for the first pair called the terminal nerve or nerve 0.
- Crepuscular** Animals that are normally active during the twilight hours of dawn and dusk.
- Crista (plural cristae)** The folds of the inner mitochondrial membrane and the sensory structures located in the ampullae of the semicircular canals.
- Critical partial pressure of oxygen or  $P_{crit}$**  The partial pressure of oxygen (PO<sub>2</sub>) at which an oxyconformer is no longer able to maintain its rate of oxygen consumption
- Critical velocity** The velocity of a fluid at which the transition between laminar and turbulent flow occurs.
- Crop** Enlarged chamber of the GI tract used to store food temporarily prior to digestion found in a variety of animals including insects, birds, gastropods, and earthworms.
- Cross-current gas exchanger** Air flows in one direction through the tertiary bronchi in the lungs of birds and some species of reptiles and these bronchi are at right angles to the major blood vessels.
- Crustaceans** Animals in the sub-phylum Crustacea, which encompasses crabs, lobsters, shrimps and sessile barnacles and constitutes a branch of the phylum Arthropoda. *See also Arthropods.*
- Cryoprotectants** Substances that help protect the tissues from damage in those animals that are tolerant of some freezing of body fluids, including antifreeze molecules that reduce the rate at which the extracellular fluids freeze.
- Cryptochromes** Highly-conserved group of photoreceptor proteins that directly modulate light input into the circadian clocks of various animal groups.
- Ctenidia** The single (ctenidium) or paired respiratory organ or gills (ctenidia) of some molluscs, which are also used for filter feeding.
- Cutaneous** Processes taking place across the skin or affecting the skin.
- Cuticle** The non-cellular multi-layered outer covering of many invertebrates, particularly nematodes (roundworms) and arthropods.
- Cyanobacteria** A phylum of bacteria (which do not possess chloroplasts) that can photosynthesize and produce oxygen.
- Cyclic AMP (cAMP)** An important second messenger that regulates many cellular processes.
- Cyclostomes** Lampreys and hagfish (or round mouths) which represent the living jawless fish.
- Cytokinesis** A process that follows the division of the nucleus into two daughter nuclei, by which a cell splits into two daughter cells each containing a daughter nucleus and sharing between them the cytoplasmic components of the mother cell.
- Cytoplasm** The cytosol and cellular organelles, except the nucleus.
- Cytoskeleton** An organelle that determines the spatial organization of a cell by forming a lattice made of three types of filamentous structures.
- Cytosol** The aqueous intracellular medium of a cell surrounding the organelles.
- Daily torpor** A reduction of energy demand and body temperature on a daily basis, which is determined by a number of factors, such as the availability of food and environmental temperature.
- Decompression sickness** Condition caused by production of bubbles of nitrogen in the body of air-breathing vertebrates upon surfacing too quickly from a deep dive. When an animal dives to any depth in a water column nitrogen is forced into solution in the blood and tissues by an increase in pressure in the lungs and bubbles form when the pressure decreases too quickly upon surfacing.
- Dehnel's phenomenon** Seasonal and reversible changes in the skeleton and major organs in some species of small mammals.

- Demersal** Animals (particularly fish) living and feeding on the bottom of lakes and seas (benthic species) or near to the bottom. *Contrast with pelagic species.*
- Dendrite** Anatomical part of a neuron that receives signals from other neurons.
- Dense bodies** Microscopic structures in smooth muscle cells to which actin-filaments are anchored.
- Depolarization** A membrane potential that becomes less negative (i.e. more positive), usually implying a *reduction* in the amount of charge separation across the membrane.
- Desmosomes** Tight mechanical connections between the cytoskeletons of neighbouring cardiac cells.
- Deuterostomes** Bilateral animals of the superphylum Deuterostomia (including humans) in which the first opening in the developing embryo (blastopore) becomes the anus and the second opening becomes the mouth.
- Deutocerebrum** The midsection region of the arthropod brain which processes sensory inputs from the antennae.
- Diabetes insipidus** A rare condition in mammals in which excessive urination of a dilute urine and extreme thirst results from inadequate production and release of arginine vasopressin (antidiuretic hormone, ADH) or the lack of the normal response to ADH by the kidney.
- Diabetes mellitus** A chronic condition in mammals resulting in high levels of glucose in the blood due to inadequate production of insulin by the pancreas or a reduced sensitivity of cells to insulin's action on glucose uptake.
- Diapause** A genetically programmed period of suspended development and low rate of metabolism, either in unfavourable environmental conditions, or in embryonic diapause as a means of controlling the timing of births relative to mating.
- Diapause hormone** A peptide neurohormone secreted from the sub-oesophageal ganglion of insects, which is one of the hormones involved in the induction of embryonic diapause.
- Diaphragm** A dome-shaped muscular sheet which separates the thorax from the abdomen in mammals, and whose flattening on contraction results in a reduction of pressure in the thoracic cavity so that air is drawn into the lungs through an open glottis.
- Diastole** Relaxation phase of the ventricle(s) in the vertebrate heart.
- Diastolic blood pressure** Lowest pressure reached in the arterial system during the relaxation phase of the heart.
- Dichromatic vision** Ability to distinguish and use two frequencies of the electromagnetic light spectrum for conveying visual information to the brain.
- Diencephalon** One of the two regions of the forebrain in vertebrates.
- Diffusion** The passive movement of molecules or particles dissolved in solution, from a region of higher to a region of lower concentration, or of respiratory gases from a region of higher to a region of lower partial pressure.
- Digestion** The process in the gastrointestinal tract during which ingested food is broken down into simpler molecules that can be absorbed into the body.
- Digestive system** The system of organs responsible for the ingestion, digestion, and absorption of food.
- Diploid** Cells or organisms that contain two homologous copies of each chromosome.
- Dipterans** True flies (Diptera) characterized by a single pair of membranous wings. The hind wings are reduced to balancing organs (halteres).
- Discontinuous gas-exchange cycle** A pattern of ventilation in insects during which the spiracles remain closed for most of the time and gas exchange occurs predominantly when the spiracles are open for an extended period.
- Diuresis** The production of urine at a higher rate than usual as a result of either high glomerular filtration rates (= glomerular diuresis), or reduced water reabsorption by the renal tubules (= tubular diuresis).
- Diurnal** Animals that are active during the day.
- Diving bradycardia** A reduction in heart rate of an air-breathing vertebrate when submerged under water.
- Diving response** The response of a diving, air-breathing animal when submerged under water, which includes bradycardia and peripheral vasoconstriction and is thought to conserve oxygen for use by those parts of the body least resistant to a lack of oxygen.
- Domain (taxonomy)** The highest taxonomic rank of organisms. The three domains in biological taxonomy are Bacteria, Archaea and Eukarya (eukaryotes).
- Dopamine** Neurotransmitter involved in excitatory and inhibitory synapses in the central nervous system of vertebrates and invertebrates.
- Dorsal horn** Grey matter of the spinal cord containing predominantly sensory neurons that relay information received from (peripheral) sensory neurons to different regions of the central nervous system.
- Dorsal vagal motor nucleus** One of the regions in the brainstem in which the vagal motor nerve cells, which send branches to the heart, are located.
- Double circulation** A circulation in which blood circulates through a gas-exchange organ and around the body in parallel. There are two atria: one receiving oxygen-rich blood from the gas exchanger, the other receiving oxygen-poor blood from the body. Some mixing of these two blood streams may occur in the heart if there are not two anatomically separate ventricles.
- Drag force** Resistance exerted by water or air in moving animals.
- Eccentric (or lengthening) contraction** Type of muscle contraction during which the muscle lengthens while contracting because the force produced by the muscle is less than the load applied on the muscle.
- Ecdysis** The shedding of the cuticle or exoskeleton in juvenile invertebrates belonging to the superphylum Ecdysozoa (nematodes = unsegmented roundworms, tardigrades (water bears), and arthropods) or the shedding of the entire skin of reptiles.
- Ecdysone** A steroid hormone secreted by the prothoracic glands which after transformation to 20-hydroxyecdysone stimulates moulting.
- Echinoderms** Exclusively marine animals in the phylum Echinodermata, which encompasses starfish, sea urchins, sea stars and sea cucumbers.
- Echolocation** Ability of some mammals to locate and identify objects by listening to echoes of brief calls made by the animal itself.
- Ecdlosion** The emergence of an adult insect from its pupal case or the hatching of an insect larva from its egg.
- Ecoregion** An ecologically and geographically defined large area of land or water in which there is a distinct assemblage of species and communities and environmental conditions.
- Ecosystems** The environments in which communities of animals and plants live.
- Ectotherms** Animals whose body temperature is determined by the thermal conditions of the external environment and by their behaviour.

- Effector cells** Cells that respond to neuronal signals such as muscle, secretory and endocrine cells.
- Efferent** A blood vessel or nerve leaving an organ. For example, the efferent glomerular capillaries carry blood away from the glomerulus and efferent neurons carry signals from the central nervous system to effector organs such as muscles.
- Elasmobranch** A subclass of cartilaginous fish (Chondrichthyes) comprising sharks, skates and rays and their extinct relatives.
- Electric organs** Species-specific organs that generate electric fields.
- Electric potential energy** Potential energy resulting from Coulomb forces; should not be confused with electrical potential which is the electric potential energy per unit charge.
- Electrical potential difference** The difference in electrical potential between two points.
- Electrical resistance** Describes the extent to which a material opposes the flow of an electric current.
- Electrical synapse** Tight structures between two cells featuring nonselective channels that pass through both membranes such that ionic currents can flow unimpeded from one cell to another.
- Electrocardiogram** Electrical activity recorded externally from the heart.
- Electrochemical potential** The combination of chemical potential resulting from the concentration of an ion, and the electrical potential resulting from the charge carried by the ion.
- Electrocytes** Modified skeletal muscle cells (also called electroplaques, or electroplaxes) that can produce action potential-like pulses of 0.15 V amplitude when stimulated by neurons.
- Electrogenic** Membrane ion pumps that produce a net charge difference across the membrane (an electrical potential difference).
- Electrolytes** Inorganic ions such as sodium, potassium and chloride that result from the dissociation of salts (such as sodium chloride) in body fluids.
- Electromagnetic radiation** The entire spectrum of radiation emitted by the Sun, which includes radio waves, heat (infrared radiation), visible light, x-rays, microwaves and gamma rays.
- Electromechanical coupling** Mechanism of smooth muscle contraction initiated by surface membrane depolarization.
- Electron transport chain** A series of four protein complexes (I–IV) located in the inner mitochondrial membrane that transfers electrons from electron donors to electron acceptors.
- Electroreception** Ability of some species, both invertebrate and vertebrate, to sense electric fields in their environment.
- Electroreceptors** Receptors sensitive to electrical fields.
- Emissivity** A value given to an object, between 0 and 1.0, to explain how good an emitter of radiation the surface of the object is compared to a perfect emitter (emissivity of 1)—a black body.
- Endergonic reaction** A reaction that has a net positive Gibbs energy change and requires energy from outside for it to proceed.
- Endochondral bone** Bone that develops on and within a template of cartilage that is destroyed by the calcification and replaced by bone.
- Endocrine axis** The combination of an endocrine gland, its secreted hormone, and the tissues on which it acts, including any further endocrine glands and subsequent hormones and tissues in the axis.
- Endocrine glands** Various ductless glands and tissues that secrete hormones into body fluids.
- Endolymph** Fluid in the membranous labyrinth of the inner ear containing a high  $K^+$  concentration (about 150 mmol  $L^{-1}$ , similar to that of the cytosol) and about 20  $\mu\text{mol } L^{-1}$  ionized calcium.
- Endometrium** The inner lining of the mammalian uterus.
- Endomysium** Thin layer of connective tissue surrounding each muscle fibre together with its blood capillaries and nerve tissue.
- Endoplasmic reticulum** Network of interconnected membrane-bound compartments which acts as an intracellular store for  $Ca^{2+}$  ions and is also involved in the production of proteins and lipids essential for cell function.
- Endorphins** Peptides involved in pain relief released from the anterior pituitary gland of the brain by strenuous exercise, emotional stress, pain, and orgasm.
- Endoskeleton** Internal skeleton such as the skeleton of vertebrates.
- Endothelial barrier** One of the two main physical barriers between blood and the cerebrospinal fluid that exists at the level of CNS capillaries.
- Endothelium** The single layer of epithelial cells that lines the lumen of blood vessels.
- Endothermic reaction** A reaction during which heat is absorbed from the surroundings.
- Endotherms** Animals (mainly birds and mammals) that use internal sources of energy to regulate their body temperature above that of their environment.
- Energetic cost of transport** Amount of energy consumed to transport one g of body mass over one km when an animal moves at a particular speed.
- Energy metabolism** The energy changes associated with the various biochemical reactions that take place in an animal's body and with the interactions between an animal and the environment.
- Enkephalins** Opiate-like peptides that bind to receptors in the postsynaptic membrane and are responsible for producing euphoric states.
- Enteric (nervous) system** Division of the autonomic nervous system in vertebrates that comprises the neurons that are embedded in the lining of the digestive tract.
- Entrainment** The process by which biological clocks become synchronized to local environmental conditions.
- Ependymal cells** Cells lining the cavities of the central nervous system in vertebrates that produce the cerebrospinal fluid.
- Epicuticle** Outer layer of the arthropod exoskeleton. Lipids in the outer epicuticle provide the waterproofing layer of insects and arachnids.
- Epidermis** The outer layer of cells covering an organism. In animals with a skin, the epidermis refers to the surface epithelium.
- Epigenetic trait** A stable heritable phenotypic characteristic resulting from changes in a chromosome that excludes changes to its DNA sequence.
- Epimysium** Thick layer of connective tissue covering muscles.
- Epipelagic zone** The uppermost layer of the ocean through which sufficient sunlight penetrates to enable photosynthesis.
- Episodic ventilation** Periodic bursts of ventilation separated by longer periods of no ventilation, which are often seen in resting ectotherms and hibernating mammals.
- Epithelial cells** Cells that form a barrier at the body's interface with its external environment and around internal body cavities.
- Equilibrium** A state of balance that does not require energy input from outside to be maintained.
- Equilibrium potential** The electrical potential difference across a barrier that balances out the effect of the concentration difference on the movement of a particular ion across the barrier.
- Erythrocytes** Cells in the blood of vertebrates which contain molecules of haemoglobin.
- Erythropoiesis** Process by which red blood cells are produced in vertebrates.



- Eukaryotes** Organisms consisting of cells that have membrane-bound organelles, including a nucleus; all animals are eukaryotes.
- Euryhaline** Animals that can live in environments of a range of external salinities.  
*See also Salinity.*
- Eurythermal** Animals that can live in environments that have a wide range of temperatures.
- Eutherian mammals** One of the two clades of mammals. All living eutherian mammals are placental mammals: pregnant females nourish their foetus via a placenta.
- Euthermia** Normal body temperature, mainly of endotherms
- Evaporation** The vaporization of a liquid into a gaseous phase that is not saturated with the evaporating liquid. Vaporization occurs at the surface of the liquid.
- Evolution** A change in the heritable characteristics (traits) of a population over successive generations. Heritable traits within a population can be altered by gene mutations, genetic drift, gene migration and natural selection.
- Evolutionary adaptations** The adaptations of animals as a consequence of evolutionary changes that enable them to live in particular habitats by possessing particular structural, behavioural or physiological traits.
- Exaptation** A character that did not evolve by natural selection for a specific function, but was already present in the population for other causes.
- Excitable cells** Types of cells that respond promptly to stimuli by changing their membrane properties, which in turn, initiate an electrical or chemical signal. Typical examples of excitable cells are neurons, sensory cells and muscle cells.
- Excitation-contraction coupling** Sequence of events that begins with muscle fibre excitation and ends with muscle fibre contraction.
- Excitatory postsynaptic potentials** The postsynaptic potentials associated with activation of excitatory synapses (generally small depolarizations).
- Excitatory synapses** Chemical synapse which on activation causes depolarization of the postsynaptic membrane increasing the chance of activation of the postsynaptic cell. Excitatory synapses normally have ligand-gated channels in the postsynaptic membrane, which are equally permeable to monovalent cations ( $\text{Na}^+$  and  $\text{K}^+$ ).
- Excretory system** The system of organs responsible for the removal of toxic waste products.
- Exergonic reaction** A reaction in which energy is released, and there is a net reduction in Gibbs energy.
- Exocrine glands** Glands, such as salt glands, sweat glands and salivary glands that secrete solutions onto epithelia and external surfaces via a duct or canal.
- Exome** The protein-coding region of the genome.
- Exons** DNA (or RNA) sequences that are coded into peptide chains and proteins.
- Exoskeleton** External skeleton such as that exhibited by arthropods.
- Exothermic reaction** A reaction during which heat is released to the surroundings.
- Exocytosis** A process of cellular secretion in which substances contained in vesicles are discharged from the cell by fusion of the vesicular membrane with the outer cell membrane.
- Exteroceptors** Sensory receptors that respond to stimuli in the external environment.
- Extracellular fluid** Body fluids outside the cells. In animals with closed circulations, extracellular fluid is divided into interstitial fluid (found between the cells) and blood plasma.
- Extracellular matrix** Extracellular structure comprising different types of molecules secreted by cells that provides structural and biochemical support to the surrounding cells.
- Facilitated diffusion** Passive movement of substances by carriers.
- Facultative air breather** A species of aquatic animal which only obtains its oxygen from the air when the water is hypoxic, the temperature is unusually high, and/or the animal is particularly active.
- Fascicle** Bundle of muscle fibres aligned in parallel arrays surrounded by perimysium.
- Fast-twitch muscle fibres** The broad subdivision of twitch skeletal muscle fibres that contract distinctly faster than the twitch fibres from the same species that belong to the slow-twitch fibre subdivision.
- Fat body** The tissue in insects that stores fat, protein and carbohydrate reserves, and has some equivalent functioning to the intermediary metabolism of the liver of vertebrates.
- Faveoli** Small compartments in the lungs of some species of amphibians and reptiles where gas exchange occurs.
- Feed forward networks** Neural networks where the flow of information is unidirectional, from 'neurons' in one layer that is closer to the input layer, to 'neurons' in another layer that is closer to the output layer.
- Fibro-lamellar bones** Bones with a ramification of canals, known as Haversian canals, that carry blood vessels and nerves. They communicate with bone cells by way of connections called canaliculi.
- Field metabolic rate** The average daily metabolic rate of a free-living animal in its natural environment.
- Filtration (blood)** The pressure-driven bulk flow of water and small solutes out of blood plasma, across the walls of capillaries or other membranes, which leaves behind solutes of high molecular mass and haemocytes.  
*See also Ultrafiltration.*
- Fish schooling** The synchronized swimming of a large number of fish of same species, during which they move together at same speed in the same direction and in a highly regular formation pattern.
- Flat-sheet eye** Simple type of eye common to the larval forms of many invertebrates characterized by one layer of rhabdomeric photoreceptor cells lined by one layer of pigmented epithelium.
- Follicle stimulating hormone** A glycopeptide hormone secreted by the anterior pituitary gland of vertebrates, which stimulates gonadal development and maturation in both sexes.
- Follicular phase** The phase in the ovarian cycle of female mammals during which follicles develop prior to ovulation.
- Folliculogenesis** The process in which a primordial follicle grows and develops under stimulation by gonadotrophic hormones into a mature Graafian follicle.
- Food chain** A series of organisms interrelated in their feeding habits in which each one uses members of a lower level in the series as a source of food.
- Forced convection** The main method of transfer of heat or respiratory gases when a fluid (gas or liquid) is forced to flow over a surface, or in a tube by an external source such as the pumping activity of a heart or respiratory muscles, or animal movements causing water or air flow around the animal.
- Force-length diagram** Relationship between isometric force produced and muscle or sarcomere length when muscles or muscle fibres are maximally activated.

- Force-velocity curve** The plot of the force developed by a muscle (expressed as a fraction of isometric force) against the velocity with which the muscle shortens (expressed as a fraction of maximum velocity of shortening).
- Forebrain** The frontal part of the brain in vertebrates.
- Foregut** The upper part of the gastrointestinal tract involved in food conduction, storage and partial digestion.
- Foregut fermenters** Herbivorous mammals with four specialized chambers in the stomach, which provide suitable environments for the microbial communities that carry out fermentation.
- Fossorial** Animals living underground by digging; fossorial animals have limbs that are adapted for burrowing.
- Fovea centralis** Small central area of the retina that provides the maximum sharpness of vision as it contains the highest density of cones packed closely together.
- Frank-Starling relationship** The relationship between muscle fibre length and force of contraction whereby, up to a certain point, the greater the increase in length of the muscle fibres of the ventricle during diastole, the greater their force of contraction during systole, and the greater the stroke volume.
- Freezing point** The highest temperature at which a liquid when cooled changes to a solid (freezes). Freezing point is a normally identical to the melting point of the solid when temperature is increased, unless antifreezes are present.
- Fresh water** Earth's naturally occurring water found mainly in glaciers, ice sheets or ground water, and in surface water in ponds, lakes, rivers, streams and bogs.
- Frontal lobe** Anatomical subdivision of a cerebral hemisphere in mammals, located at the front the hemisphere.
- Futile cycle** A metabolic cycle oscillating between two states that has no overall effect, other than to produce heat.
- Gait** The pattern of limb movement during locomotion over a solid substrate.
- Gametes** Reproductive cells (eggs and sperm) that unite during sexual reproduction to form a new cell called a zygote.
- Gametogenesis** The process by which mature haploid ova and sperm (gametes) are formed following meiosis of the diploid spermatogonia of males and diploid oogonia of females.
- Gamma( $\gamma$ )-aminobutyric acid** Neurotransmitter that is prevalent at inhibitory synapses of the vertebrate and invertebrate CNS and neuro-muscular inhibitory synapses in arthropods.
- Ganglion (nervous system)** Aggregations of interconnected neurons and neuronal components.
- Ganglion cells (retina)** A type of neuron located near the surface of the retina facing the incoming light. Ganglion cells receive visual information from the photoreceptor cells via the bipolar neurons and amacrine cells and transmit it to the brain via their axons, which form the optic nerve.
- Gap junctions** Specialized intercellular connections in cell membranes of various animal cell-types that allow various molecules, ions and electrical signals to pass between adjacent cells.
- Gas-exchange (cardio-respiratory) system** The system of organs responsible for uptake of  $O_2$  from the environment and its delivery to the cells, and excretion of the  $CO_2$  continuously produced by cells.
- Gastrointestinal (GI) tract** Also called the alimentary canal, consists of a tube with chambers in which food is subjected to mechanical and chemical processing. The GI tract is lined by an epithelial layer that acts as a barrier between the lumen of the gut, which is connected to the external environment, and the internal environment of the animal.
- Gastropods** A group of molluscs (class Gastropoda) that usually have a coiled shell (snails, limpets), or no shell at all (slugs and nudibranchs), a ventral muscular foot, and eyes and tentacles on a distinct head.
- Gene migration** The introduction into a population of new gene variants that exhibit different heritable traits carried by new individuals joining the population.
- Genetic code** The set of 64 possible codons that include the start and stop codons and the codons for the 20 naturally-occurring amino acids.
- Genetic drift** The random change over successive generations in the frequency of alleles in a gene pool because of incomplete sampling of all alleles between generations.
- Genetic variation** The variation in the DNA sequence of the genome of individual members of a population.
- Genome** Complete genetic material of an animal consisting of inheritable DNA.
- Genotype** DNA-coded, inherited information.
- Genus (*plural genera*)** Group of species that exhibit similar characteristics and are genetically related. Genus is also the first part of a species' formal name.
- Germ cells** The cells that differentiate into the gametes required for sexual reproduction.
- Gestation period** The period of development from fertilization of the ovum to birth of the young in viviparous animals.  
*See also viviparity.*
- Ghrelin** Peptide hormone produced by the stomach that promotes the expansion of the fat tissue in mammals to increase the energy store.
- Gibbs energy** The energy associated with reversible processes that occur at constant temperature and pressure.
- Gigantothermy** The phenomenon whereby the larger an animal, the smaller the surface area to volume ratio and, therefore, the slower the rate of heat loss compared with that in a smaller animal. Gigantothermy explains why some large reptiles retain metabolic heat during activity and can maintain a more or less stable body temperature.
- Gills** Major organs of gas and ion exchange in aquatic organisms, which are outgrowths of the body surface.
- Gizzard** Also referred to as the ventriculus, is a specialized stomach constructed of thick muscular walls used for grinding up food. Found in a variety of animals including birds, crocodiles and alligators, earthworms, some gastropods, some fish and some crustaceans.
- Glia cells** Cells found in insects that provide structural and metabolic support to neurons.
- Glomerular filtration (kidney)** The process by which the glomeruli perform ultrafiltration of the blood as the initial step in driving the excretion by the kidneys of most vertebrates.
- Glomerulus (kidney) (*plural glomeruli*)** A ball-like arrangement of capillaries in which ultrafiltration forms a filtrate containing freely filterable solutes (primary urine) that enters the Bowman's capsule.
- Glomerulus (olfaction)** Globular anatomical structure consisting of nerve endings of all receptor cells expressing one specific odorant receptor.
- Glomus cells** The type I cells of the carotid body that are sensitive to a reduction in the partial pressure of oxygen.
- Glucagon** Peptide hormone which acts on the liver to increase the concentration of glucose in the blood.
- Glucocorticoids** Steroid hormones secreted by adrenocortical tissue, mainly cortisol or corticosterone, which act on

- glucocorticoid receptors to enhance the concentration of metabolic fuels in circulation and exert immunosuppression.
- Gluconeogenesis** The metabolic pathway which generates glucose from non-carbohydrate sources of carbon, including some amino acids, glycerol and lactate, primarily in the liver.
- Glycogenolysis** The breakdown of stored glycogen molecules in the liver and skeletal muscle in response to hormonal and neural signals; glycogenolysis releases glucose-1-phosphate which is used for the release of glucose into the bloodstream by the liver cells and as an immediate energy source for contraction in muscle cells.
- Glycolysis** The metabolic pathway by which glucose is broken down to pyruvate ( $\text{CH}_3\text{COCOO}^-$ ) or lactate ( $\text{CH}_3\text{CH}(\text{OH})\text{COO}^-$ ) with net production of ATP.
- Goitre** A swelling resulting from an enlarged thyroid gland in humans, either as a result of hypothyroidism (a non-toxic goitre) or hyperthyroidism (a toxic goitre).
- Goldman-Hodgkin-Katz (GHK) equation** An equation that quantifies the difference in the electrical potential that develops across a barrier that is permeable to various degrees to any set of monovalent ions which differ in concentration across the barrier.
- Golgi apparatus** A stack of flat compartments within which molecules destined for secretion, such as hormones, are processed and packaged. The Golgi apparatus is connected to the endoplasmic reticulum.
- Golgi tendon organs** Stretch-sensitive mechanoreceptors associated with muscle tendons that detect the amount of force produced by the muscle.
- Gonadotrophin releasing hormone (GnRH)** A neuropeptide synthesized by hypothalamic neurones, which stimulates the release of follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary.
- Gonadotrophins** Hormones secreted by the gonadotrophs of the anterior pituitary, which stimulate the growth of the gonads and production of gametes in both sexes.  
*See also Follicle stimulating hormone (FSH) and Luteinizing hormone (LH).*
- G-protein** An important protein complex in cell signalling by G-protein coupled receptors. Binding to the extracellular side of these receptors results in separation of G-protein subunits on the inner surface of the plasma membrane, which activate second messengers that initiate specific cell responses.
- Graded potential** A change in the membrane potential that varies in size with stimulus intensity; the opposite of an all-or-none response such as an action potential.
- Grey matter** Parts of the central nervous system in vertebrates, which consist of a high density of neuron cell bodies and unmyelinated axons that are darker in colour.
- Growth hormone** A peptide hormone synthesized by the somatotrophs of the anterior pituitary, and a paracrine, which is involved in control of growth and metabolism, and has osmoregulatory actions in some vertebrates.
- Gustation** The sense of taste.
- Gut flora** The complex community of microorganisms (bacteria and protozoa) living in an animal's gastrointestinal tract.
- Habitat** The location or environment characterized by particular abiotic and biotic factors in which an organism or population of organisms lives.
- Haematocrit** The percentage volume of red blood cells relative to the total volume of blood.
- Haemocoel** Body cavity in between organs through which haemolymph circulates; the haemocoel is the remnant of the primary body cavity, the blastocoel.
- Haemocyanin** A copper-based respiratory pigment found within most species of molluscs and arthropods, which binds reversibly with oxygen.
- Haemocytes** All the cell-types in the blood or haemolymph.
- Haemoglobin** An iron-based respiratory pigment found within the blood of vertebrates, and a few other groups of animals, which binds reversibly with oxygen.
- Haemolymph** The circulatory fluid of most invertebrates which bathes all internal tissues.
- Hair cells** Sensory receptor cells in both vertebrates and invertebrates involved in hearing and the maintenance of balance.
- Haldane effect** The inverse relationship between the level of oxygenation of haemoglobin and its capacity for carrying carbon dioxide.
- Halocline** A sharp vertical gradation in the ocean water column below the well-mixed surface saline water layer in which salinity changes rapidly with depth.
- Haploid cells** Cells, such as gametes, which contain only one copy of a set of chromosomes.
- Heat balance equation** An equation that incorporates all of the possible routes of heat gain and loss in an animal.
- Heat increment of feeding (HIF)** The increase in metabolic rate above resting level associated with feeding.
- Heat shock proteins** Protein chaperones which reduce and repair damage to cellular proteins that arises from many forms of stress, most notably high temperature.
- Hemichannels** Large transmembrane channels connecting the intracellular and extracellular space, which allow ions and small molecules such as ATP to pass across membranes.
- Hemimetabolous** Describes insects that undergo partial metamorphosis during development from egg to pronymph, and through a series of instar nymphs of increasing size, before forming a winged adult.
- Henry's law** A law that states that the amount of a given gas at a constant temperature, dissolved in a given volume of liquid, is directly proportional to the partial pressure of that gas in equilibrium with that liquid.
- Hepatopancreas** An organ in crustaceans that is connected to the stomach, and which secretes digestive enzymes, absorbs nutrients, and stores lipids, carbohydrate and calcified granules.
- Herbivores** Animals that eat food of plant origin.
- Herbst corpuscle** The most widely distributed touch receptor in birds.
- Hermaphrodite** An animal that has both male and female gonads in its lifetime, either producing male and female gametes at the same time (=simultaneous hermaphroditism) or one at a time (=sequential hermaphroditism).
- Heterothermy** Describes animals with variable thermal conditions either:  
(i) at different times (= temporal heterothermy): some birds and mammals undergo daily or seasonal variations in body temperature that exceed those seen during homeothermy, or  
(ii) in different parts of their body at one time (=regional heterothermy): some species of birds and mammals allow the temperature of parts of their body, such as limbs which have little or no insulation, to change relative to their core temperature.  
*See also Homeothermy.*
- Hexapods** The largest group of arthropods; hexapods have six thoracic legs and are mostly insects and insect-like animals.

- Hibernaculum** Winter quarters where some species of animals, including hibernating mammals, spend the winter.
- Hibernation** Torpor in some species of mammals, which lasts for several days or even for the whole winter, during which the hibernating animal survives on their stored fat reserves.
- Hindbrain** One of the three major parts of the vertebrate brain located at the interface between the brain and the spinal cord.
- Hindgut** The posterior (caudal) part of the gastrointestinal tract.
- Hindgut fermenters** Herbivorous mammals that ferment ingested plant material in the caecum and an enlarged colon.
- Hippocampus** Brain structure in the form of a horseshoe located in the medial region of the temporal lobes, which plays a crucial role in memory formation.
- Histamine** Neurotransmitter involved in excitatory and inhibitory synapses in the CNS of vertebrates and invertebrates.
- Holometabolous** Describes insects that undergo complete metamorphosis, passing through four distinct stages: eggs, larvae, pupae, adults.
- Homeostasis** Ability of living systems (e.g. cells, organisms) to regulate their internal environment and maintain a stable set of conditions.
- Homeothermy** The almost continual maintenance by animals of a more or less constant body temperature irrespective of environmental temperature. Birds and mammals are the obvious homeotherms.
- Homologous chromosomes** Pairs of chromosome (one from each parent) that are similar in length, gene position, and centromere location. The genes on the two chromosomes may display different alleles.
- Homoplasy** The situation in which a similar trait or character is present in two or more species but was not present in their last common ancestor.
- Hormonal system** The glands that synthesize and secrete hormones (endocrine secretions), and which control the functions of cells, tissues and organs; also called endocrine systems.
- Hormones** Chemical substances of three main types (peptides, steroids and amines) produced by glands and released into circulation, and which control and regulate the activity of particular target cells.
- Humidity** The amount of water vapour in the atmosphere.
- Hydric** An environment/habitat (or biome) with wet conditions.
- Hydrofoil** Streamlined surface that generates lift when water flows over it; the hydrofoil has a rounded leading edge, a sharp trailing edge and curved upper and lower surfaces.
- Hydrophilic** Capable of readily interacting with water molecules.
- Hydrophobic** Tending to repel or fail to mix with water molecules.
- Hydrostatic pressure** The pressure exerted at a given point by a column of liquid.
- Hydrostatic skeleton** Type of skeleton supported by fluid pressure, which is common among soft body invertebrates.
- Hymenopterans** Bees, wasps, sawflies and ants with four wings that form a large sub-group (Hymenoptera) of Hexapoda. Females usually have a stinger.
- Hypercapnia** An increase in the concentration or partial pressure of carbon dioxide above the normal level in the environment or within an animal.
- Hyperglycaemic action** Any hormonal action that promotes hyperglycaemia, an elevation in blood glucose.
- Hypernatraemia** A state in which the animal has higher concentrations of sodium in the blood plasma than usual for the animal type or species.
- Hyperosmoregulation** The process of maintaining extracellular fluids at a higher osmolality than that of the external environment.
- Hyperoxia** A situation in which the partial pressure of oxygen is above the normal level.
- Hyperpolarization** A membrane potential that becomes more negative because it implies an *increase* in the amount of charge separation across the membrane.
- Hypersaline environments** Aqueous habitats in which salt concentrations (salinity) are greater than that of ocean seawater.
- Hypertension** Blood pressure which is above the normal level.
- Hypertonic solution** A solution in which cells shrink due to the higher concentration of non-penetrating solutes than in the cytosol.
- Hyperventilation** An excessively high level of ventilation for the rate of oxygen consumption, which tends to lower the level of carbon dioxide in the blood and increase blood pH (alkalosis).
- Hypo-osmoregulation** The process of maintaining extracellular fluids of lower osmotic concentrations than that of the external environment.
- Hypothalamus** A part of the brain of vertebrates located below the thalamus, which links the nervous system to the endocrine system via a stalk connected to the pituitary gland. The hypothalamus is involved in the regulation of many processes including salt and water balance, control of body temperature and circadian rhythms.
- Hypotonic solution** A solution in which cells swell, due to the lower concentration of non-penetrating solutes than in the cytosol.
- Hypoxia** A reduction in the concentration or partial pressure of oxygen below its normal level in the environment or within an animal.
- Hysteresis** A phenomenon whereby the value of a property (such as heart rate) lags behind the changes in the factor causing it (e.g. temperature). Thermal hysteresis also occurs when antifreeze compounds lower the freezing point of body fluids relative to their melting point.  
*See also Antifreeze compounds.*
- Ileum** The last section of the small intestine in most vertebrates, including mammals, reptiles, and birds.
- Immune system** The system of organs responsible for the protection of an animal's identity by neutralizing potentially harmful foreign agents that may enter the body and cause disease or death.
- Infinite pool gas exchanger** An area of the body surface where gas exchange occurs, but has no special pumping mechanism to maintain a regular flow of the respiratory medium over it.
- Infrared radiation** The part of the electromagnetic spectrum with a wavelength between 700 nm and 1 mm.
- Infrasound** Sound waves with frequencies between 1 and 20 Hz, which are below the lower limit of human hearing.
- Inhibitory postsynaptic potentials** The postsynaptic potentials associated with activation of inhibitory synapses (generally small hyperpolarizations).
- Inhibitory synapses** Chemical synapses which on activation decrease the chance of triggering an action potential in the postsynaptic neuron; inhibitory synapses often have ligand-gated channels in the postsynaptic membrane, which, when open, are permeable to monovalent anions (i.e. to chloride, the most abundant anion).
- Inka cells** Endocrine cells associated with the trachea of insects, which secrete pre-ecdysis triggering hormone and ecdysis triggering hormone. These hormones initiate nervous and muscular activity that results in shedding of the cuticle.



**Inner hair cells** Hair cells in the organ of Corti situated on the inner side of the basilar membrane involved in the process of sound transduction.

**Inositol trisphosphate** A second messenger used in cell signalling which mobilizes calcium from intracellular stores, leading to a cascade of cellular responses—causing, for example, calcium release from the sarcoplasmic reticulum of smooth muscle cells in blood vessels and vasoconstriction in response to some hormones.

**Inotropic effect (on the heart)** A change in the strength of beating of the heart caused by a component of the autonomic nervous system or by a drug.

**Insects** Small arthropods with six legs (called hexapods) and generally one or two pairs of wings, which represent the largest and most diverse group of animals with nearly 1 million described species.

**Insolation** The incoming radiation to the Earth from the Sun.

**Insulation** Separation of an object from others by non-conducting materials to prevent or reduce the transfer of heat, electrical charges or sound.

**Insulin** A peptide hormone secreted by the pancreas of vertebrates that regulates glucose, fatty acid and protein metabolism. Insulin promotes uptake of glucose by cells and promotes glycogen synthesis, which lowers blood concentrations of glucose.

**Integument** The outer covering or coat of an animal, such as the skin or cuticle.

**Intercalated disc (or disk)** Structure that anchors myofibrils from neighbouring vertebrate cardiac cells at the level of the Z-lines across the narrow gap between their surface membranes.

**Intermediary metabolism** The collection of biochemical reactions that take place within cells, including those involved in the synthesis of cellular components and ATP production.

**Intermediate filaments** Rope-like protein structures that confer mechanical strength to the cytoskeleton.

**Interoceptors** Sensory receptors that respond to stimuli from within the body of the animal, such as variation in the composition of gases in the blood.

**Interstitial fluid** The fluid between cells. Interstitial fluid is the main component of extracellular fluid, which also includes blood plasma.

**Intertidal zone** The area of sediment uncovered during each tidal cycle, and which is above water at low tide and under water at high tide.

**Intestine** The part of the gastrointestinal tract following the stomach, where most of the digestion and absorption take place.

**Intracellular fluid** Fluid inside the cells, which is also called cytosol.

**Invertebrates** Animals without a vertebral column. Most animals are invertebrates.

**Inverted retina** Arrangement whereby the photoreceptor cells are not located on the side of the retina facing the incoming light, but at the base of the retina after light passes through several layers of transparent neurons.

**Involuntary muscles** Muscles whose pattern of contraction is not under an animal's voluntary control.

**Ion pump** A complex of proteins located in the cell membrane that is responsible for actively transporting ions across the membrane against the electrochemical difference using energy released by cleavage of ATP.

**Ionotropic receptor** An ion channel or a protein that *directly* affects the opening of the ion channel when a stimulus acts on it. *See Ligand-gated channels.*

**Isometric contraction** Type of muscle contraction during which the length of the muscle does not change.

**Isometric relationship** If  $y$  in the scaling equation ( $y = a x^b$ ) is a biological attribute such as the heart mass that would be expected to vary in proportion with a body size characteristic, such as the body mass ( $x$ ) and the experimentally observed scaling factor  $b$  equals 1, then the relationship is said to be isometric.

**Isosmotic (iso-osmotic)** Describes solutions that have the same osmotic concentration.

**Isotonic** Describes solutions that have the same tonicity.

**Isozymes** Different molecular forms of a specific enzyme within the same species. Isozymes differ in amino acid sequence and hence usually have different kinetic parameters in the catalysed chemical reaction. Also called isoenzymes.

**Iteroparous** Describes species in which multiple reproductive cycles occur over the course of their lifetimes.

**Johnson's organ** Consists of several hundred scolopidia located in the second segment of the antennae in insects; it detects fine motions in the uppermost segment of the antenna, called the flagellum.

**Joint** Articulation between rigid skeletal components which permits body parts to move.

**Juvenile hormones** A group of neurohormones secreted by a pair of neurosecretory glands, the corpora allata. Juvenile hormones regulate many processes in insects including development, adult diapause, and the outcome of a moulting cycle.

**Juxtaglomerular cells** Specialized smooth muscle cells found primarily in the walls of the afferent glomerular arterioles of the kidney, which synthesize and secrete renin. *See also Renin-angiotensin system.*

**Keratin** A fibrous protein forming the main structural constituent of hair, feathers, and claws, and the cells in the outermost layers of skin.

**Krogh cylinder** A simplified model proposed by August Krogh to explain how oxygen diffuses from a length of capillary into a uniform cylinder of tissue surrounding the tube.

**Lactation** The process of producing and secreting milk by the mammary glands of mammals and the period during which milk is provided to the suckling offspring.

**Laminar flow** Flow of an ordered, streamlined nature through a tube or over a solid surface.

**Latent heat of vaporization** The amount of energy in the form of heat that is required to transform one gram of a liquid into vapour at a given temperature.

**Lateral line** Sensory organ located in the skin of fish and aquatic amphibians that provides information about the direction of water movement, and the presence of objects that cause specific disturbances in water.

**L-cones (human vision)** Cones that are sensitive to longer wavelengths in the visual spectrum.

**Leak channels** Channels in cell membranes that are usually open.

**Left to right (L → R) shunt** The situation in air-breathing vertebrates with an incompletely divided ventricle whereby more blood flows from the right side of the ventricle to the lungs than from the left side to the body.

**Lepidoptera** A sub-group (Lepidoptera) of Hexapoda characterized by four wings and a larval caterpillar stage in development, exemplified by butterflies and moths.

**Leptin** Peptide hormone produced by fat cells (adipocytes), which contributes to the decrease of appetite in mammals.

**Leucokinins** A group of diuretic hormones in insects.

**Leydig cells** Interstitial cells between the seminiferous tubules of the testes of vertebrates that synthesize and secrete testosterone in response to luteinizing hormone.

- L-glutamate** Neurotransmitter that is prevalent at excitatory synapses of the vertebrate CNS and neuro-muscular excitatory synapses in arthropods.
- Lift** The force generated on the hydrofoil (aerofoil) that is perpendicular to the direction of the water (air) flow over it.
- Ligament** Type of connective tissue made primarily of collagen that connects bone to bone in vertebrates.
- Ligand-gated channel** Channels that open when a specific molecule (a ligand) binds to one or several sites on the channel.
- Lipid bilayer** Two layers of amphipathic lipid molecules sandwiched between two aqueous compartments. A universal component of all cellular membranes.
- Lipids** Organic compounds consisting of carbon, hydrogen and oxygen that are generally insoluble in water. These include triacylglycerols, fatty acids, glycerolphospholipids, waxes and steroids.
- Load** Force against which the muscle exerts an opposing force.
- Lobe-finned fish** Mostly extinct bony fish, which include probable ancestors of amphibians, recognizable by the paired fleshy lobe-like scaly extensions from the body (fins). Also called sarcopterygians (class Sarcopterygii).
- Locomotory system** The system of organs responsible for generating the movement used when searching for food, water or shelter, to find a partner for reproduction, and to escape predators.
- Lophotrochozoans** Animals of the superphylum Lophotrochozoa, which includes annelids, flatworms and molluscs, that are characterized by spiral cleavage during embryonic development in which cell division occurs obliquely to the main axis, and which results in a spiral arrangement of cells.
- Lower critical temperature** For ectotherms, the lowest ambient temperature at which available oxygen can no longer sustain aerobic metabolism, even though physical activity is reduced. For endotherms, the ambient temperature at the lower limit of the thermoneutral zone.  
*See also Thermoneutral zone.*
- LT<sub>50</sub>** The lethal temperature at which 50 per cent of animals in a population die under laboratory conditions, and varies with the duration of the test, which should always be stated with the LT<sub>50</sub>.
- Luminal membrane** The part of the cell membrane facing toward the lumen of the central cavity in tubular epithelia such as the kidney tubules or the gastrointestinal tract.
- Lungs** Gas-exchange organs of terrestrial animals, except insects, which are ingrowths (invaginations) of the body surface.
- Luteal phase** The phase in the mammalian ovarian cycle following ovulation during which a corpus luteum is formed, and which ends in pregnancy, pseudopregnancy, or by the luteolysis of the corpus luteum.  
*See also Corpus luteum.*
- Luteinizing hormone** A peptide hormone synthesized by the anterior pituitary of vertebrates, which together with follicle stimulating hormone stimulates gonadal development and production of gametes.
- Lymphatic system** Part of the circulatory system of vertebrates that returns to the heart fluid that is filtered from the blood into the interstitial space through capillary walls. The lymphatic system is also an important part of the immune system.
- Lymphocytes** One of the types of white blood cells (leucocytes) found in the blood and lymphatic system of vertebrates.
- Lysosomes** Membrane-bound organelles containing enzymes that break down damaged molecules or molecules that are no longer needed by cells.
- Macula** The portion of the retina that processes sharp, clear, straight-ahead images.  
*See also Fovea centralis.*
- Maculae** Sensory structures within the sacculle and utricle of the vestibular organ involved in maintaining balance in vertebrates.
- Magnetite** A specific form of iron oxide (Fe<sub>3</sub>O<sub>4</sub>) crystals found in some animal species that can sense the Earth's magnetic field.
- Magnetoreception** Ability of some animals, both invertebrate and vertebrate, to detect the Earth's magnetic field using sensory receptors called magnetoreceptors.
- Malpighian tubules** The excretory tubules that produce the urine of most insects, some arachnids (spiders, mites and scorpions), and myriapods (millipedes and centipedes).
- Mantle cavity** The cavity surrounded by the mantle of molluscs, which secretes the shell, where present. The mantle cavity contains the gills (ctenidia), or the lung in pulmonates, osphradium, and other body organs and their openings (anus, nephridiopores, and gonopores).
- Mass extinction events** Major events in the Earth's history that caused massive extinction (>50 per cent) of the then existing species.
- Mass-specific power** Power generated by 1 kg of muscle; it is a measure of the intrinsic power-generating capacity of a muscle under given conditions. Also called power density.
- Maximum metabolic rate** The metabolic rate associated with the maximum level of activity (which could be digestion following a large meal) in animals.
- Maxwell-Boltzman distribution** The distribution of kinetic energies of molecules within a gas or solution. This distribution is skewed to the right (positively skewed) and its exact shape depends on the temperature of the chemicals.
- M-cones (human vision)** Cones that are sensitive to medium wavelengths in the visual spectrum.
- Mechanoreceptors** Sensory receptors that are sensitive to mechanical stimuli, such as stretch and pressure.
- Mechano-sensitive channels** Channels that are sensitive to stress (stretch) applied to the membrane lipid bilayer.
- Medulla oblongata** Part of the hindbrain in vertebrates that lies between the pons and the spinal cord.
- Meiosis** Cell division that produces four haploid gametes from an initial germ cell, after an initial chromosome replication, and two nuclear divisions.
- Meissner's corpuscle** Mechanoreceptor in the skin of mammals that detects vibrations up to 50 Hz.
- Melanism** Darkening of the skin by production and dispersion of melanin, as a form of colour variation in animals.
- Melatonin** Hormone released in the blood by the pineal gland of vertebrates at night conveying information about the length of the night. The presence of melatonin in the blood synchronizes circadian rhythms in the body to the rhythm of the body clock (e.g. Suprachiasmatic nuclei in mammals).  
*See also Suprachiasmatic nuclei.*
- Membrane capacitance** Ability of membranes to store electrical charges.
- Membrane potential** The (electrical) potential difference between the inside of the cell ( $V_{in}$ ) and the outside ( $V_{out}$ ).
- Meninx (plural meninges)** Impermeable membrane structure covering the entire surface of the CNS in vertebrates made of one layer in fish, two layers in amphibians, reptiles and birds, and three layers in mammals.
- Menstrual cycle** The ovulatory cycle in some female primates in which development of mature follicles and their ovulation,

and thickening of the uterus lining, occurs in preparation for the implantation of a zygote; if fertilization does not occur, the uterine lining is shed in menstruation.

**Merkel's disc** Tonic mechanoreceptor found in the skin of all vertebrates that remains stimulated for as long as pressure is applied to the skin.

**Mesic** Describes an environment/habitat (or biome) with a moderate availability of water, or an animal adapted to live in a moist environment.

**Mesopelagic zone** An oceanic zone generally at a depth of 200 m to 1000 m in which insufficient light penetrates for photosynthesis to occur. It lies beneath the epipelagic zone and above the bathypelagic zone.

**Metabolic acidosis** A decrease in pH of the blood resulting from the release of acidic metabolites, such as lactic acid from muscles during strenuous exercise.

**Metabolic alkalosis** An increase in pH of the blood resulting from the removal of acidic metabolites, such as the acidic contents of the stomach during vomiting.

**Metabolic pathway** Sequence of biochemical reactions that convert specific molecules into particular end products.

**Metabolic rate** Amount of energy used by an animal per unit time.

**Metabolic water** Water formed by chemical reactions in the body during aerobic metabolism.

**Metabolism** The whole set of chemical reactions and physical processes occurring in an animal's body that are necessary for the maintenance of life.

**Metabotropic receptor** Type of membrane receptor that acts through a second messenger. Metabotropic receptors are often coupled to a G-protein.

**Metamorphosis** A developmental process that brings about a dramatic change in the structure and function of an organism as it passes between distinct stages in its life cycle.

**Metanephridia** The excretory organ of many types of invertebrates (annelids, arthropods, molluscs).

**Metaphase** Third phase of mitosis during which chromosomes line up along a plane (the metaphase plate) in the middle of the mitotic spindle.

**Microglia** Type of glial cell in vertebrates with immune-like functions, such as removal of dead neurons.

**Micropyle** A narrow channel opening at the surface of the ova of some animals (e.g. fish) through which the spermatozoa can enter and fertilize the egg.

**Microtubules** Hollow filamentous structures which are major components of the cytoskeleton and the mitotic spindle.

**Midbrain** One of the three major parts of the vertebrate brain, which is located between the forebrain and the hindbrain, and which acts to maintain homeostasis, posture, balance and coordinate movement.

**Ossicles** Small bones in the middle ear of birds and mammals that transmit vibrations from the tympanum to the oval window that is in contact with fluids of the inner ear.

**Midgut** The middle part of the gastrointestinal tract where food is broken down into small molecules and absorbed.

**Mineralocorticoids** Steroid hormones that regulate the mineral ( $\text{Na}^+$ ,  $\text{K}^+$ ) balance of vertebrates.

**Minute ventilation volume ( $\dot{V}_m$ )** The amount of respiratory medium moved over the gills or in and out of lungs or tracheae per unit time.

**Mitochondrial matrix** Space packed with enzymes enclosed by the inner mitochondrial membrane.

**Mitosis** The process by which replicated chromosomes in cells are segregated into two daughter nuclei.

**Mitotic spindle** Apparatus responsible for the segregation of chromosomes during cell division.

**Mitral cell** Neuron located in the olfactory bulb of mammals which receives information from the axons of all olfactory receptor cells that express the same specific odorant receptor.

**Molluscs** A diverse animal grouping (phylum Mollusca) of mostly aquatic invertebrates including mainly gastropods (snails and slugs), bivalves and cephalopods (squid, cuttlefish and octopus).

**Monochromatic vision** State of having one single type of photoreceptor in the eyes for conveying visual information.

**Monophyletic group** A group of organisms with a single ancestral lineage.

**Motor neuron (or motoneuron)** Neuron whose cell body is located in the central nervous system, or a ganglion, and whose axon innervates an effector organ such as muscle or secretory gland.

**Motor end-plate** The region on the surface membrane of a muscle fibre that contains the complex synaptic contacts made by the terminals of a motor neuron with the muscle fibre.

**Motor unit** One motor neuron and all the skeletal muscle fibres that it innervates.

**Moulting** An imprecise term, which can refer to the entire process that culminates in the shedding or sloughing of the entire skin (reptiles), or exoskeleton (insects), or just the final stage of this process. Also refers to a shedding of parts of the pelage such as mammalian hair or bird feathers.

**Muscle fatigue** Reduced ability of muscle to produce force after a period of intense muscle activity.

**Muscle spindles** Stretch receptors located throughout skeletal muscles of vertebrates that can detect absolute changes in muscle length and the rate of change in muscle length, both of which contribute to the animal's sense of limb position and movement.

**Myelin** A sheath of multi-layered membranes produced around axons by oligodendrocytes in the CNS and Schwann cells in the peripheral nervous system.

**Myocardium** The muscular wall of the heart. It is thickest in the ventricle(s).

**Myofibril** Thin (1–4  $\mu\text{m}$ ) quasi-cylindrical longitudinal unit of striated muscle fibres, which runs from one end of the fibre to the other, and comprises myosin and actin filaments organized in sarcomeres.

**Myogenic pacemakers** Muscle cells that act as pacemakers, especially in the hearts of vertebrates.

**Myoglobin** An iron-based respiratory protein found predominantly in the oxidative muscles of vertebrates, which binds reversibly with oxygen (for which it has a relatively high affinity).

**Myomeres (or myotomes)** Longitudinal series of segmental skeletal muscle structures in the fish, which permits the delay of muscle excitation along the trunk of the fish to produce body and tail fin oscillations for efficient swimming.

**Myometrium** The outer smooth muscle layer of the mammalian uterus.

**Myosin** The motor protein in muscles.

**Myosin-filament** Filamentous structure consisting predominantly of myosin molecules; the myosin-filaments together with the actin-filaments form the contractile apparatus in muscle.

- Na<sup>+</sup>, K<sup>+</sup>-ATPase** An enzyme in the plasma membrane of all animal cells which functions as an active ion pump, using energy released from the hydrolysis of ATP which transports sodium out of cells and potassium into cells (usually in a 3:2 ratio) against their concentration differences.
- Natriuresis** An increase in sodium excretion in the urine, for example as a result of the action of natriuretic peptides.
- Natural selection** The phenomenon whereby a heritable trait that increases the survival rate and reproductive capacity (fitness) of the population becomes more common in successive generations until it becomes a population-level characteristic.
- Near ultraviolet (UV) light** The portion of the electromagnetic spectrum with wavelengths between 300 and 400 nm that is in part, visible to birds, insects and fish.
- Negative feedback** The mechanism whereby the output from the system feeds back and reduces the output from the system.
- Nephridia** The tubular excretory organs (singular nephridium) of many invertebrates.
- Nephron** The individual unit of the vertebrate kidney, comprising interrelated vascular and tubular components.
- Nernst equation** Quantifies the potential difference across a barrier (membrane) where the chemical and electrical forces acting on an ion are in balance such that the net flow of the ion through an open channel is zero.
- Nerve** Bundle of nerve fibres in the peripheral nervous system.
- Nerve cord** Cord of nerve fibres along the body of invertebrates that connects nerve ganglia located in different body segments. This term also applies to vertebrates, in which it is dorsally placed.
- Nerve fibre** The axon of a neuron, which may be covered by myelin.
- Nerve impulse** Signal transmitted along a nerve fibre. An action potential is only the *electrical manifestation* of a nerve impulse; the tiny movements of Na<sup>+</sup> and K<sup>+</sup> across the membrane during a nerve impulse are *chemical manifestations* of the nerve impulse and the minute emission of infrared electromagnetic waves is the *radiation manifestation* of a nerve impulse.
- Nervous system** The main communication system that links an animal to its surrounding environment; it consists of neurons and glial cells.
- Neural circuit** Functional entity of interconnected neurons that is able to regulate its own activity using a feedback loop.
- Neural integration** The overall process by which one neuron responds to all inputs from other neurons reaching it within a given time interval.
- Neural networks** Computer-based representations of theoretical (mathematical) models that consist of several layers of interconnected units called processing elements or 'neurons', where the units have some of the properties of CNS neurons in animals.
- Neural pathway** A series of neurons connected together, which transmits signals from one part of the nervous system to another.
- Neuroepithelial cells** Cells of epithelial origin with specialized sensory functions.
- Neurohaemal organ** An organ composed of the nerve endings of neurosecretory cells, which stores neurohormones, and is surrounded by capillaries or haemolymph into which the hormones are released.
- Neurohormone** Hormones synthesized and secreted by neurons (neuroendocrine cells).
- Neuromasts** Lateral line organs consisting of hair cells with their cilia embedded in a wedge-shaped cupula, which projects into the centre of the lateral line canal.
- Neuromuscular junction** Chemical synapse formed by multiple contacts between the synaptic terminals of a motor neuron and a muscle fibre.
- Neuron** Type of excitable cell that processes and transmits information via electrical and chemical signals.
- Newtonian fluid** Fluid in which the viscosity remains constant whatever its velocity, and which normally contains relatively small molecules. Blood containing haemocytes is a non-Newtonian fluid.
- Nitric oxide** An important messenger molecule that affects synaptic transmission between neurons, controls the smooth muscle tone in blood vessels and airways, and modulates immune responses.
- Nociception** The ability of animals to perceive noxious or damaging stimuli.
- Nociceptors** Sensory receptors located on free nerve terminals that are sensitive to stimuli capable of causing damage to the animal; for example, nociceptors are very sensitive to bradykinin released by damaged cells.
- Nocturnal** Animals that are active at night.
- Nodes of Ranvier** Small (1-10 μm wide) gaps occurring at about 1-2 mm intervals in the sheath of myelin along the length of a myelinated axon.
- Non-shivering thermogenesis** The uncoupling of oxidation from phosphorylation in the mitochondria of mammals, which occurs mainly in the brown adipose tissue and is an important source of heat for maintaining body temperature in mammals.
- Non-spiking neurons** Nerve cells that do not produce action potentials when they depolarize.
- Noradrenaline (norepinephrine)** Neurotransmitter secreted by the sympathetic nerve terminals and some neurons in the CNS. Noradrenaline is also a hormone secreted by the adrenal medulla.
- Notochord** A flexible rod composed of material similar to cartilage which supports the body of all embryonic and some adult chordate animals.
- Nuclear envelope** The double-layered membrane with large pores, which encloses the nucleus.
- Nuclear receptors** Receptors within cells that bind specific lipid soluble hormones (e.g. steroid hormones, thyroid hormones) and then interact with DNA at the hormone response element, which regulates transcription of the adjacent gene.
- Nucleolus** Round granular body composed of protein and RNA in the nucleus, where ribosomes are assembled.
- Nucleus** The membrane-enclosed organelle, which contains most of an organism's genetic material (DNA).
- Obligate air breathers** Those species of aquatic animals that predominantly obtain oxygen from air, even when they are in well aerated water.
- Obligatory ureotelic** Animals obliged to excrete urea for nitrogenous excretion.
- Occipital lobe** Anatomical subdivision of a cerebral hemisphere in mammals, located at the back of the hemisphere.
- Occludin** An integral protein in the plasma membrane located at the tight junctions.
- Ocean acidification** The outcome of an increase in H<sup>+</sup> concentration of seawater, which can be measured as a decrease in the pH and a decrease in the ocean concentration of carbonate ions (CO<sub>3</sub><sup>2-</sup>).
- Odorant receptor** G protein-coupled receptor protein, which becomes activated when an odorant molecule binds to it.
- Oesophagus** The part of the alimentary canal connecting the pharynx to the stomach.
- Oestrogens** Any of several steroid hormones produced by the ovaries that help to control sexual and reproductive development.



- Oestrous cycle** The cycle of hormonal changes and their effects on the reproductive system of sexually-mature female mammals.
- Oestrus** The period when female mammals are sexually receptive, which in animals that spontaneously ovulate occurs around the time of ovulation, under the influence of gonadotrophins.
- Olfaction** The sense of smell.
- Olfactory sensilla** Sensilla with many pores in the cuticle through which odorant molecules can enter, situated predominantly on antennae of arthropods.
- Oligodendrocytes** Type of glial cells in vertebrates that produce the sheath of myelin around axons in the CNS.
- Ommatidium (plural ommatidia)** The basic unit of the compound eye, which consists of a dioptric apparatus situated above a ring of closely-packed photoreceptor cells.
- Omnivores** Animals that eat food of both plant and animal origin.
- Oogonia** Immature diploid cells in the ovary, derived from primordial germ cells, which proliferate by mitosis.
- Opercular suction pump** An active part of the ventilatory cycle of bony (teleost) fish caused by the enlargement of the opercular cavities sucking water through the gill mesh.
- Opsin** Protein to which the chromophore is covalently bound in a photopigment molecule.
- Optic chiasm** The region of the brain where the optic nerves partially cross.
- Optic disc** The small circular area devoid of photoreceptor cells in the back of the eye where the axons of the ganglion cells converge to form the optic nerve, which then exits the eye.
- Organ** Distinct part of an animal's body that performs a specific function.
- Organ of Corti** The hearing organ in mammals containing the acoustic sensory cells (hair cells); it runs along the entire length of the basilar membrane.
- Organ system** A group of organs that work together to perform one or more major functions.
- Organelles** Intracellular structures that perform specific functions within a cell.
- Organism** Any individual living entity such as an animal, a bacterium or a plant.
- Osmoconformers** Aquatic animals that allow the osmotic concentration of their body fluids to follow (conform with) any changes in the osmotic concentration in their environment.
- Osmolality** The osmotic concentration of a solution expressed relative to the mass of solvent (osmol per kg, Osm kg<sup>-1</sup>).
- Osmolarity** The osmotic concentration of a solution expressed relative to a volume of solution (osmol per litre, Osm L<sup>-1</sup>).
- Osmoregulation** The regulation of the osmotic concentrations (salt and water balance) of the body fluids.
- Osmoregulators** Aquatic animals that maintain relatively stable osmotic concentrations of their extracellular fluids when environmental osmolality varies.
- Osmosis** Flow of water across a semi-permeable barrier from a more osmotically dilute solution (which has a higher water concentration) into a more osmotically concentrated solution (which has a lower water concentration).
- Osmotic pressure** The pressure that needs to be exerted on a solution to prevent the flow of water across a semi-permeable barrier from a compartment that contains pure water.
- Osteoblasts** Bone cells that produce the matrix, which is then mineralized. Bone mass is determined by the balance of activity between the osteoblasts that form bone and the osteoclasts that break it down.
- Osteoclasts** Bone cells that secrete digestive enzymes and protons, resulting in dissolution of bone tissue in resorptive pits as part of the continual process of bone maintenance, repair and remodelling.
- Otoliths** Tiny dense particles of calcium carbonate embedded on the surface of the cupula in maculae.
- Ova (singular = ovum)** The female sex cell or haploid gamete often referred to as the egg. Fertilization of an ovum by a spermatozoon (motile sperm cell) to form a diploid zygote is usually required to produce a new individual, but some animals are capable of parthenogenesis in which their ova can develop without fertilization.
- Oval organ** Mechanical receptor found in the major component (the bailer or scaphognathite) of the respiratory system of decapod crustaceans.
- Oval window** Oval opening covered by a membrane linking the middle ear to the vestibular duct in the inner ear.
- Overshoot (action potential)** The amount by which the membrane potential shoots over the zero line during an action potential.
- Oviparous** Animals that release eggs in which there has been little or no embryonic development.
- Ovoviviparity** A mode of reproduction in which the females retain the fertilized eggs, and protect the developing embryos until live young are born, but do not provide additional nutrition to the embryos.
- Ovulation** The process of releasing an ovum or several ova (eggs) from the ovary.
- Oxidative phosphorylation** The final (fourth) segment of aerobic respiration which couples the oxidation of the electron carriers to the phosphorylation of ADP to ATP.
- Oxyconformer** A species of animal that is unable to maintain its rate of oxygen consumption at the resting level as the partial pressure of oxygen in the environment falls.
- Oxygen carrying capacity** The maximum amount of oxygen that can be carried by a given volume of blood or haemolymph. Most of the oxygen is bound to the respiratory pigment.
- Oxygen deficit** The difference between the amount of oxygen required by an animal at the onset of exercise and the amount actually taken up by the cardiorespiratory system before a steady state is reached.
- Oxygen equilibrium curve** A plot of the relationship between the oxygen concentration (or percentage saturation) in the blood and its partial pressure.
- Oxyregulators** Those animals that can maintain their rate of oxygen consumption at the resting level as the partial pressure of oxygen in the environment declines.
- Ozone layer** Layer of ozone (O<sub>3</sub>) produced high in the atmosphere by ultraviolet radiation from the Sun that acts as a shield to limit damaging ultraviolet radiation reaching the Earth's surface.
- P<sub>50</sub>** The partial pressure of oxygen at which a respiratory pigment is 50 per cent saturated.
- Pacemaker cells** Excitable cells that do not have a resting membrane potential as such because they never rest.
- Pacemaker potential** The spontaneous oscillations displayed by the membrane potential of pacemaker cells.
- Pacinian corpuscle** Mechanoreceptor in the innermost layer of mammalian skin that responds to sudden changes in pressure both when pressure is applied and when the pressure is removed; it detects vibrations up to several hundred Hz.
- Panting** Rapid and shallow breathing that ventilates the non-respiratory surfaces, and results in evaporation of water and thereby loss of heat. Common in some air-breathing species of vertebrates other than fish.

**Paracellular pathway** The route between epithelial cells.

**Paracrine secretions (paracrines)** Chemicals secreted by cells that act on nearby cells.

**Parallel evolution** The process whereby similar or identical features evolve independently, by similar developmental pathways, in different groups of animals.

**Paramyosin** Protein associated with myosin-filaments in invertebrate muscles, which plays an important role in producing functional diversity of invertebrate muscles.

**Parasympathetic (nervous) system** Division of the autonomic nervous system that is responsible for maintaining normal body functions in the animal at rest.

**Parathyroid glands** Small endocrine glands often found near to or embedded in the thyroid gland of vertebrates, and which secrete parathyroid hormone.

**Parathyroid hormone (PTH)** A hormone released by parathyroid glands of vertebrates that raises blood concentrations of calcium, i.e. PTH has hypercalcaemic actions. Fish that do not have parathyroid glands produce hypercalcaemic PTH-related peptides from a range of tissues.

**Parietal lobe** Anatomical subdivision of a cerebral hemisphere in mammals positioned behind the frontal lobe.

**Parthenogenesis** Asexual reproduction from unfertilized eggs in which embryos develop into genetically identical clones of the female producing the eggs:

*Facultative parthenogenesis* is exhibited in many animal groups including vertebrates (but not mammals) when males are low in number or are completely absent;

*Persistent parthenogenesis* is an obligate form of parthenogenesis found in some invertebrates such as species of ants, bees, aphids, which allows rapid population expansion.

**Partial pressure** The pressure exerted by an individual gas in a mixture of gases, which is directly related to the proportion of that gas in the mixture. The partial pressures of all the gases in the air add up to atmospheric pressure.

**Passive electroreception** Ability of some animals to sense electric fields produced by various sources in their habitat.

**Passive transport** Transport of substances across cell membranes without energy expenditure.

**Pattern recognition** Neural networks that learn to predict future events based on previously observed patterns.

**Pavement cells** The most abundant type of epithelial cell on both the filament and lamellae of fish gills.

**Pectoralis muscle** Muscle that powers the downstroke flap of the wing in birds.

**Pejus temperatures** The upper and lower temperature limits for optimal performance by ectotherms.

**Pelagic species** Species that live and feed away from the bottom of a water body.

**Pendular movement** The up and down movement of the centre of gravity experienced during locomotion by terrestrial animals.

**Pericytes** Type of smooth muscle cells in contact with endothelial cells of blood capillaries in the central nervous system that affect the effectiveness of the endothelial barrier.

**Perilymph** A typical extracellular fluid with high sodium concentration (about 150 mmol L<sup>-1</sup>).

**Perimysium** Layer of connective tissue surrounding muscle fascicles.

**Peripheral chemoreception** Ability of animals to detect changes in internal or external chemical parameters through structures that are an extension of the peripheral nervous system.

**Peripheral nervous system** The part of the nervous system that is located outside the central nervous system and connects it with various parts of the body.

**Peristalsis** A travelling wave of muscular contraction characterized by alternate contraction and relaxation of muscles in the wall of tubular structures.

**Permeability** For a cell membrane or an epithelium, the ease with which a particular solute or water passes through.

**Pharynx** The part of the alimentary canal immediately behind the mouth.

**Phasic (sensory) receptors** Rapidly adapting sensory receptors.

**Phasic receptor potential** Short-lived receptor potential that occurs when there is a change in stimulus intensity.

**Phenotype** Observable features of an animal.

**Phenotypic flexibility** The ability of an organism reversibly to modify its phenotype by changes in physiology, morphology and/or behaviour.

**Pheromones** Chemicals released by animals that influence the reproductive and social behaviours of others of the same species: *aggregation pheromones* attract large numbers of individuals to a location; *alarm pheromones* trigger an escape response or aggression in the other members of the community; *sex pheromones* are associated with mating behaviours or dominance; *trail pheromones* are used by social insects to mark foraging paths.

**Phosphagens** High-energy phosphates that act as rapid buffers to maintain the ATP pool high and the ADP concentration low, and which are particularly important when there is a rapid requirement for a supply of energy, such as at the beginning of exercise.

**Phosphorylation** Enzymatic attachment of a phosphate group to specific chemical groups on proteins, carbohydrates and lipids.

**Photoisomerization** Process by which the chromophore changes conformation from 11-*cis*-retinal to all-*trans*-retinal.

**Photon** Particle of light or other electromagnetic radiation, which is not electrically charged and has no static mass but carries energy that is inversely proportional to its wavelength.

**Photoperiod** The number of hours of light per 24-hour day; commonly called day length.

**Photopigments** Light-sensitive proteins that change configuration when they absorb photons of specific wavelengths.

**Photopsin** The protein component (opsin) of photopigments expressed in cone-structured ciliary photoreceptors.

**Photoreceptors** Sensory receptors that are sensitive to electromagnetic radiation in the form of light.

**Phrenic nerves** Motor nerves which innervate the diaphragm of mammals and which arise mainly from the inspiratory neurons of the dorsal respiratory group.

**Phylogenetic tree** A branching diagram showing the inferred evolutionary relationships among various species. The main difference between a phylogenetic tree and a cladogram is that the length of the branches in some phylogenetic trees may estimate evolutionary time.

**Phylogeny** The evolution of a genetically related group of organisms or the pattern of evolutionary relationships among organisms.

**Phylum (plural phyla)** A level of classification or taxonomic rank above *class* and below *kingdom*.

**Pigment cells** Cells containing the pigments that impart colour to an animal's surface.

- Pillar cells** Cells that separate the two layers of epithelial cells in the gills of some aquatic organisms and which form channels filled with blood.
- Piloerection** The erection of hairs of the body of mammals in order to decrease their thermal conductance (and hence increase thermal insulation).
- Pineal gland** A small endocrine gland near the centre of the brain which secretes melatonin, which itself helps to control biorhythms. *See also Melatonin.*
- Pinhole eye** Simple type of image-forming eye occurring in some gastropods such as abalone and cephalopods such as nautilus, which consists of a folded layer of photoreceptor cells lined by a pigmented epithelium with a narrow opening.
- Pinna** The visible part of the ear in vertebrates.
- Pituitary gland** An endocrine gland in vertebrates attached to the brain hypothalamus by a stalk, and composed of two main lobes: anterior pituitary = non-neural adenohypophysis and posterior pituitary = neurohypophysis. Hormones secreted by the pituitary influence growth, reproduction, metabolism, and salt and water balance.
- Placenta** An organ formed by the foetus and its mother in placental mammals that connects the developing foetus to the uterine wall and allows the provision of nutrients to the foetus, gas exchange, and passage of waste substances from the foetus to mother. The placenta produces the hormones that maintain pregnancy.
- Placental mammals** Mammals whose pregnant females nourish their foetus in the uterus, via a placenta. All living mammals are placental mammals, except marsupials and monotremes.
- Plankton** Unicellular organisms such as bacteria and protozoa, and tiny algae, plants and animals that include immature stages of larger animals that float or drift in great numbers in bodies of salt or fresh water.
- Plasma** The fluid of the blood of vertebrates within which the red blood corpuscles and other cells are suspended.
- Plasma membrane** The cell's outer membrane.
- Plastron** A very dense pile of water-repellent hairs holding a thin layer of air on the outside of the body of aquatic insects that allows the exchange of gases between an animal via its spiracles, and the surrounding water.
- Platyhelminths** Flatworms (phylum Platyhelminthes) that lack fluid-filled body cavities and specialized organs for oxygen uptake.
- Pleurae** Two delicate membranes surrounding the lungs of mammals; one lines the chest wall and the other lines the lungs. They are separated by a narrow, fluid-filled space. This arrangement gives the lungs some freedom of movement within the thorax.
- Pneumostome** The narrow sphincter-like opening to the mantle (lung) cavity of pulmonate molluscs.
- Podocytes** Epithelial cells of Bowman's capsule with numerous interdigitating processes that wrap around the glomerular capillaries and determine which solutes pass into the ultrafiltrate. *See also Ultrafiltration.*
- Poikilothermy** A considerable variability in body temperature, which often closely matches ambient temperature, and which is exhibited by most groups of animals.
- Polycythaemia** A higher than normal number of red blood cells and haemoglobin concentration in the blood.
- Pons** Part of the hindbrain in vertebrates that lies above the medulla.
- Positive feedback** Occurs when output from a system feeds back and increases the output from that system.
- Posterior pituitary** The infundibular stalk and posterior, neural lobe of the vertebrate pituitary (=neurohypophysis), which stores and releases into circulation particular peptide hormones synthesized by the connected hypothalamic neurons, e.g. oxytocin, arginine vasotocin or arginine vasopressin.
- Postsynaptic potential** The change in the membrane potential of the postsynaptic membrane in response to the activation of a chemical synapse.
- Pre-Bötzinger complex** A group of neurons in the ventro-lateral region of the brainstem of mammals which is essential for the generation of the respiratory rhythm.
- Precocial** Describes species in which the young hatch, or are born, at a relatively advanced stage in development and are mobile from birth/hatching.
- Preferred body temperature** The body temperature that ectotherms maintain by behavioural thermoregulation.
- Preformed water** Water already present in food as H<sub>2</sub>O that is taken in when feeding.
- Prestin** Protein present on the surface of outer hair cells that changes shape to cause rapid cell shortening upon membrane depolarization and lengthening upon hyperpolarization.
- Primary bronchi** The two main bronchi which divide from the trachea and run the whole length of the lungs in birds and some species of reptiles.
- Primary consumers** Animals and unicellular organisms that feed on organic compounds synthesized by primary producers.
- Primary producers** Photosynthetic cyanobacteria, algae and plants, which trap energy from the Sun to produce organic compounds that are used as food by primary consumers.
- Primary urine** The initial fluid formed in kidney tubules or nephridia either by filtration or secretion.
- Primary visual cortex** Region of the cerebral cortex that occupies the entire surface of the occipital lobes, where visual signals are processed.
- Primordial follicle** An ovarian follicle in which a single layer of flattened cells—the granulosa cell layer—surrounds the primary oocyte, which is arrested in prophase of the first meiotic division.
- Proboscis** An elongated sucking organ that is typically tubular and flexible.
- Progesterone** A steroid hormone secreted by the corpus luteum of female vertebrates and the placenta of placental mammals.
- Prokaryotes** Micro-organisms that have no cell nucleus or any other membrane-bound organelles in their cells.
- Prolactin** A paracrine and peptide hormone synthesized and secreted by the anterior pituitary hormone of vertebrates, which has many actions, including roles in salt and water balance (fish), stimulation of mammary gland development and milk production (mammals), calcium homeostasis, and actions on immune function and behaviours.
- Prometaphase** Second phase of mitosis, when chromosomes interact with the mitotic spindle.
- Prophase** First phase of mitosis, when chromosomes undergo compaction.
- Proprioception** Ability of animals to sense the relative position of their own body parts, movement, balance and posture.
- Prostaglandins** A family of potent autocrine and paracrine substances synthesized from particular membrane fatty acids such as arachidonic acid, which occur in most tissues and body fluids, and which influence many physiological processes, including vasodilation/vasoconstriction, inflammation, cell growth, hormonal secretions.

- Protocerebrum** One of the three regions of the arthropod brain which innervates the eyes and processes visual information.
- Proto-eye** Common precursor of animals' eyes, which is thought to have consisted of an opsin-Vitamin A-based precursor photoreceptor cell and associated pigment cell to detect the direction of light.
- Protomicrons** Very small (~150 nm) droplets of lipid and protein mixtures used to transport dietary lipids in birds from intestines to the blood.
- Proton pump** A complex of integral membrane proteins that actively transport protons (hydrogen ions) across membranes, using ATP as an energy source.
- Proventriculus** The part of the gastrointestinal tract between the crop and the stomach in arthropods, or between the crop and the gizzard (ventriculus) in most birds.
- Proximal segment** The nearest segment of the nephron to the glomerulus, characterized by a brush border that increases the surface area of the luminal border of the tubular epithelium.  
*See also Brush border.*
- Ptilorection** The erection of feathers of the body of birds to decrease their thermal conductance (and hence increase thermal insulation).
- Pulse pressure** Difference in pressure between systolic and diastolic blood pressure during the cardiac cycle.
- Pyloric valve** A structure that regulates the movement of the chyme from the stomach into the small intestine.
- Q<sub>10</sub>** The extent to which a reaction rate changes with a change in temperature of 10°C
- Radiation** Transfer of energy through space by means of electromagnetic waves in the same way as the Sun transmits light and heat to Earth.
- Radiation energy** Form of energy associated with electromagnetic waves such as light.
- Radula** A tongue-like structure with rows of microscopic teeth that gastropods use in feeding.
- Ram ventilation** Ventilation of an enclosed respiratory surface through open entrance(s) and exit(s) by the movement of the animal through the respiratory medium, which occurs particularly in some species of fish and insects.
- Rate (velocity) of reaction** The rate of product formation in a chemical reaction, which is directly proportional to the concentration of the reactants and the proportionality constant (the rate constant).
- Rate constant** A proportionality coefficient relating the rate of a chemical reaction at a given temperature to the concentration of reactant (in a unimolecular reaction) or to the product of the concentrations of reactants. The rate constant increases exponentially as temperature increases.
- Ray-finned fish** Actinopterygii—one of the two classes of bony fish—which have fins supported by thin bony rays.
- Reactive oxygen species (ROS)** Chemically reactive oxygen-containing molecular species such as superoxide. ROS are by-products of oxygen metabolism.
- Receptor potential** The change in the membrane potential of a sensory receptor in response to a stimulus.
- Receptor proteins** Membrane proteins that bind specific compounds or respond to specific signals.
- Reciprocal inhibition** Reciprocal inhibition of activity in one set of neurons (and their associated muscles) by activity in another set of neurons (and their associated muscles).
- Rectal gland** A specialized organ attached to the rectum of cartilaginous fish that secretes and excretes sodium chloride.
- Regional endothermy** The ability to warm specific parts of the body, such as the locomotor muscles.
- Regulated hypometabolic state** An active depression of metabolic rate to a new controlled level in endotherms.  
*See Metabolic suppression.*
- Reissner's membrane** Membrane that separates the cochlear duct from the vestibular duct in the inner ear.
- Relative humidity** An expression of humidity (water vapour density or partial pressure of water vapour in air) as a percentage of the humidity of fully saturated air, at the same temperature.
- Relative refractory period** Period following the absolute refractory period when another action can be triggered, but which requires a stronger stimulus than at rest (i.e. the threshold is higher).
- Renin-angiotensin-(aldosterone) system** A hormonal system beginning with release of renin primarily from the kidney, which cleaves angiotensinogen to form the peptide hormone angiotensin; this system is activated by low blood pressure/low blood volume. In tetrapods, angiotensin II stimulates secretion of aldosterone.
- Reproductive isolation** The situation in which two populations of the same species are prevented from interbreeding by various environmental, mechanical, behavioural or physiological factors that act as barriers to the gene flow between these populations.
- Reproductive system** The system of organs responsible for maintaining (or expanding) populations in communities of animals within ecosystems.
- Resilin** Elastic protein involved in some insects for storing energy that is then suddenly discharged to extend the hind legs and make the insect jump.
- Resistance** Describes: (i) the ability of an animal to resist or repel, for example parasites or pathogens, (ii) the opposition to a flow of electric current (electrical resistance), (iii) restriction of water passage across membranes e.g. resistance to evaporative water loss (the inverse of permeability), (iv) opposition to flow in a blood vessel.  
*See Appendix 1.*
- Resonant frequency** The frequency of oscillation of an object that requires minimal energy to maintain that oscillation compared to the energy required to vibrate it at any other frequency.
- Respiratory acidosis** Decrease in pH of blood due to the accumulation of CO<sub>2</sub> during hypoventilation.
- Respiratory alkalosis** Increase in pH of blood due to the excessive removal of CO<sub>2</sub> during hyperventilation.
- Respiratory exchange ratio** The ratio between the rate of carbon dioxide produced and the rate of oxygen consumed by an animal. Only if the animal is in a steady state is this equivalent to respiratory quotient.
- Respiratory quotient (RQ)** The ratio between the rate of production of carbon dioxide and the rate of consumption of oxygen in the tissues when foodstuffs are oxidized.
- Respiratory sinus arrhythmia** Variation in heart rate with ventilation in air-breathing vertebrates; heart rate increases during inspiration and decreases during expiration.
- Respiratory tidal volume** The amount of respiratory medium moved over or in and out of the gas-exchange organ per ventilation cycle.
- Respiratory turbinates** Long, narrow, curled shelves of bone that protrude into the nasal passage in a number of air-breathing vertebrates. In birds and mammals they are more extensive than in reptiles and are important for water and heat conservation.



**Resting membrane potential** The membrane potential of cells when the membrane potential is steady and the cells are 'at rest'.

**Resting metabolic rate** The lowest value of the metabolic rate during the daily cycle of an animal.

**Rete mirabile** Intricately intertwined net structure of capillaries, which functions as a countercurrent exchange system.

**Reticular formation** Region of the brainstem of vertebrates consisting of a mesh of neurons and their fibres distributed through the medulla, pons and midbrain.

**Retina** A multi-layered structure of neurons at the back of the eye containing ciliary photoreceptors (rods and cones) which make chemical synapses with secondary neurons.

**Retinular cells** Closely packed elongated rhabdomeric photoreceptor cells in an ommatidium.

**Rhabdomeric (photo)receptors** One of the two major types of photosensitive cells in animals where the photoreceptor cell has a highly folded apical surface with microvillar projections containing the photopigment molecules.

**Rhesus proteins** Members of an ancient family of integral membrane proteins in the plasma membrane of certain cells that act as ammonia channels.

**Rhodopsin** Photopigment made of retinal and the protein scotopsin present in all rod-structured ciliary photoreceptors.

**Right-to-left shunting** The situation in air-breathing vertebrates with an incompletely divided ventricle whereby more blood flows from the left side of the ventricle to the body than from the right side to the lungs.

**Rods** One of the two types of ciliary photoreceptors whose outer segment is in the shape of a rod.

**Root effect** Named after R W Root, a description of the phenomenon whereby, for the negatively-charged haemoglobins in some species of teleost fish, their affinity and their oxygen carrying capacity are inversely related both to the concentration of carbon dioxide and acidity.

**Rough endoplasmic reticulum** Section of the endoplasmic reticulum with ribosomes attached to it.

**Ruffini's corpuscle** Tonic touch mechanoreceptor that remains stimulated for as long as the pressure is applied to the skin. Ruffini's corpuscles are responsible for the sensation of the stretch of the skin and sustained pressure on the skin.

**Sacculae** One of the two compartments of the vestibular organ in vertebrates; amphibians that lack basilar papillae have sensory cells for hearing located in the sacculae.  
*See also Basilar papillae.*

**Salinity** The sum total of inorganic dissolved substances in water expressed in  $\text{g kg}^{-1}$  (parts per thousand) or measured on a dimensionless scale in practical salinity units (psu).

**Salt glands** Organs excreting concentrated salt solutions (aside from kidneys); these include rectal glands of elasmobranchs, nasal glands of birds, lachrymal (tear) and lingual salt glands (opening on the tongue surface) of reptiles.

**Saltatory conduction** Type of propagation of action potentials in a myelinated nerve fibre that gives the impression that the action potential jumps from one node of Ranvier to another.

**Salting out effect** Reduction in the solubility of gases in solution as the concentration of a solute, such as lactate, increases.

**Sarcolemma** Surface membrane covering a muscle fibre.

**Sarcomere** Structural and functional unit of striated muscle fibres running between two adjacent Z-lines.

**Sarcoplasmic reticulum** The intracellular  $\text{Ca}^{2+}$ -store in muscle fibres.

**Saturation deficit** The amount by which water vapour pressure in air must increase before saturation occurs, in the absence of changes in temperature or pressure.

**Saturation water vapour pressure** The maximum water vapour pressure for the particular air temperature that can stably occur.

**Scansorial** Describes animals adapted for climbing, their form of locomotion, and their adaptations (e.g. claws).

**Schwann cells** Type of glial cell in vertebrates that produces the sheath of myelin around axons in the peripheral nervous system.

**S-cones (human vision)** Cones that are sensitive to shorter wavelengths in the visual spectrum.

**Second messenger** An intracellular chemical signal (such as cAMP or inositol trisphosphate,  $\text{IP}_3$ ) that initiates a series of biochemical events and physiological actions when molecules of a hormone or a neurotransmitter, acting as the first messenger, bind to specific receptors.

*See Cyclic AMP and Inositol trisphosphate.*

**Secondary active transport** A form of transport by an integral membrane protein in which the movement of a substance (often ions) occurs against an electrochemical difference due to its coupling to the transport of another ion down its electrochemical difference produced by primary active transport.

**Secondary bronchi** Two sets of bronchi, called ventrobronchi and dorsobronchi, which arise from the primary bronchi of birds as they pass through the lung.

**Secondary sexual characteristics** Physical characteristics that distinguish mature males and females of a species, and that may be important in behaviour and sexual attraction, but are not directly involved in the formation or delivery of gametes.

**Secretory cells** Cells that release chemicals with specific functions, such as hormones.

**Selectively-permeable** Biological interfaces such as membranes with a high permeability to some solutes but low permeability to others.

*See also Semi-permeable membrane.*

**Semelparous** Describes species that die after a single reproductive event. *Contrast with iteroparous.*

**Semicircular canals** Canals broadly oriented in the three planes of space found in the vestibular organ of mammals.

**Seminiferous tubules** The coiled tubules within the testes that produce spermatozoa.

**Semi-permeable membrane** A biological or synthetic membrane that allows the passage of solvent such as water but prevents the passage of solutes such as ions or other molecules.

**Sensilla (singullar sensillum)** Sensory hairs covered by a very thin cuticle and located on antennae, legs, wings and mouth parts of arthropods. *Olfactory sensilla* are situated predominantly on the antennae and have many pores in the cuticle through which odorant molecules can enter. *Gustatory sensilla* are generally situated on mouth parts, legs and wings and have only one pore at their tip.

**Sensory adaptation** The decrease in the amplitude of the receptor potential during prolonged stimulation.

**Sensory organ** Multicellular structure consisting of sensory receptors and supporting cells which is specialized to acquire a particular type of stimulus at low levels of energy while filtering out other types of stimuli.

**Sensory perception** The ability of animals to interpret their surrounding environment by processing information that is acquired through exteroceptors.

- Sensory reception** The process of sensory transduction in which sensory receptors convert specific stimuli into electrical signals.
- Sensory system** Encompasses the sensory organs specialized for acquiring a particular type of stimulus together with the parts of the nervous system that participate in processing the information those organs have acquired.
- Sensory transduction** Conversion of stimulus energy into action potentials.
- Sensory-somatic nervous system** Part of the peripheral nervous system that connects the central nervous system with sensory structures associated with the external environment in which the animal is situated, and with effector organs such as the musculo-skeletal system, surface epithelia and their derivatives.
- Serotonin** An important neurotransmitter molecule which functions in synapses of the central nervous system of vertebrates (mainly inhibitory synapses) and invertebrates (both inhibitory and excitatory synapses), and which regulates urine production and composition in insects. Also named by its chemical structure as 5-hydroxytryptamine (5HT).
- Sertoli cells** Cells in the testes of all vertebrates that are essential for spermatogenesis, by providing the correct conditions, nourishing the germ cells and supporting their progression along the lateral margins of the Sertoli cells to the lumen of the seminiferous tubules.
- Serum** Plasma without any clotting agents.
- Set point** The reference point that is used by the central nervous system of an animal to determine whether body temperature, blood pressure or extracellular fluid osmolarity is lower or higher than it should be, and to initiate the appropriate remedial action to return the variable back toward the set point value.
- Sex chromosomes** Chromosomes in the genome that are involved in genetic sex determination of most organisms and their development of sexual characteristics.
- Sexual differentiation** The series of processes that result in the development of gonads (testes or ovaries), genital organs and ducts, and the development of secondary sexual characteristics.
- Shivering thermogenesis** The use of shivering as a means of generating heat.
- Short wave radiation** The high energy radiation from the surface of the Sun, which includes ultra violet and visible radiation.
- Shunts** Bypass routes: *Anatomical* shunts that allow blood to bypass its normal route (for example, a gas exchange surface), or the respiratory medium (air or water) to bypass the gas-exchange surface; *Physiological* shunts exist when blood or respiratory medium are too far away from the exchange surface to undergo gas exchange in the time available.
- Signal transduction** The sequence of events in which extracellular chemical signals such as hormones trigger cellular responses; also called cell signalling.
- Single circulation** The situation in which the heart has a single chamber (ventricle) which pumps the blood through the gas-exchange organ and then round the body before returning to the single chamber of the heart.
- Sinoatrial node** The dominant pacemaker in the heart of most vertebrates that sets the pace of the heart. The sinoatrial node is derived from the sinus venosus of fish and is located at the junction between the superior vena cava and the right atrium.
- Sinus glands** Paired neurohaemal organs in decapod crustaceans that store neuropeptides secreted by the X-organs and release them into the haemolymph.
- Skeletal muscle** Muscle connected to an animal's skeleton, which contracts only when fibres are stimulated by motor neurons.
- Slow-twitch muscle fibres** The broad subdivision of twitch skeletal muscle fibres that contract distinctly more slowly compared with fast-twitch fibres from the same species.
- Smooth muscle** Muscle made of cells that are uniform in their appearance when viewed under a microscope.
- Soaring** Passive mode of locomotion in birds involving gliding in raising air currents (thermals).
- Solubility coefficient of a gas ( $\alpha$ )** The increase in the amount of gas at a constant temperature, dissolved in a given volume of liquid per unit increase in partial pressure of that gas. Solubility is inversely affected by temperature.
- Solute carriers** A large group of membrane proteins that transport particular solutes across plasma membranes.
- Solutes** Molecules dissolved in a solvent such as water.
- Soma** The cell body of a neuron.
- Somatic reflex arc** The anatomical basis for reflex behaviour involved in motor coordination.
- Spatial summation** The process whereby sub-threshold electrical signals arriving at different locations on a neuron summate at the spike-initiating zone, where the depolarization may reach the threshold for triggering an action potential.
- Speciation** Evolutionary process through which new species arise.
- Species** Group of similar individuals capable of exchanging genes to produce fertile offspring in the wild.
- Specific dynamic action** The increase in metabolic rate above resting level associated with feeding; also known as heat increment of feeding or thermic effect of food.
- Specific force** Force produced per cross-sectional area of muscle.
- Spermatogenesis** The process of male gamete formation including the formation of spermatocytes, their meiotic division, and the transformation of spermatids into spermatozoa.
- Spermatophore** A protein capsule containing a mass of spermatozoa (sperm) which is transferred to the female during the mating of some species, including salamanders, some sharks, cephalopod molluscs, and various arthropods.
- Spermatozoa (*singular spermatozoon*)** The motile sperm cells (sperm) produced by spermatogenesis in male gonads. The male haploid gamete fuses with the female gamete (ovum) to form the diploid zygote.
- Spike-initiating zone** Anatomical part of a neuron located where the axon emerges, immediately after the cell body (soma); propagating action potentials are generated at this level.
- Spinal cord** The cord-like part of the central nervous system in vertebrates that descends from the base of the brain and is enclosed within the vertebral column; the spinal cord connects most parts of the body to the brain.
- Spinal nerves** Nerves that emerge in pairs from the spinal cord. Spinal nerves have dorsal and ventral roots just outside the spinal cord, where the cell bodies of the spinal nerves are located.
- Spiracles** Openings into the tracheae of insects and some other species of terrestrial arthropods, which can be opened and closed to enable gas exchange to occur.
- Spontaneous ovulation** Ovulation that occurs due to hormone actions, whether or not mating takes place.
- Standard metabolic rate** The minimum metabolic rate in ectotherms at a particular environmental temperature.
- Standard temperature and pressure dry (STPD)** The standard conditions (273.15 K or 0°C, 101.3 kPa or 760 mmHg in a dry atmosphere) used when comparing the volumes of gases that are measured under non-standard conditions.

- Statocysts** Balance sensory organs in aquatic invertebrates consisting of a mineralized mass (statolith) surrounded by an epithelial layer containing sensory hair cells.
- Steady-state** Stable condition with respect to particular variables, which do not change in time but which requires continuous input of energy and/or matter to be maintained.
- Stenohaline** Describes an animal that can only survive in a narrow range of external salinities.
- Stenothermy** The ability of animals to tolerate only narrow temperature limits.
- Stereocilia** Microvilli-like structures (numbering 20 to hundreds) located at the apical end of hair cells which behave as rigid rods that can only bend at their point of insertion into the hair cell.
- Steroidogenesis** The complex series of chemical steps involved in the biosynthesis from cholesterol of steroids that act as hormones.
- Stimuli (singular stimulus)** Detectable factors in the external or internal environment that are associated with particular forms of energy.
- Stimulus modality (or sensory modality)** What an animal perceives after a stimulus. Basic stimulus modalities include light, sound, smell, taste, temperature and pressure.
- Stomach** The most dilated part of the GI tract situated before the intestine.
- Stomatogastric nervous system** One of the three components of the autonomic nervous system in arthropods, which contains central pattern generators capable of eliciting foregut movements.
- Stratum corneum** The outermost layer of the epidermis, which consists of dead cells (corneocytes).
- Striated muscle** Muscle made of cells that display a regular banded pattern (striations) due to regular arrangement of the actin- and myosin-filaments.
- Supercooling** The cooling of a fluid below its freezing point but without freezing and formation of ice crystals.
- Superphylum (plural superphyla)** A taxonomic classification between *phylum* and *kingdom*.
- Suprachiasmatic nuclei (SCN)** Pair of neuron groups (nuclei) in the hypothalamus above the optic chiasm that act as the master circadian clock in mammals.
- Supracoracoideus muscle** Muscle that raises the wings in birds.
- Surfactants** Compounds lining the alveoli of the lungs of air-breathing vertebrates, which lower the surface tension at the air/fluid interface and reduce the tendency for the alveoli to collapse.
- Suspension feeders** Aquatic animals that feed directly on the plankton suspended in the water column.
- Swim bladder** A gas-filled buoyancy organ found in teleost fish.
- Symmorphosis** A hypothesis suggesting that each step in a pathway, such as the transport of oxygen from the environment to the metabolizing cells, is matched to the maximum demand of those cells, without imposing a limit and without having excess capacity.
- Sympathetic (nervous) system** Division of the autonomic nervous system that mobilizes body systems during activity and provides background (tonic) activity to the cardiovascular system.
- Symport carriers** Carriers that transport two coupled molecules in the same direction.
- Synapse** Junction where signals pass between two neurons or between two excitable cells.
- Synaptic strength** The amplitude of the postsynaptic potential at a chemical synapse.
- Synchronous flight muscles** Insect flight muscles that contract and relax in synchrony with each nerve impulse that stimulates them.
- Systole** Contraction phase of the ventricle(s) of the heart.
- Systolic blood pressure** Peak pressure reached in the arterial system during the contraction phase of the heart (systole).
- Tachycardia** Increase in heart rate above the resting level.
- Taenidia** Spiral thickenings of the cuticular lining of the tracheae of insects, which prevent the tracheae from collapsing.
- Tapetum lucidum** Layer of a highly reflective tissue at the back of the eyes of some animals that enhances the sensitivity of their eyes to enable them to see in the dark.
- Target cells** Cells that have receptors for a hormone, drug or another substance, and that initiate physiological or pharmacological responses to the signalling molecule.
- Tastants** Compounds that act on taste receptor cells.
- Taste buds** Clusters of taste receptor cells and other neuroepithelial cells that form compact 'islands' embedded in the surrounding epithelium.
- Taste receptor** G protein-coupled receptor protein, which becomes activated when a tastant molecule binds to it.
- Taxon (plural taxa)** Any taxonomic category or group: e.g. phylum, genus, or species.
- Tectorial membrane** Non-cellular, gel-like structure that covers the hair cells in the organ of Corti.
- Tectum** The sensory part of the midbrain in vertebrates.
- Tegmentum** The motor region of the midbrain in vertebrates.
- Telencephalon** See *Cerebrum*.
- Teleost fish** The main group of ray-finned bony fish (Actinopterygii) which have fins supported by thin bony rays.
- Telophase** Last phase of mitosis during which a new nuclear membrane forms around each set of chromosomes and the mitotic spindle disintegrates.
- Temporal lobe** Anatomical subdivision of a cerebral hemisphere in mammals located below and behind the frontal lobe and below the parietal lobe.
- Temporal summation** Process whereby subthreshold electrical signals arriving in quick succession at the spike-initiating zone of a neuron summate and may reach the threshold for triggering an action potential.
- Tendon** Type of connective tissue made primarily of collagen that connects muscles to bones in vertebrates.
- Terminal cisternae** Enlarged compartments of the sarcoplasmic reticulum in striated muscles where most of the internal  $\text{Ca}^{2+}$  is stored.
- Tertiary bronchi (parabronchi)** Long narrow tubes that join the dorsal and ventral secondary bronchi. Gas exchange occurs in the tissue surrounding these tubes, where intertwining air capillaries and blood capillaries are located.
- Testosterone** A steroid hormone produced by the testes that stimulates gonadal development in males and development of male secondary sexual characteristics. In females, oestrogen is produced from testosterone synthesised by the gonads. Small amounts of testosterone are also secreted by the adrenal cortex and the ovaries of females.
- Tetanic contraction** Sustained muscle contraction of twitch fibres in response to successive action potentials triggered at rates that cause summation of the  $\text{Ca}^{2+}$ -transients and do not allow the twitch force response to return to resting level between action potentials.



- Tetrachromatic vision** Ability to distinguish and use four frequencies of the electromagnetic light spectrum for conveying visual information (colour) to the brain.
- Tetrapods** Four footed animals, with two pairs of limbs. Tetrapods include amphibians, reptiles, birds and mammals. During evolution, some tetrapods (such as snakes and whales) have lost some or all of the limbs of their ancestors.
- Thalamus** Mass of grey matter in the dorsal part of the diencephalon that connects with all structures of the brain.  
*See also Diencephalon.*
- Theca cells** Cells forming the outer layers of the developing ovarian follicle, which respond to luteinizing hormone by synthesizing androgens, and which results in formation of oestrogens by the underlying granulosa cells.
- Thermal conductance** The capacity of an object to conduct heat, or the ease with which a material conducts heat.
- Thermal conductivity** The property of a material to conduct heat: heat transfer occurs at a lower rate across materials of low conductivity than across those with high conductivity.
- Thermal stratification** The formation of layers of different temperature with depth in a water body.
- Thermal windows** Poorly insulated areas of the bodies of endotherms that enable the dissipation of excess heat.
- Thermals** Raising columns of warm air.
- Thermocline** A layer in an ocean or a lake in which water temperature changes more rapidly with depth than it does in the layers above or below.
- Thermodynamic equilibrium** The situation that arises when there is no tendency for spontaneous change in the observable properties of the system; at thermodynamic equilibrium the system is simultaneously in thermal, mechanical, chemical, electrical and radiative equilibrium.
- Thermoneutral zone** The range of environmental temperatures over which an endothermic animal can maintain its basal metabolic rate and body temperature by modifying its thermal conductance.
- Thermoreception** Ability of animals to detect temperature on their body surface and in tissues deeper inside their bodies.
- Thermoreceptors** Sensory receptors sensitive to heat or changes in temperature on the body surface (= peripheral (external) thermoreceptors) or deeper in the body (internal thermoreceptors).
- ThermoTRPs** Types of ionic channels that become activated at specific temperatures.
- Threshold (excitable cells)** The minimum level of depolarization at a particular point on the membrane that triggers an action potential at that point.
- Thrombocyte** A blood cell type that, in concert with coagulation factors, stops bleeding by clumping and clotting.
- Thunniform swimming** The most energetically efficient mode of swimming that uses vertical hydrofoil-shaped tails hinged to rigid bodies.
- Thyroid gland** A discrete endocrine gland of vertebrates (though less clearly localized in some species), which is composed of follicles that produce, store and secrete thyroid hormones.
- Thyroid hormones** The collective name for the iodinated hormones, primarily thyroxine ( $T_4$ ) and some triiodothyronine ( $T_3$ ), which are synthesized in the thyroid follicles of vertebrates; most  $T_3$  in the circulation is formed from  $T_4$  in the peripheral tissues.
- Thyroid stimulating hormone** A peptide hormone secreted by the anterior pituitary gland that promotes the growth of the thyroid gland and its production of thyroid hormones.
- Tidal volume** The normal amount of air moved in and out of lungs or over gills per ventilation cycle
- Tight junctions** The closely apposed areas of membrane between two adjacent epithelial cells that form a seal at their lateral edges.
- Tip links (stereocilia)** Protein filaments connecting each stereocilium to its taller neighbour such that stereocilia move together as a unified bundle of rigid rods.
- Tissue** Group of cells with similar structure and function.
- Titin** Elastic protein connecting myosin-filaments to the Z-lines.
- Tone (smooth muscle)** The state of tension in the smooth muscle.
- Tonic receptors** Slowly adapting sensory receptors.
- Tonic muscle fibre** Muscle fibre that produces graded contractions in response to stimuli of different intensities.
- Tonic receptor potential** Receptor potential that is maintained for the duration of stimulus.
- Torpor** The physiological state reached by some species of mammals and birds as a result of a reduction in metabolic rate followed by a fall in body temperature, which is regulated at a new, low set point.
- Tracheae (singular, trachea)** Air-filled tubes that form the respiratory system of insects and some other terrestrial arthropods, transporting the respiratory gases to and from the surrounding environment to the cells.
- Tracheal gills** Almost exclusively confined to the larvae of some species of aquatic insects; tracheal gills are (usually external) gas-exchange organs whose locations and numbers differ between groups of insects.
- Tract (nervous system)** Bundle of nerve fibres in the central nervous system.
- Transcription** The process by which information contained in a gene (as DNA) is copied into pre-messenger RNA.
- Translation** The process by which the amino acid sequence of polypeptide chains and proteins synthesized on ribosomes is determined by the sequence of nucleobases in the mature mRNA.
- Transport proteins** Membrane proteins responsible for the transport of hydrophilic compounds across cellular membranes.
- Tricarboxylic (TCA) cycle** A cyclic series of enzymatic reactions used by all aerobic organisms to transfer chemical energy released from the oxidation of acetyl-CoA to electron carrier molecules (coenzymes used in electron transport) with the formation of carbon dioxide and water. One ATP molecule per cycle is also produced. The TCA cycle is the third segment of aerobic respiration.
- Trichromatic colour vision** Ability to distinguish and use three frequencies of the electromagnetic light spectrum for conveying visual information (colour) to the brain.
- Tritocerebrum** The smallest region of the arthropod brain, which links the brain to the ventral cord and the stomatogastric nervous system.
- Trophic level** The position occupied by organisms in a food chain.
- Tropomyosin** Rod-like protein molecule that joins end to end with other tropomyosin molecules to form a filamentous structure along the grooves of muscle actin-filaments, thereby blocking the interaction between myosin heads and actin.
- Troponin complex** Part of the  $Ca^{2+}$ -regulatory system associated with actin-filaments in striated muscle, a protein complex consisting of three subunits: troponin C (the  $Ca^{2+}$ -binding subunit), troponin T (the tropomyosin binding subunit) and troponin I (the inhibitory subunit, which binds to actin and keeps the myosin head binding sites on actin covered by tropomyosin).



- Trypsin** Endopeptidase that works in slightly alkaline environments.
- T-tubules** Network of tubules in continuation with the surface membrane of striated muscle fibres running transversally to the fibre axis and closely associated with the terminal cisternae of the sarcoplasmic reticulum.
- Tubular maximum** The maximum amount of a substance that the renal tubular epithelium can transport in a given period.
- Turbulent flow** A flow pattern of a fluid characterized by irregular changes in pressure and flow.
- Twitch (muscle)** A set, brief contraction of some vertebrate muscle fibres in response to one stimulus that triggers an action potential.
- Tympanal organ** Hearing organ in insects.
- Tympanic duct** One of the three ducts running for the entire length of the cochlea, which is separated from the cochlear duct by the basilar membrane; the tympanic duct is filled with perilymph.
- Tympanum** Eardrum.
- Ultrafiltration** The process of separating an ultrafiltrate of water and small solutes from blood plasma or haemolymph, which occurs in the glomerular capillaries of vertebrate kidneys and some invertebrate nephridia. The ultrafiltrate largely lacks solutes of high molecular mass (colloids) including most plasma proteins.
- Ultrasound** Sound waves with frequencies exceeding 20 kHz, which is the upper limit of human hearing.
- Ultraviolet (UV) radiation** The part of the electromagnetic spectrum with wavelengths between 10 and 400 nm.
- Undulatory swimming** The most common form of swimming in fish in which a wave forms along their propulsive surface.
- Universal ancestor** The earliest form of life from which all subsequent forms of life on Earth evolved.
- Upper critical temperature** (i) For ectotherms, the highest ambient temperature at which available oxygen can no longer sustain aerobic metabolism and physical activity is limited. (ii) For endotherms, the ambient temperature at the upper limit of the thermoneutral zone.  
*See also Thermoneutral zone.*
- Upstroke** The rapid depolarization of an excitable membrane after the threshold condition for triggering the action potential is reached.
- Urea transporters** Membrane proteins that facilitate the movement of urea across the plasma membrane, and which help to determine the renal handling of urea.
- Ureosmotic animals** Those marine and saline tolerant animals which retain high concentrations of urea (and other organic solutes) in their extracellular fluids, which increases their osmolality to become isosmotic or hyper-osmotic to the environment.
- Ureotelic** Describes animals that synthesize and excrete urea as the majority of their nitrogenous waste, either routinely (obligatory ureotelic) or when environmental conditions impede ammonia excretion (= facultatively ureotelic).
- Uricolytic pathway** The main metabolic pathway for producing uric acid.
- Uricotelic** Describes animals that synthesize uric acid or related urate salts as their main nitrogenous waste.
- Utricle** One of the two compartments of the vestibular organ in vertebrates; bony fish use sensory cells in the utricle to transduce sound waves into electrical signals.
- Varicosities** Swellings containing transmitter molecules along nerve terminals in close proximity to cardiac and smooth muscle cells in vertebrates.
- Vasa recta** A series of capillaries in the medulla of the mammalian kidney that run parallel to the loops of Henle, and which are used in countercurrent exchange.
- Vasoconstriction** Reduction in the diameter of peripheral blood vessels resulting from contraction of the smooth muscle in their walls.
- Vasodilation** Increase in the diameter of peripheral blood vessels resulting from relaxation of the smooth muscle in their walls.
- Venous oxygen reserve** The amount of oxygen remaining in mixed venous blood or haemolymph after it has circulated around the body.
- Venous return** The venous blood or haemolymph returning to the heart after it has circulated around the body.
- Ventilated pool gas exchanger** Structures such as sac-like lungs and air-breathing organs, which are ventilated by air being pumped in and out of them.
- Ventilation-convection requirement** The ratio between the rate of ventilation and the rate of oxygen consumption of an animal.
- Ventral horn (spinal cord)** Grey matter of the spinal cord, which contains the cell bodies of motor neurons that send nerve impulses to effector cells via axons leaving the spinal cord through the ventral roots.
- Ventral visceral nervous system** One of the three components of the autonomic nervous system in arthropods, which innervates the midgut and other internal organs such as the heart.
- Ventricles** (i) Muscular chambers of the heart that provide the major force to pump the blood or haemolymph around the body. (ii) A communicating network of cavities in the brain filled with cerebrospinal fluid.
- Vertebrates** Animals with a vertebral column that form the subphylum Vertebrata, within the phylum Chordata.
- Vesicular (camera) eye** Eyes characterized by the presence of a lens that focuses the image on the retina.
- Vestibular duct** One of the three ducts running from the oval window the entire length of the cochlea; the vestibular duct is filled with perilymph.
- Vestibular organ** A bony labyrinth in vertebrates, which contains a membranous labyrinth as part of the inner ear, itself consisting of the semicircular canals and two compartments called the saccule and the utricle; the major function of the vestibular organ is to maintain an animal's balance.
- Viscera** Internal organs.
- Visceral muscles** Muscles associated with internal organs.
- Viscosity** The extent to which a Newtonian fluid resists the tendency to flow.
- Visible light** The part of the electromagnetic spectrum with wavelengths between 400 and 700 nm, to which the human eye is sensitive.
- Vitellogenesis** The process of production of vitellogenin, its transport in blood or haemolymph, its incorporation in developing oocytes, and conversion into yolk proteins as a nutrient source for developing embryos.
- Vitellogenins** The precursor proteins for the egg yolk that provides the nutrients to the developing embryos, and which occur in the blood/haemolymph of all oviparous (egg laying) females, including invertebrates, fish, amphibians, reptiles, birds and monotreme mammals.

- Vitrification (glassification)** The production of an intracellular organic glass-like substance that stabilizes the contents of the cells and halts the harmful interactions between intracellular components.
- Viviparity** A mode of reproduction in which the embryo derives continual nourishment from its mother until the separation at birth of the live young.
- Voltage sensors** Electrically charged groups on channel proteins that sense a change in the potential difference across the membrane and respond by altering the configuration of structural elements in the channel to open or close the pore to the passage of ions through the channel.
- Voltage-clamp technique** A technique that uses an electronic negative feedback loop to hold the membrane potential at predetermined, constant levels; the electrical current flowing across the membrane to hold the membrane potential constant quantitatively describes the net flux of electrical charges carried by ions moving through channels across the membrane.
- Voltage-gated channels** Channels that are sensitive to changes in the voltage difference across the membrane, often with high selectivity for a particular ion.
- Voluntary muscles** Muscles responsible for moving the body of animals.  
*See also Skeletal muscle.*
- Vomerinasal organ** Specialized organ that detects pheromones that influence mating and social behaviour and some odours, in reptiles, amphibians and non-primate mammals.
- Warm receptors** Receptors that become more active as the skin warms up. Warm receptors in the dermis of mammals are silent below a skin temperature of about 30° C; they also occur in the pre-optic area of the hypothalamus and are involved in initiating defences to heating and to cooling.
- Water economy index** The rate of water influx divided by the rate of energy metabolism.
- Wein's displacement law** States that, at any given surface temperature, the wavelengths of electromagnetic radiation emitted by an object follow a positively-skewed distribution. As an object heats up, the peak of this distribution increases in intensity and shifts to shorter and shorter wavelengths. In other words, the wavelength of maximum emission energy is inversely proportional to the absolute temperature of an object.
- White matter (CNS)** Parts of the central nervous system in vertebrates that consist of a high density of myelinated fibres, and which are white in colour.
- Wind chill** The phenomenon caused by the velocity of the wind increasing the rate of heat loss from an endothermic animal and making it feel colder than if it was surrounded by still air at the same temperature.
- Xeric** Describes an extremely dry environment/habitat (or biome), or an animal adapted to live in a very dry habitat.
- X-organs** Paired neurosecretory organs in the eyestalks or head of crustaceans, which secrete peptides that influence reproductive processes, glucose metabolism, fluid balance, moulting, and colouration. Axons from the X organs neurons pass into sinus glands.  
*See also Sinus glands.*
- Yolk sac** A membranous sac attached to the gut of an embryo which encloses yolk, in fish, reptiles, mammals, and birds.
- Y-organs** Organs in the head of crustaceans that secrete ecdysone.
- Z-disc (Z-line) (striated muscle)** Darker line in the middle of the I-band consisting of a latticework made predominantly of the protein actinin to which the actin-filaments are anchored. Myosin-filaments are also connected to the Z-line via the protein titin.
- Zeitgeber** Any external cue in the environment that can entrain (synchronize) an animal's biological clocks.