

Glossary

11-ketotestosterone (11KT) Potent androgenic steroid hormone in teleost fishes that is analogous to dihydrotestosterone in tetrapod vertebrates in terms of inducing the development of secondary sexual characters often associated with territoriality and courtship in large males.

Abiotic Nonliving.

Abscending In honeybees, an absconding colony leaves its nest and searches for a new nest site. Abscending in response to low food availability, parasites, or predation is more common in 'African' strains of *Apis mellifera* than in 'European' strains.

Absolute sensitivity The lowest amount of light that can be perceived by an animal.

Acanthocephalan A phylum of parasitic worms known as 'acanthocephalans,' 'thorny-headed worms,' or 'spiny-headed worms,' characterized by the presence of an eversible proboscis, armed with spines, which it uses to pierce and hold the gut wall of its host. Acanthocephalans typically have complex life cycles, involving a number of hosts, including invertebrates, fishes, amphibians, birds, and mammals. About 1150 species have been described.

Accessory gland A gland associated with reproductive organs of either males or females and producing substances accompanying the sperms or eggs.

Accommodation An optical adjustment made by the eye to focus an object at a given distance.

Acoustic startle response The behavioral and/or physiological response of an individual to an unexpected acoustic stimulus such as the sound of a nearby predator.

Action component Any behavior elicited on the part of an evaluator by the act of recognition.

Action-oriented representations The idea that internal representations should describe the external world by depicting it in terms of the possible actions an animal can take.

Activational effects A change in behavior and/or physiology that occurs in response to a hormonal signal and that disappears once the influence of the hormonal signal ends.

Active electrolocation The ability of weakly electric fish to detect objects and orient in their environment based on their electric sense. For active electrolocation, fish generate a carrier signal (EOD), which is modulated in amplitude and phase by the environment, resulting in the projection of a modulated signal onto their electrosensory skin surface. By sampling, the thus projected electric image fish can gain information about the properties and the location of nearby objects.

Active space The area in which a signal (or cue) can be detected from the source.

Actual conflict Observed conflict over reproduction in a social group; actual conflict can be much lower than potential conflict.

Acute phase response A rapid, systemic, innate immune response that includes heterothermy (fever or hypothermia), production of proinflammatory cytokines, synthesis of defensive and other immune regulatory proteins, and sickness behaviors.

Ad libitum sampling Noting whenever something of interest occurs.

Adaptation (1). At the level of evolution, a process, driven by natural selection, whereby species or populations become better suited to the environment. It occurs over generations and results in an increase in those genes that allow individuals in a population to better survive and reproduce in an environment. (2). At the individual level, the use of regulatory systems, with their behavioral and physiological components, in order to allow an individual to cope with its environmental conditions.

Adaptive demography The composition of eusocial insect workers within a colony so that different sizes and/or ages enhance the efficiency of colony operations and fitness.

Adaptive flexibility The ability of individuals to adjust behavior or physiology as ecological or social conditions change in ways that enhance their fitness.

Adaptive radiation Evolutionary diversification of a lineage into multiple species or differentiated populations (radiation), in which natural selection in novel environments has played a prominent role (adaptive).

Adaptive response Refers to flexible behavior that an individual uses to adjust to another type of behavior or situation. Adaptively flexible behavior allows an individual to enhance its reproductive success or survival.

Adaptive suicide Individual mortality that enhances inclusive fitness by benefiting relatives.

Additive character optimization A type of character coding that applies differential costs for transformations across character-states arranged in leamer order. For example, if character-states {0,1,2} are observed, and 1 is assessed to be of intermediate similarity, additive coding can be employed to apply this conclusion. Thus, transformations from 0 to 1 and from 1 to 2 would cost the same, but the cost of transforming 0 directly to 2 would be equal to the cost of transforming from 0 to 1 plus the cost of transforming from 1 to 2 (hence, additive).

Additive genetic variance The genetic variance of a quantitative character associated with the average effect of substituting one allele for another. Additive genetic effects are the only strictly heritable genetic effects.

Adipose tissue Tissues that serve as the principal storage sites for body fat.

Adrenal glands Endocrine glands located on the kidneys, which play a role in water and electrolyte balance.

Adrenocorticotrophic hormone (ACTH) Small polypeptide hormone derived from a larger precursor (proopiomelanocortin) produced by the anterior pituitary gland that stimulates the adrenal cortex (inter-renal glands in nonmammalian species) to produce corticosteroids (primarily glucocorticoids).

Aestivation Spending the summer in a dormant stage. It occurs in crustaceans, snails, amphibians, reptiles, and lungfishes.

Affect Subjective feelings.

Affective states Emotional state, that is, feelings.

Affiliative social relationship Strong association between individuals, usually manifested by high rates of physical proximity to one another and nonaggressive social interactions.

Affordance learning A form of observational learning in which the crucial information an observer acquires is about properties of objects manipulated by the model and the opportunities they 'afford,' the observer then exploits this information rather than imitating the model's actions.

'African' honeybee Bees derived from *A. mellifera* ecotypes that evolved in Africa were introduced into Brazil in the 1950s. Fiercely defensive of their nest, these bees have caused public health problems, due to the dangers of massive stinging, and agricultural management problems as their range has increased to cover much of South America, all of Central America, Mexico, California, Arizona, Texas, and parts of the southern United States.

Age polyethism A mechanism for division of labor in which individuals within a social group specialize in different tasks at different developmental stages or different ages.

Aggression Overt, complex, social behavior with the intention of inflicting damage or status change upon another individual.

Aggression against females A category of male aggression. Some aggression against females may be mistaken for forced copulation.

Agonism (adj., agonistic) Aggressive behavior including responses to aggression such as flight and submission. Conflict resolution through a series of aggressive or submissive signals.

Alarm call A chemical, auditory, or visual signal emitted in the presence of a predator that may serve one or more functions, including advertisement of perception to the predator, advertisement of signaler quality, and warning conspecifics.

Alarm pheromone Pheromones released in response to threats. In honeybees, the alarm pheromones are associated with the sting.

Alarm reaction A behavior induced by chemical stimuli that tend to bring the animal in a position where it is less exposed to predation.

Alarm substance Substance(s) in the skin of fishes that induce alarm reactions.

Allele One of several alternative forms (nucleotide sequences) of a gene.

Allelochemical A chemical signal produced by an organism that influences the behavior or physiology of an organism of a different species.

Alliance A close social bond between two or more adult individuals. Alliances often support each other during conflict and are more likely to share resources with each other than with other animals.

Allochthonous Originating elsewhere; not native to a place.

Allometric Describing the relationship between the size of an organism and the proportional size of its parts.

Allomone A chemical produced by individuals of a species used in communication with other species; typically used in defense against predators, etc.

Alloparental care (Alloparenting, alloparents) Care for infants and juveniles that mimics and substitutes for the parental behavior of a parent. Typically, the caregivers are kin and the social group is cohesive and related.

Allopatric (n. Allopatry) Geographically separated; for example, populations on different islands with little or no movement between islands. Allopatric speciation is the development of isolating mechanisms while incipient species are separated by a geographic barrier.

Allostatic load The cumulative wear and tear and energetic demand of daily and annual routines. Allostatic load can also include increased demands of poor habitat, injury and infection, human disturbance and life history stages, such as breeding, migration, etc.

Allostasis An elaboration on the concept of homeostasis, where there is an emphasis on the fact that (1) what counts as an ideal physiological measure can change over time, and (2) numerous physiological systems may become activated in the body's attempt to solve a challenge to its equilibrium.

Allotype The allorecognition phenotype of an individual. An allotype is the composite of an individual's allorecognition genes, or the expressed gene products of allorecognition loci that confer cue specificity.

Alternative reproductive tactics (ARTs) Discontinuous variation in mating behavior within one sex of a species, often associated with morphological variation.

Alternative splicing Different exons of an RNA transcript from a single gene are spliced together to produce different mRNA transcripts and thus different proteins.

Altricial Relatively immobile young (usually birds or mammals) depend on parents for food and warmth.

Altruism A behavior that is costly to the performer's fitness, but beneficial to others (evolutionary biology); helping behavior resulting from selfless concern for the positive well-being of other individuals (social science).

Altruistic punishment The costly infliction of harm on another individual or group that produces net benefits for all the individuals in the group (social science).

Alzheimer's disease Neural disease accompanied by cognitive dementia and occurrence of plaques and tangles in the brain.

Ammocoete Premetamorphic larva of a lamprey.

Amoebic dysentery (or amoebiasis) An infection of the intestine caused by *Entamoeba histolytica*, a unicellular protozoan parasite, which causes severe diarrhea. Infection occurs by consuming food or water contaminated with amoeba cysts.

Amplified fragment length polymorphism (AFLP) Genetic variation found by cutting DNA strands with restriction enzymes and amplifying the resulting segments by using PCR (polymerase chain reaction).

Amplitude Sound intensity, as determined by the magnitude of vibration by a sound-producing object. This physical property of sound is the primary determinant of our psychological experience of the loudness of sound.

Amplitude modulation Changes in the amplitude of a sound over time. The process of modulation produces extra frequencies in the sound, called sidebands.

Amygdala A brain region that (among other functions) plays a critical role in fear, anxiety, and aggression.

Anadromy Migratory pattern of fish that hatch and develop in fresh water and then migrate to saltwater for adult development to return to fresh water and breed.

Analogy (Analogical reasoning) (In the field of *logic*) A form of reasoning in which one thing can be inferred (see *inference*) as similar to another thing in certain respects, on the basis of the known similarity between the two things in other respects.

Anautogeny The adult female ectoparasite requires that protein be ingested, often in the form of a blood meal, in order to mature her eggs.

Androgen (pl. androgens) A steroid hormone with 19 carbon atoms, so named because of their *andros* (male)-generating effects. Examples include testosterone, androstenedione, 5- α dihydrotestosterone, and 11-ketotestosterone. Although the testes are an abundant source of androgens, they can also be synthesized in other glands, including the adrenal gland and ovaries. Some androgens such as testosterone can be converted by the enzyme aromatase into estrogens. Responsible for the development and maintenance of male-typical characteristics, including development of secondary sex characteristics and behaviors.

Androgenic gland A gland near the distal portion of the sperm duct in crustaceans that secretes androgenic gland hormone.

Angiotensin II An octapeptide that plays a prominent role in the regulation of cardiovascular and body fluid homeostasis.

Angular acceptance function Photoreceptors have a limited 'field of view.' The angular extent of visual space over which a receptor receives light is described by its angular acceptance angle or function.

Anhedonia The inability to feel pleasure; a defining symptom of clinical depression.

Animal communication A behavior in which an animal produces a signal, which conveys information and influences the behavior or physiology of another animal.

Anisogamy Refers to the differences in size of the gametes of the two sexes: sperm are generally small and eggs are generally large.

Anorexia A change in eating behavior characterized by markedly reduced appetite or a total aversion to food. Anorexia is a component of sickness behavior but may refer to a behavioral change apart from febrile illnesses, such as with food allergies or psychological stress.

Anosmic animals Animals without the sense of smell.

Antagonistic pleiotropy A single gene controls for more than one trait with at least one trait being beneficial to the organism's fitness and at least one being detrimental to the organism's fitness. In analogy, a certain maternal hormone may have beneficial or detrimental effects on different offspring traits.

Anthropocentrism Regarding humans as the central element of the universe; interpreting reality exclusively in terms of human values and experience.

Anthropogenic Related to or caused by human activities (e.g., human-induced).

Anthropomorphism Attribution of human motivation, characteristics, or behavior to animals.

Antiaphrodisiacs Compounds transferred by the male to the female during mating that are either synthesized by the male or sequestered from the environment that render the female unattractive to rival males.

Apical gland A gland associated with the reproductive tract of the sea hare that produces a hormone that influences egg-laying behavior.

Aposematic signal Traits of the prey that predators can detect prior to attack and that inform the predator that the prey is defended or otherwise unattractive to attack.

Aposematism The correlation between conspicuous signals, particularly warning coloration, and the presence of defenses in prey.

Apparent competition When the fitness of one species is indirectly lowered by the presence of another species because of a shared parasite or predator.

Appeasement Post-conflict interaction directed from a bystander to the aggressor to reduce the risk of being attacked.

Appetitive behavior Behaviors that increase the probability that a particular need is satisfied. In the case of food deprivation, appetitive behavior would increase the organism's chance of locating food.

Appetitive cue A stimulus associated with a resource (such as a food item, a host plant, or a prospective mate) that an individual would normally respond to, but which is ignored when the individual is actively migrating.

Appetitive movement Movements that an individual makes while searching for, or in response to, appetitive cues (also called 'Trivial Movements').

Appetitive sexual behavior A phase of reproductive behavior during which male searches, orients toward, and courts a female in preparation for copulation.

Apyrase A calcium-dependent enzyme, found in mosquito saliva, that catalyzes the hydrolysis of ATP to ADP and inorganic phosphate.

Arginine-vasopressin Peptide hormone involved in osmoregulation in both sexes, aggression and affiliative behavior of males.

Arginine vasotocin Nine amino acid neuropeptide that is the homolog of arginine vasopressin found in mammals. These hormones are released at the posterior pituitary gland, but also widely in the brain where they act as neuromodulators.

Armpit effect A system of kin recognition in which individuals learn their own phenotypic cues and use them as a template for determining the kinship status of other individuals.

Arms race A metaphor for predator-prey coevolution wherein adaptation proceeds in an escalation/counterescalation dynamic that leads to ever exaggerated traits on both sides of the interaction.

Aromatase The enzyme that catalyzes the transformation of androgens such as testosterone into estrogens such as estradiol.

Arthropod Animals with an exoskeleton, a segmented body, and jointed appendages.

Artificial fruit A device modeled on the natural problems animals deal with in opening difficult-to-process natural foods, such as fruits that needed cracking, peeling, and other forms of manipulation; typically designed to afford two or more successful opening techniques so that the fidelity of social learning about such alternatives can be objectively measured and compared.

Artificial neural network modeling The mathematical modeling of biological nervous systems in order to simulate animal behavior and its evolution.

Asset protection Organisms act to protect their expected future reproductive success (the asset here) from loss due to predation. Because predation would eliminate future reproduction, individuals that can expect great future success are predicted to take greater actions to protect it.

Association (In psychology) The process of forming mental connections or bonds between sensations, ideas, or memories; two stimuli or events are associated when the experience of one leads to the effects of another, because of repeated pairing.

Associative class A collection of objects or events signaling the same consequence or follow-up event; the members are grouped on the basis of a common association.

Assortative mating A system in which individuals choose mates nonrandomly on the basis of a particular characteristic, selecting either mates more dissimilar to themselves than expected under random mate choice (negative assortative mating) or mates more similar to themselves than expected under random mate choice (positive assortative mating).

Asymmetric game A subset of games in game theory, in which the differences between the contestants may affect their choice of strategies.

Attentional states Perceptual states of the eyes that are either directed toward a viewer or directed away from them.

Attractivity A female's ability to elicit sexual responses from a male.

Attractor Mathematically, a set of values that a dynamical system maintains after a sufficient time, with 'sufficient' depending upon the system. An important property of an

attractor is that the system returns to this set of values even after it has been slightly disturbed, that is, when it is moved a small distance away from the set of values.

Auditory template model The model of vocal development which proposes that an animal is constrained only to copy the sounds that it hears which match a template with which it hatches or is born.

Autochthonous Native to a place; indigenous.

Autogeny A female ectoparasite that is able to mature a batch of eggs without an external protein meal.

Autonoesis A special form of consciousness that allows us to be aware of being the author of the episodic memory and the episodic future imagined event.

Autotomous sting When the sting easily tears from the body of the worker insect, sting autotomy is found in all honeybee species and some wasps.

Autotomy The loss of a body part (generally a limb or tail) by an animal, generally as a means of escape when held by that body part.

Avoidance The use of a habitat that has few associated natural enemies (i.e., enemy-free space).

***Avpr1a* gene** A gene coding the arginine-vasopressin receptor V1aR.

Awareness Refers to the ability to perceive or feel something; awareness can refer to a wide range of sensitivity and experience, from dim perceptions to detailed conscious experience.

Bacillus A rod-shaped bacteria cell.

Bag-cells Neurosecretory cells of the abdominal ganglion of the sea hare that secrete egg-laying hormone.

Balanced polymorphism The condition of having two or more alleles maintained in a population as a result of opposing evolutionary forces.

Banding (ringing) Placing an inscribed metal or colored plastic band (ring) on the 'leg' of a bird so that the movement of the bird can be determined when recovered.

Basolateral membrane Basal and lateral surfaces of *enterocyte* epithelial cells of intestinal *mucosa*.

Bateman gradients Are regression lines that show the relationship between the number of mates and reproductive success for each sex in a group or population. Sometimes, they are also referred to as 'sexual selection gradients.' Generally, the steeper the slope of the regression line, the more intense will be sexual selection on that respective sex.

Batesian mimicry Mimicry of body coloration and patterning of a toxic species by another coexisting toxic species. Sharing of the same aposematic signal between a defended species (called 'the model') and an undefended species (called 'the mimic'), such that individuals of the

mimic species gain an antipredatory advantage from the shared signal.

Bathyal Associated with benthic habitats of the continental slope between 200 and 4000 m deep.

Bayesian Relative to animal behavior, the assumption that animals continually use new information to change their expectations of the environment (and therefore change their behavioral decisions).

Bayesian information criterion A measure of the fit of a model to the data combining the log-likelihood of the model with a penalty term, taking into account the complexity of the model. This measure can be used to select a model among several alternatives.

Beacon A unique marker for a location, analogous to a sign post.

Beeswax A complex mix of hydrocarbons produced from wax glands on the abdomen of honeybees and worked into the comb structure to form the bees' nest.

Behavior sampling Observing a group of animals and recording each occurrence of a particular behavior along with the individuals who perform it.

Behavioral deficit A change in a behavior as a result of a contaminant or other treatment, usually having a negative effect on the animal.

Behavioral ecology The study of the evolution and adaptive significance of behavior in the framework of recent views on the levels of action of natural selection and the importance of kin selection. There is an underlying assumption that behavior is selected for individuals to maximize the representation of their genes in the gene pools of future generations.

Behavioral fever An increase in temperature as a response to parasites or disease. In endotherms, fevers are physiological, but in ectotherms, they may be caused by basking or the production of heat through muscular contractions.

Behavioral hierarchy A description of interactions among behaviors, taken two at a time, that indicates which of each pair of behaviors overrides the other. Such maps are generally unidirectional (behavior A overrides B, which overrides C, which overrides D), but can have branches ($A \geq B \geq C$ or D), or feedback ($A = B \geq C \geq A$). Typically, these maps can be modified by such factors as an animal's state (e.g., hungry, sleepy, reproductive) and age.

Behavioral strategy In game theory, a player's complete plan of action in a game, taking all other players possible actions into account.

Behavioral tradition Nongenetic, heritable differences in behavior among groups or populations with overlapping generations, which are socially transmitted within and between generations.

Behavioristic psychology A branch of psychology. The goal is to use the animal in an effort to understand a process of interest. Such processes include the mechanisms of learning, the prediction and control of learned behavior, and motivational processes. Some behaviorists focus on the prediction and control of behavior.

Betweenness Centrality based on the number of shortest paths between every pair of other group members on which the focal individual lies.

Bidirectional control procedure Manipulation of the direction of movement of an object (e.g., screen or rod) by a demonstrator to determine if an observer will manipulate the object in the same direction.

Bidirectional sex change An individual is capable of changing sex in both directions.

Binary Having two states; communication codes having two alternative signals.

Binding globulin A protein molecule that binds steroids in the bloodstream and prevents both hepatic metabolism and the hormone from binding to its receptors, thus keeping the hormone in circulation. In some cases, hormones bound to binding globulins are capable of binding to receptors specific to binding-globulin-bound hormones.

Binocular stereopsis Animals with widely separated eyes can judge the relative distance of objects because objects at different distances are imaged on slightly different parts of the retina in the two eyes. This difference is called 'retinal disparity.'

Bioassay An appraisal of the biological activity of a substance, performed by testing its effect on an organism and comparing the result with some agreed standard.

Biodiversity The variety of life forms at all levels of a biological system, but most often referring to the number of species.

Biogenic amine A neurotransmitter, such as serotonin or dopamine, that can regulate behavior.

Bioindicator A species or attribute (morphology, behavior, reproductive success) of a species or population that can be used to assess the health and well-being of an animal or plant species, a population or an ecological community.

Biological fitness An individual's ability to survive and reproduce.

Biological model A conceptual or mathematical description of a biological phenomenon, which generally aims to facilitate comprehension and/or to make predictions.

Biologically active (or bioactive) Describes a substance, usually a chemical, that acts upon or influences the bodily functions of an organism.

Biologically inspired robots Robots that are inspired by principles and mechanisms of biological systems. Bioinspired robots often share certain detailed morphological features with their biological analogs, but this is not a requirement.

Bioluminescence Light produced by living organisms.

Biomagnification The ability of chemicals to increase in concentration with each step in the food chain. That is, when a large fish eats a smaller fish with a given level of a contaminant, it accumulates a higher level of that contaminant in its own tissues.

Biomimesis Mimic or imitate biological systems by artificial means (adj: biomimetic).

Biotic Living.

Biotype An ill-defined term generally applied to a herbivore exhibiting a specific host plant association that is noteworthy for some reason.

Bit Contraction of *binary* digit, the unit of information in the mathematical theory of communication.

Bitter pith chewing A form of self-medication practised by chimpanzees in which an ill animal removes the outer bark and leaves of a plant, *Vernonia amygdalina*, to chew on the exposed, bitter pith. The pith has medicinal properties.

Blind to treatment Refers to the investigator being unaware and unable to identify which animal has been treated (e.g., with a chemical) and which is a control (and has not).

Blood-brain barrier The limited diffusion of substances from the bloodstream into the brain and cerebrospinal fluid. Small molecules and molecules that have active transport mechanisms can cross the blood brain barrier, whereas larger molecules without active transport mechanisms are prevented from crossing. The barrier makes the brain less susceptible to blood-borne substances.

Bonanza food source A very (quantity-) rich food source that lasts for a long time.

Bouton The enlarged terminus of a nerve cell that forms a connection, or synapse, with another nerve cell.

Bradycardia A decrease in heart rate.

Brain size The absolute mass or volume of the brain, based on measures of fresh tissues, brain images, or corrected endocranial volumes. The term 'relative brain size' usually refers to allometrically-corrected measures, most often residuals of log-transformed brain mass regressed against log-transformed body mass.

Branchiostegal membrane The membrane deep to the gill operculum, connected to the small support bones of the gills (the branchiostegal bones).

Breeding dispersal The distance between the breeding site of an individual in one year and the breeding site of the same individual in another year.

Breeding range In migratory birds, the area in which populations reproduce.

Bridge whistle A whistle used by animal trainers to immediately indicate to the animal that it has performed a behavior correctly. The use of the bridge whistle facilitates training if rewards cannot be given immediately after a task was performed, for example when the animal is far away from the trainer.

Bridging stimulus A conditioned stimulus that signals the imminent delivery of reinforcement.

Broadband A vocalization with a broad energy spectrum that often lacks sharp harmonic peaks and has an irregular pulse repetition rate.

Broodiness Behavior of female poultry as they sit on and incubate a clutch of eggs.

Brood parasitism Leaving eggs or young to be raised by a nonparent, usually heterospecific, host.

Brood reduction Occurs when the number of chicks in a brood falls due to the death of one or more of them. Brood reduction is considered an adaptive process if it enhances the viability or survival of the remaining chicks or parental prospects for future reproduction.

Brush-border Microvilli-covered apical surface of *enterocyte* epithelial cells of intestinal *mucosa*.

Budding Mode of colony multiplication in which new colonies are founded by the departure of a relatively small force of workers accompanied by one or more queens.

Bumblefoot Bacterial infection and inflammatory reaction of the foot.

By-product mutualism Where two or more individuals benefit each other by investing in a cooperative behavior.

Calf A young animal dependent on its mother.

Cameleon A genetically engineered protein that consists of two fluorescent proteins on the N and C terminus with calmodulin and M13 domains in between. It is used to detect calcium ion concentration, using fluorescence resonance energy transfer (FRET). Cameleon remains in a linear form when no calcium ions are present. When calcium ions are present, calmodulin binds to calcium, which allows M13 to bind to calmodulin/calcium ion complex and leads to a change in confirmation (shape). The confirmation change induced by M13 and calmdulin/calcium binding pulls the two fluorescent proteins into close proximity that allows FRET to occur.

Camouflage Concealment strategies that have evolved to reduce the chances of being detected or recognized by predators.

Candidate gene A gene whose function suggests it may be involved in specifying variation in a quantitative trait.

Canid Species that are dog-like, classified within the family Canidae in the order Carnivora.

Cannibalism Feeding on conspecifics.

Capturing A training technique that involves reinforcing a behavior that is offered spontaneously and in its final target form.

Carapace The part of a crab's exoskeleton that covers the cephalothorax (the fused head and thorax segments).

Cardiovascular disease Disease of the heart and/or blood vessels.

Carrier-mediated transport Passage of glucose, amino acids, and other polar molecules through a cell membrane by 'carrier' or 'transporter' proteins in the cell membrane.

Carry-over effect Nonfatal condition that transfers between periods of the annual cycle and influences an individual's performance through effects on the condition or timing.

Caste Distinct social roles within a colony. Caste typically refers to reproductive caste (queen or worker), but may also refer to specialized groups within workers. These are persistent specializations in function or task.

Caste totipotency The capacity of a social insect larva to develop into any caste within the colony.

Catadromy The migratory pattern of fish that hatch and develop in saltwater, then migrate to fresh water for adult development, and then return to the sea and breed.

Catecholamines The class of hormones that includes epinephrine and norepinephrine.

Categorical perception Occurs when the continuous, variable, and confusable stimulation that reaches the sense organs is sorted by the mind into discrete, distinct categories the members of which somehow come to resemble one another more than they resemble members of other categories.

Category (The representation of) A specifically defined, general or comprehensive division in a system of classification; often used synonymously with 'class' (see 'class').

Cation An ion with more protons than electrons giving it a net positive charge.

Caudodorsal cells Neurosecretory cells in a particular part of the pond snail brain that secrete a hormone that mediates egg-laying behavior.

Causal knowledge Knowledge of causal structures or properties.

Causal properties The properties of objects that dictate the possible ways in which they can interact with one another (e.g., solid objects cannot pass through one another).

Causal structure The directionality of physical events (i.e., cause and effect).

cDNA library A collection of cDNA molecules that have been inserted into host cells, typically bacteria or viruses, so that the individual cDNAs can be replicated in high numbers.

Ceilometers A brilliant shaft of light projected on the base of the cloud layer for cloud height measurement. On misty nights, with low ceiling, birds were attracted to the light beams and collided with other birds and the ground. These devices are no longer used by the weather service.

Central pattern generator (CPG) A neuron or neuronal circuit that produces an activity pattern that varies in time and space to produce a behavior without any need for sensory feedback. For instance, the CPG for walking in a mouse coordinates the four legs (variation in space) to produce a series of steps (variation in time), and the basic motor output pattern can be elicited in an isolated spinal cord from which all connections to sensory and motor structures have been eliminated. Although the best-studied CPGs are those that produce rhythmically patterned behaviors (e.g., walking, swimming, breathing), there are also CPGs for nonrhythmic behaviors (e.g., withdrawal, shortening, vomiting).

Centrality A measure of an individual's structural importance in a group on the basis of its network position.

Cephalofoil Flattened and lateral extensions of the head, typically used to describe the head of the hammerhead shark.

Cercaria (plural: cercariae) A small free-living larval stage of the Trematoda which swims using a tail and does not feed, relying on stored glycogen for energy to find and infect the subsequent host, often a mammal.

Cerebral ganglia Ganglia located in the head of arthropods. In insects, these are the supra and subesophageal ganglia ('brain' and SEG, respectively).

Cervical connectives Large nerve bundles passing through an insect's neck; comparable to the spinal cord.

Cestodes Class of parasitic flatworms, commonly called 'tapeworms,' that live in the digestive tract of vertebrates as adults and often in the bodies of various animals as juveniles.

CF-FM bats Bats that emit a long constant frequency component terminated by a brief frequency modulated sweep for echolocation. CF-FM bats compensate for Doppler shifts in the echoes they receive.

c-fos An immediate early gene that is expressed in cells relatively rapidly (e.g., within 30 minutes) in response to the experience of environmental stimuli or after engaging in a particular behavior. The expression of the mRNA for the c-fos gene or the protein product of this gene has been widely employed by behavioral neuroscientists to localize brain areas implicated in the expression of a given behavior.

Chagas disease A tropical disease also known as American trypanomiasis. It is caused by the flagellate protozoan *Trypanosoma cruzi* and is transmitted by the assassin bug.

Chain migration Where northern wintering populations breed in the northern portions of the breeding range and the southern wintering population breed in the southern parts of the range.

Channel A communication system; the collection of alternative signals composing a communication system; the physical system conveying signals.

Channel capacity The maximum amount of information a communication system is theoretically capable of transmitting.

Chappius effect A phenomenon in which wavelength-specific absorption by ozone affects the spectral composition of atmospheric light; there is a relative reduction in the spectral region of 540–625 nm (yellow) and increases near 500 nm (blue-green) and 680 nm (red).

Character A biologically transmitted attribute of a species; in behavioral phylogenetics, such attributes might include learned behaviors not encoded in the genome.

Character reconstruction An illustration of the simplest (and putatively most likely) pattern of evolutionary changes of a trait as depicted on a phylogenetic tree.

Chase-away coevolution A form of arms race dynamics in which reciprocal selection pushes one species to stay ahead (in terms of a trait value) of the other.

Cheating, cheater, cheat A party in a social interaction that does not contribute its fair share. In the case of *Dictyostelium*, it would be a clone that contributed proportionally more to fertile spore cells than to sterile stalk cells during the social stage.

Chelae Front legs of crustaceans that have been modified into claws.

Chemoreceptor Sensillum that houses either olfactory or gustatory neurons.

Chemosensor A sensory receptor that detects specific chemical stimuli in the environment.

Chimera An organism that is made up of two genetically distinct lineages.

Choosy Rejecting a particular encountered potential mate.

Chromatic aberration Optical imperfection caused by light of different wavelengths being focused in different planes by a refractive element such as a lens.

Chromophore Part or moiety of a molecule responsible for its color. In vertebrate visual pigments, the chromophore is either retinal or 3,4 dehydroretinal, aldehydes of vitamin A.

Chronesthesia The subjective awareness of the passage of time, an ability that allows us to address our own personally experienced past.

Chronic stress Either long-term exposure to a stressor or repeated exposure to an acute stressor.

Chronobiology Chronobiology, which comes from 'chrono,' meaning time, and biology, is the field of science that deals with cyclic activities in organisms and their relations to time. It is the formal study of biological rhythms.

Circadian rhythm The term 'circadian' comes from the words, 'circa,' which means about, and 'diem,' meaning day. Circadian rhythms are endogenously organized oscillations in biological processes that occur roughly with a period of about 24h and are sustained in constant conditions.

Circannual rhythm Circannual rhythms are endogenously organized oscillations in biological processes that occur each year, such as the migration patterns of some birds.

Circumboreal Occurring around the globe in the boreal, or northern regions.

Circumventricular organ A brain structure lacking a blood-brain barrier.

cis-Regulatory regions DNA regions outside of the protein coding region of a gene involved in regulating transcription.

Class A collection of things sharing a common attribute, characteristic, quality, or trait.

Classic foraging theory A body of economic models concerned with prey choice and patch residence time characterized by the use of simple optimization that applies to cases without frequency-dependent payoffs and hence mostly nonsocial situations.

Classical (aka Pavlovian or Respondent) conditioning A stimulus (the unconditioned stimulus) that normally elicits a response (e.g., altered respiration) is repeatedly paired with a stimulus that does not normally elicit the response (the conditioned stimulus, e.g., light). The CS and US eventually become associated, and the organism begins to produce the behavioral response to the CS alone.

Claustal founding Colony foundation by a non-foraging queen or queens, in which energy to rear the first generation of workers comes entirely from queens stored body reserves.

Clever Hans effect The artifact that occurs when animals, including humans, may be sensitive to cues from the experimenter or the environment of which the experimenter is unaware. Double blind designs are often used to minimize Clever Hans effects.

Cloaca A single posterior opening of the gut to which the bladder and reproductive organs also join.

Cloacal protuberances Seasonally variable, occurring during the breeding season, in male birds. The protuberances are from engorgement by sperm of the storage tubules around the cloaca.

Clone A genetically identical population of cells.

Clustering coefficient (C) The density of the subnetwork of a focal individual's neighbors; the number of edges between neighbors is divided by the maximal possible number of edges between them.

Cnidocytes Stinging cells found in cnidarians (e.g., jellyfish) that contain cnidocysts that are fired out into potential predators, injecting venom.

Coalition formation Agonistic acts that involve at least two aggressors simultaneously joining forces to direct aggression toward the same target; such acts of coalitionary support indicate short-term cooperation between coalition partners, whereas the relationship between two individuals that repeatedly join forces over long time periods is considered to be an alliance.

Cochlear nucleus The first auditory nucleus in the brain that receives the projections from the auditory nerve. The projections from neurons in cochlear nucleus are then sent into the medulla as a series of parallel pathways that form the ascending auditory system.

Code word In certain types of codes, an ordered collection of signals making up the smallest decodable unit.

Code The way in which signals stand for their referents.

Coevolution Evolution of organisms of two or more species in which each adapts to changes in the other.

Cofoundress A female that founds a new colony in association with other females.

Cognition Psychological mechanisms that process perceptual information to enable behavioral decisions to be made, for example, learning, memory, generalization, and categorization.

Cognitive control Process in which one cognitive mechanism exerts inhibitory, excitatory, or supervisory influence on another cognitive process; executive control, executive function.

Cognitive imitation Adopting a decision rule after observing another use of that rule.

Cognitive psychology The study of the mind's function, including perception, attention, memory, imagery, and decision-making.

Collective behavior A phrase to describe how interactions between individuals produce group-level patterns of behavior.

Collective decision-making The selection of one from two or more options by a group of individuals in which all members contribute to the choice, rather than following the decision of a leader.

Collective detection Transfer of information within a group from animals that detect predation threats to others that have not detected the threats directly. Collective detection assumes that once an individual in the group has detected a threat, conspicuous signals of detection, such as alarm calls or flushing, will rapidly alert all other group members.

Collective intelligence A group of agents that together act as a single cognitive unit to solve problems, make decisions, and carry out other complex tasks. Natural examples include social insect colonies, fish schools, and bacterial aggregations. Artificial examples include robot collectives and decentralized computer algorithms. Also known as 'swarm intelligence.'

Collective robotics The design of groups of autonomous artificial agents that cooperate to carry out tasks. This field is strongly inspired by examples of collective behavior in animal groups.

Colonial spider Spiders living in individual webs or nests that are interconnected by silk threads.

Colony budding Colony founding by a group of workers and one or more queens.

Colony collapse disorder A syndrome of unknown origin and cause afflicting beekeepers with high rates of colony mortality.

Combinatorial neurons Neurons that respond best to signals that have two frequencies, that are harmonically or nearly harmonically related.

Command neurons Neurons that, when stimulated individually or in small groups, can elicit a complex behavior. By strict definition, to be called a command neuron, that neuron must be active whenever the behavior occurs (correlation), stimulation of the neuron must elicit the behavior (sufficiency), and elimination of the neuron must make it impossible to trigger the behavior by its normal sensory input (necessity). Because necessity is often difficult to test, neurons that show just correlation plus sufficiency are often called command neurons.

Commensalism An interaction between species in which at least one species is not affected, although others benefit.

Common orientation The phenomenon whereby multiple individuals flying at high altitudes and not in visual contact of each other all take up similar flight headings, which are usually closely aligned with either the downwind direction or a seasonally preferred compass direction.

Communication The transfer of information from a sender to a receiver by means of signals.

Communication system An evolved network involving signal givers that produce information containing messages intended for a particular set of signal receivers; both signalers and receivers experience a net gain in reproductive success from their actions and responses.

Communicative culture A group-specific system of signals, responses to those signals, and preferences for the class of individuals toward which signals are directed, that is socially learned and transmitted across generations.

Comparative psychology Defined in many different ways. One approach would be the study of a great variety of behavior in a variety of species with a goal of understanding the evolutionary history, adaptive significance, development, and immediate control of behavior.

Competition In strict biological terms, competition occurs when a necessary resource is in short supply and the use of the resource by one party denies access to that resource by another. Note that the two parties do not even have to be aware of one another, as in scramble competition, where the first party uses the resource before the second arrives and with neither necessarily aware of the other. In more general discussions of social behavior, competition may be described as a striving to outperform another where both parties are aware of the other.

Complete dimorphism A size distribution of workers composed only of large and small individuals, with no intermediates.

Complete migration All populations leave the breeding range of the species and move in some cases considerable distances to occupy a nonbreeding range of the species.

Components of fitness Measures of individual fitness. Reproductive success components include the number of mates, the number of eggs laid or offspring born, the number of offspring that survive to reproductive age, the number of offspring that produce grand-offspring, and the number of grand-offspring. Survival components include age at death or lifespan.

Compound eyes Crabs, like insects, have eyes that are composed of many repeated units called *ommatidia*, each with a *facet lens* and a transparent *crystalline cone*, which together focus light onto a narrow, elongated light-sensitive structure called the *rhabdom*. The rhabdom consists of densely packed microvilli, protruding from eight *retinula cells*, the photoreceptors. The membranes of these microvilli contain visual pigment molecules, the transmembrane protein part of which is called *opsin*.

Screening pigments in special pigment cells and in retinula cells prevent stray light from reaching the rhabdom from any other direction except through the fact lens belonging to the same ommatidium (apposition compound eyes).

Comprehension learning Where an animal comes to extract a novel meaning from a signal as a result of experience of the usage of signals by other individuals.

Computational neuroethology The modeling of the neural basis of animal behavior, with an emphasis on the interaction of the simulated animal with its simulated environment.

Concentrated animal-feeding operations (CAFOs) Agricultural facilities that house a number of large animals; these operations may release waste into the environment (see http://cfpub.epa.gov/npdes/home.cfm?program_id=7 for additional information).

Concept An abstract or general idea inferred or derived from specific instances; a mental construct or representation or idea of something formed by (mentally) combining all its characteristics or particulars (synonymously used with a general notion, a scheme or a plan).

Concerted evolution The changes in one brain region caused as a result of changes in other associated brain regions, often thought to be due to underlying developmental mechanisms.

Condition dependence Expression of a trait or behavior depends on the state of the organism. Many possible state variables are possible including size, age, energetic reserves, immune function, nest quality, and presence of a mate.

Conduction velocity The speed with which action potentials travel along an axon; increases with increasing axon diameter; in vertebrates, also increased by myelin around the axon; for unmyelinated axons, typically below 20 m s^{-1} .

Conflict outcome The result of an actual conflict in terms of the amount of conflict in the colony and the winning party, if any. For example, in honeybees, the outcome of the conflict over caste fate is that selfish individuals lose because they lack means to successful selfish behavior.

Conflict resolution Exchange of threat and submissive signals between individuals over ownership of resources.

Conformity A term used to define a family of biases towards high levels of fidelity in social learning, most commonly the case of copying whichever of various options is being shown by the majority of other group members.

Confound To mingle so that the causes cannot be distinguished or separated.

Confusion effect A reduction in capture rate by predators attacking a group resulting from their inability to single out one prey from the group.

Consciousness In a strict medical sense, it is the state of being awake. Often refers to the state of being aware of oneself or environment.

Consensus decision When the members of a group choose between two or more mutually exclusive actions and reach a consensus, that is, they all 'agree' on the same action.

Conservation reintroduction/benign reintroduction An attempt to establish a species for the purpose of conservation outside its recorded distribution but within an appropriate habitat and ecogeographical area.

Consistency index The number of character states specified in the character matrix, divided by the number of character-state transformations appearing on a phylogeny in question. The index is widely used to measure how closely the data fit a given tree.

Consolation Postconflict affiliation from a bystander to the recipient of aggression with a stress-reducing function for the recipient of aggression. Reassuring body contact provided by a bystander to a distressed party.

Conspecific sperm precedence Disproportional fertilization of a female by conspecific over heterospecific sperm following mating with both a con- and a heterospecific.

Conspecific Used as either an adjective or noun to refer to another member of the same species, as contrasted with *heterospecific*, referring to a member of another species.

Constrained parents Individuals mated to partners they do not individually prefer.

Constraints on mate preferences Social or ecological factors that reduce the likelihood or opportunity for individuals to mate with partners they individually prefer under the assumption that mate preferences predict offspring viability.

Consummatory sexual behavior The terminal phase of a sexual behavior sequence during which male gametes are emitted so that they can fertilize oocytes produced by the female the male is mating with.

Contagion The unconditioned release of a predisposed behavior in one animal by the performance of the same behavior in another animal.

Contaminant A chemical that has the potential to cause adverse effects in plants or animals.

Context The circumstances under which a decision is made, which could be including but is not limited to, number of alternative options, nature of alternative options, temporal and spatial information.

Context-specific behavior A behavior that occurs in one situation, but not others; the context can be defined by a social setting like aggression or mating, an environmental

cue like darkness, internal condition like reproductive state or hunger, ongoing activity like flight or walking, or other factors.

Contextual fear conditioning Pavlovian conditioning can be used to study contextual learning in which the composite properties of an experimental apparatus (e.g., its configuration, odor, illumination) frequently accompanied by an acoustical cue, act as conditioned stimuli predicting a previously experienced foot shock. Rats receiving foot shocks will typically display conditioned freezing when placed in the apparatus the following day.

Continuous (all-occurrences) sampling or recording Observational method in which an observer records all behavioral onsets, transitions, and interactions of a single, focal animal during an observation period.

Conventional signal A signal whose meaning could, at least theoretically, be exchanged for another within the same repertoire.

Convergent evolution The development of similar anatomical, physiological, behavioral, or cognitive traits that may have a similar function, in two or more distantly related species; for example insects, birds, and bats all have evolved wings enabling them to fly. The traits may evolve through similar selection pressures, such as finding and processing food. Convergent evolution (analogy) is different from evolution via shared ancestry (homology), in which traits evolve because they are present in closely related species with a shared ancestor.

Cooperation A behavior which provides a benefit to another individual (recipient), and which is selected for because of its beneficial effect on the recipient (cf. altruism which is a special case of cooperation).

Cooperative breeding A social system in which individuals help care for young that are not their own. The parental care givers may be other reproducing adults or reproductively mature but nonreproducing adults.

Co-option or exaptation Co-option or exaptation is the use of an ancestral adaptation (gene-trait relationship) for a new function for which the adaptation did not originally evolve. Evolutionary co-option occurs when natural selection causes traits, including behavioral traits, to assume new functions, often in new contexts. Motor patterns that are elicited in new contexts ('co-opted') can subsequently become ritualized.

Copulation Mating; the act of inserting the male reproductive organ into the female.

Copulation solicitation display An estrogen-dependent courtship display performed by female songbirds.

Corm Bulblike underground part of a plant stem.

Cornicles A pair of small upright tubes found on the hind dorsal side of aphids that are used to excrete droplets of defensive compounds.

Corpora allata Glands near the insect brain that secrete juvenile hormone.

Corpora cardiaca Neurohemal organs near the insect brain that store and release prothoracicotrophic hormone and other neuropeptides.

Corticoids A class of C₂₁ steroid hormones secreted primarily from the adrenal cortices. There are two main types of corticoids: glucocorticoids (e.g., cortisol and corticosterone) and mineralocorticoids (e.g., aldosterone).

Corticosterone Glucocorticoid hormones found in birds, reptiles, and mammals.

Corticotropin-releasing factor (CRF) Forty-one amino acid polypeptides produced in the hypothalamus and extrahypothalamic sites that stimulate the release of ACTH (all vertebrates studied) and TSH (nonmammalian vertebrates) by the anterior pituitary gland. CRF-like peptides play central roles in developmental, behavioral, and physiological responses to stressors.

Cortisol Glucocorticoid hormone most commonly found in mammals.

Corvids Members of the crow family, which includes the rooks, ravens, magpies, jackdaws, jays, and choughs as well as crows.

Cost-benefit analysis Cost-benefit analysis as applied to animal behavior predicts that if a behavior is adaptive, the benefits of a behavior must exceed the costs of that behavior. These costs are typically measured in terms of energy, time, and survival or reproduction.

Counterconditioning A respondent learning technique designed to replace an undesirable response with a more desirable one. Often used to reverse fear conditioning.

Courtship A suite of behaviors by members of one sex to attract members of the other sex for the purposes of mating.

Crepuscular Active during periods of twilight, that is dawn and dusk.

Criterion A rule or test on which to base a decision.

Critical flicker fusion frequency Frequency of a flickering light at which it is perceived as steady.

Crop A pouch-like enlargement of a bird's gullet.

Cryophilic Having an affinity for low temperature. In behavior, cryophilic refers to animals having a tendency to move toward lower temperature.

Crypsis Defense strategies that have specifically evolved to reduce the probability of detection.

Cryptic female choice A type of sexual selection that can occur if a female's morphological, behavioral, or physiological traits (for instance, triggering of oviposition, ovulation, sperm transport or storage, resistance to further mating, inhibition of sperm dumping soon after copulation, etc.)

consistently biases the chances that a particular subset of conspecific mates have of siring offspring, when she copulates with more than one male. This is the postcopulatory equivalent of Darwinian female choice.

Cryptochrome Flavoprotein ultraviolet-A receptor involved in circadian rhythm entrainment in plants, insects, and mammals.

Cue A change in the environment made by one animal that allows another animal to acquire information, but does not benefit the animal that produced it. A source of information that can be used during orientation (e.g., a landmark).

Cue bearer Any organism or object that carries a recognizable set of identity cues.

Cue calibration The process of comparing compass information (i.e., directional references) derived from multiple sensory cues, such as magnetic and celestial cues, and calibrating one compass with respect to another. This can lead to a hierarchy of sensory cues, in which one particular sensory cue is being used to calibrate all the others.

Cue readers Unintended receivers of signals (predators or parasites) using a signal to detect the location of a potential prey/host, but for which the information content of the signal is unimportant.

Culture (a) [as commonly used by biologists]: between-group variation in behavior that owes its existence at least in part to social learning processes; (b) [as commonly used by anthropologists]: 'the complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habits acquired by man as a member of society' (Tylor, 1924, p. 1).

Cupula Gelatinous covering of the hair cells in a lateral line neuromast. The cupula forms the mechanical coupling between water movement and the displacement of the hair cell cilia.

Currency Any quantity that can be used to evaluate the costs and benefits of different behavioral acts.

Cutaneous receptors A cutaneous receptor is a type of sensory receptor found in the dermis or epidermis. They are a part of the somatosensory system. Cutaneous receptors include cutaneous mechanoreceptors, nociceptors (pain), and thermoreceptors (temperature).

Cysticercoids The larval stage of many tapeworms.

Cytokine The name literally refers to a 'moving cell,' but in this case, cytokines refer to protein and peptide molecules that act as a cell signals. Cytokines, which are secreted by immune cells that have encountered a pathogen, encompass a large and diverse family of protein and polypeptide regulators that are critical to the development and functioning of both innate and adaptive immune responses. Endogenous pyrogens, which evoke the fever reaction and sickness behavior, are a type of cytokine.

Cytoplasmic incompatibility Differences carried within the cytoplasm of an egg or sperm prevent the formation or lead to the degradation of the zygote due to an interaction with the cytoplasm and the nuclear genetic material. The cytoplasmic effect may be due to gene products existing in the cytoplasm or cytoplasm-associated endosymbiotic organisms.

Dance language A series of movements displayed by honeybees to recruit their nestmates to food or nest sites.

Darwinian fitness or fitness The capability of an individual of certain genotype to reproduce, which is usually equal to the proportion of the individual's genes in all the genes of the next generation.

De novo synthesis Produced by the organism; self-made.

Death feigning The assumption of a false catatonic state after being captured by a predator in which the animal appears rigid and lifeless; may function to convince the predator that no further attack is necessary, allowing the prey to escape (also called: letisimulation, thanatosis, death shamming, akinesis, hypnosis, and tonic immobility).

Deception The production of a signal that induces a receiver to behave in ways that reduce its reproductive success.

Decibel A measurement of sound amplitude. A decibel is the ratio of two pressures on a logarithmic scale: $\text{dB} = 20 \log(p_1/p_2)$, where p_1 is the sound being measured and p_2 is a reference pressure referred to the threshold of human hearing.

Decision algorithm A set of behavioral steps that ends with selection of one option from a choice set. The steps govern how an individual reacts to the options themselves, other aspects of the environment, and its own state. In a collective decision, they also govern interactions among group members.

Decision-making An outcome of cognitive processes, leading to the selection of one particular course of action (or option) among several alternatives.

Declarative In memory research, declarative memories are contrasted with nondeclarative (or implicit) memories; originally, declarative memories were those that could be explicitly talked about although today other properties may be used to characterize declarative memory; declarative memories are widely thought to depend on the temporal lobes of the brain. Nondeclarative memories control behavior without the awareness of the existence of stored information, for example, one can ride a bicycle without being able to state, in detail, how it is accomplished.

Decoding The process of extracting information from signals.

Defeminization A component of the sexual differentiation process during which the capacity to display female-typical behaviors is lost or reduced.

Defense call Auditory call given by an animal standing its ground in the face of an approaching predator that may mimic the call of a species that is threatening to the predator and function to deter its further attack.

Deflective markings Patterning on the body of a prey type that produces a fitness advantage to the bearer by manipulating the point of predatory attack on the prey's body such that successful prey capture is less likely.

Degree (*k*) The number of edges a focal animal has; in an unweighted network, this is the number of other animals with which the focal individual interacts; in a weighted network, this will reflect the strength or frequency of interactions; also called *connectivity*.

Degrees of freedom In statistical analyses it is the number of independent pieces of information upon which a statistical value is based. This along with a statistical value and the rejection criteria determine the statistical significance of a test.

Deimatic signal A sudden change in the appearance of prey that can cause a predator to delay (or even abandon) an attack.

Delayed gratification task Experimental situation in which rewards accumulate over time, and decision makers can choose when to stop the accumulation.

Delay-tuned neurons Neurons in the auditory system that respond most vigorously to two brief signals that have a particular temporal separation that mimic an emitted pulse and echo that returns from a particular distance.

Demersal Living or occurring in habitats near the bottom or seafloor.

Demographic stochasticity The fact that some individuals fail by chance to encounter potential mates or by chance die, processes that cause fluctuations in demographic parameters.

Demography The size and age structure of a colony.

Dendrite Peripheral extension of a sensory neuron on which the receptor proteins are located.

Dendritic Fingerlike, branching as a tree from a single root.

Dense cored vesicles Small, intracellular, membrane-enclosed sacs found in neuronal terminals. Also called 'granular vesicles.'

Denticles (placoid scales) Small outgrowths, similar in structure to teeth, which cover the skin of many cartilaginous fish including sharks. Denticles of sharks are formed of dentine with dermal papillae located in the core. The shape of a denticle varies from species to species and can be used in identification.

Dependent founding Initiation of a new colony that requires the aid of workers. It involves colony budding or fission.

Dependent variable A variable that is presumed to be affected or controlled by one or many independent variables.

Depth perception The ability of animals to see the world in three dimensions.

DES Diethylstilbestrol is a strong estrogen that was used as a preventive treatment against miscarriage.

Desensitization The mitigation of a response to a distressing stimulus by gradual and repeated exposure to that stimulus.

Desquamation Physical loss of skin, scales, etc.

Developmental plasticity Environmental variation induces variation in phenotypes among individuals within populations and sometimes within individuals.

Developmental psychology Focused on the changes in behavior as the animal matures and the interplay between genes, environment, and the organism during ontogeny.

Dewlap A fleshy and sometimes colorful patch of skin on the throat area of some lizards. Many species have muscles that allow the dewlap to be extended as part of displays.

Dialect The situation where acoustic communication signals form a mosaic pattern of geographic variation, with individuals within a local population producing very similar signals that are separated by relatively sharp borders from those of the neighboring groups.

Diameter (*d*) The largest distance between any two vertices in the network.

Diapause A state of arrested behavior, growth, and development that occurs at one stage in the life cycle. Quiescence accompanied by decreased metabolic rate and other physiological processes.

Diel vertical migration (DVM) Vertical movements at sunrise and sunset, commonly used by aquatic organisms to balance feeding and predator avoidance. DVM usually involves an ascent to shallow water at sunset and descent to deeper water at sunrise, often linked to temperature and light.

DIF Differentiation inducing factor is a chlorinated alkyl phenone produced by strong cells that induces weaker cells to become stalk, not spore.

Differential allocation hypothesis A hypothesis about selection on parents to allocate their parental resources differently to offspring depending on the relative attractiveness of mothers versus fathers.

Differential migration When the timing or distance of migration is different for males and females, or for young and adults, or both sex and age differences.

Diffusion chain An experimental design for studying the serial transmission of information from model to novice, typically used to assess fidelity, corruption, and other changes, along a chain of individuals.

Dilution effect A decrease in predation risk due to the presence of alternative targets in a group when a predator cannot capture all group members during an attack.

Dimorphism Having two different patterns, usually referring to physical features. Males and females differ in their color patterns or sizes.

Dipsogenic Thirst provoking.

Direct benefits Material benefits of mate choice that accrue directly to the choosing individual as a result of the choice, such as nutrients, territory quality, or parental care provided by the mate.

Direct fitness Fitness achieved through direct reproduction of one's own offspring. Direct reproduction is one component of inclusive fitness.

Directionality The ability to locate the source of a stimulus in space.

Directional selection A form of selection in which more extreme phenotypes are favored over existing phenotypes, such as larger more colorful ornaments, resulting in progressive elaboration of the phenotype over evolutionary time.

Dispersal Movement of individuals away from an existing population or away from the parent organism.

Displacement activities Behaviors performed in an abnormal context and in response to a seemingly unrelated motivation.

Dissociated pattern of reproduction An annual reproductive cycle in which expression of copulatory behaviors and fertilization are not synchronized with the period of maximal activity of the gonads.

Distal Farther from a body midline – used to describe order of segments in an appendage (e.g., a hand is distal to a shoulder).

Distractor option A member of a choice set that is unlikely to be chosen but which may influence preferences for other options. Distractor effects exemplify the irrational decision-making often seen in humans and other animals.

Distributed cognition Distributed cognition is an interdisciplinary branch of cognitive science that holds that cognitive processes are not confined to the brains of animals, but extend across individuals and out into the environment. An animal's 'cognitive system' consists not of its brain alone, but of its brain, body, and environment (including other animals) acting in concert. It is closely connected to the concept of embodied cognition.

Disturbance and disturbance stimulus Disturbance is a deviation in an animal's behavior from patterns occurring without human influences. A disturbance stimulus is a human-related presence or object (e.g., birdwatcher, motorized vehicle) or sound (e.g., seismic blast) that creates a disturbance.

Diurnal Active primarily during the daytime.

Diurnal rhythm A biological rhythm that is synchronized to the 24 h light-dark cycle.

Diversionsary display A display performed by a parent at the approach of a predator that poses a risk to vulnerable young. If successful, the display attracts the attention of the predator causing it to move toward the parent and away from the young. These displays, most commonly described in ground-nesting birds, but also found in stickleback, incorporate elements that seem to have been co-opted and ritualized.

Division of labor A property of a social group in which different individuals specialize in different tasks.

DNA methylation Chemical modification of individual cytosine nucleotides in DNA that alters gene transcription.

DNQX (6,7-Dinitroquinoxaline-2,3-dione) An AMPA and kainate antagonist. It is used in neurobiology as a tool to block AMPA and kainate type ionotropic glutamate receptors.

Domain of danger The space closer to a focal individual than to any other group members.

Dominance The state of having high social status in a group, often won through aggressive encounters or threats of aggressive encounters with conspecifics. Dominance is often linked to increased acquisition of resources, including food, territories, and mates.

Dominance hierarchy A dominance hierarchy describes predictable interactions among individuals, with one giving way to another in competition for resources. A linear dominance hierarchy is transitive.

Dominance–subordination relations In groups of animals some individuals dominate (i.e., are higher in the 'pecking order') others that become subordinate (lower in the 'pecking order'). These relationships may be stable over many days, weeks, months, or even years, whereas in other cases they can be changing constantly (e.g., as in large groups).

Dominant frequency The highest amplitude frequency component in a harmonic sound.

Dominant individual High-ranking individual within a social group. This individual often has primary access to the best resources, such as food and mating partners. Dominance is often (but not always) correlated with large size and fighting ability, but also the ability to form coalitions (friendships) with other individuals.

Dopamine A neurotransmitter occurring in both vertebrates and invertebrates. Massive loss of DA neurons in the substantia nigra in humans results in Parkinson's disease whose main characteristic is the paucity of voluntary movements, or hypokinesia. It is also associated with the pleasure system of the mammalian brain.

Doppler shifts The increase in the frequency of a returning echo due to the difference in velocity between a bat and its target.

Dorsal root ganglion A nodule near the spinal cord that contains cell bodies of sensory neurons in spinal nerves.

Drone A male honeybee.

dsRNA Double-stranded RNA.

Duration eggs Encapsulated eggs, which can dry out or freeze and hatch once conditions are favorable again. Often found in zooplankton, especially in temporary ponds.

Dynamical system A mathematical description of how a system behaves as a function of time. The description consists of an equation or set of equations that define the system's current state, as well as its past and predicted trajectory. The goal in considering nervous systems as dynamical systems is to characterize their oscillatory or quasi-oscillatory behavior.

Eavesdropping The use of a signal by an animal that is not the intended receiver of the signaler.

Ecdysis The shedding of the old, overlying exoskeleton of an arthropod; a process necessary for growth.

Ecdysteroid A general term for a family of steroid hormones known in insects and other invertebrates. In insects, it is known as a molting hormone during larval stages, but has many other nondevelopmental effects. In most insects, the primary ecdysteroid is 20-hydroxyecdysone.

Echo ranging The measurement of distance between a bat and its target. The acoustic cue for ranging is the time interval between the emitted pulse and the returning echo.

Echolocation The ability to use sound waves reflected from a surface to detect objects at a distance.

Ecological determinism Similarities among closely related species that reflect the ecological selection pressures acting on species, rather than the phylogenetic relationships between species.

Ecological time scale A time scale of the same order of magnitude as the life span of the organisms investigated. Measured in days, months, or years, as opposed to evolutionary time scale, which is measured in thousands or millions of years.

Ecotoxicology The study of the effect of chemicals (toxicology) on the ecology of animals or plants.

Ectoparasitoid A parasitoid with a life-history strategy where the larva develops outside the host body by attaching or embedding in the host's tissues.

Edge A relationship between two components of a network where the two related components are vertices in the graph model representing the network; in a social network, these can be any sort of social relationship, such as social interactions or information transfer; also called a *tie* or *link*.

Education by master apprenticeship This is a phrase coined to describe how chimpanzees acquire new behaviors through observational learning. It is characterized by the following four aspects: (1) a long-term affectionate bond between mother and infant, (2) the mother takes on the role of the 'model' who demonstrates specific behaviors in the correct context, (3), the infant has a strong motivation to copy the model's behavior, and (4) the mother is highly tolerant toward the infant.

Effective population size The number of breeding individuals within an idealized population, mating at random, that would have the same amount of inbreeding or of random gene frequency drift as the population under consideration.

Efficient theory These are theories built from first principles. They are often, but not always, expressed mathematically; have few assumptions and free parameters (those that cannot be derived from a model or hypothesis); describe nature in an approximate way and is used iteratively to approach an ever-better understanding of nature. Characteristically, efficient theory has considerably fewer input variables than output variables.

Egg dumping Occurs when a female bird lays her egg or eggs in the nest of another female and leaves that other female to care for them.

Egg pod A capsule which encloses the egg mass of grasshoppers and which is formed through the cementing of soil particles together by secretions of the ovipositing female.

Egress To come out or exit.

Elasmobranch The cartilaginous fishes of the subclass Elasmobranchii including the sharks, skates, rays, and their extinct relatives.

Electric organ discharge (EOD) The electrical signal produced by the electric organs of electric fishes. Electric organ discharges create an electrical field around the fish that can be detected by electroreceptor organs in the skin. Electric organ discharges have three functions. Extremely strong discharges (hundreds of volts) of strongly electric fish such as electric eels (*Electrophorus electricus*), electric rays (*Torpedo* spp.), and strongly electric catfish (*Malapterurus electricus*) can stun prey or potential predators. Weak electric organ discharges (typically less than a volt) of South

American knifefishes (Gymnotiformes) or African Mormyrids are used to detect objects and prey or to communicate with conspecifics in dark, murky waters at night.

Electrocommunication The ability of weakly electric fish to emit and receive electrical signals for the purpose of communication. Electrocommunication is limited to aquatic environments where the electrical conductivity of the medium is sufficient to transmit electric signals.

Electromyographic activity Product of the electrical activity of muscle, which normally generates an electric current only when contracting or when its nerve is stimulated. Electrical impulses are often recorded as an electromyogram (EMG).

Electro-olfactogram An electrical recording of the voltage across the olfactory epithelium. This type of recording allows experimenters to detect the electrical responses of olfactory sensory cells to odors.

Electroreceptor organ Lateral-line-derived epidermal sense organs consisting of electroreceptor cells and associative structures located on the head and the trunk of certain fishes. They direct the flow of electrical current through low-resistive canals or through loosely layered patches of epithelial cells to specialized receptor cells containing membrane-bound voltage-gated ion channels, which convert outside electrical signals into sizable membrane potentials and subsequent transmitter release.

Electroretinogram (ERG) The massed electrical response of the retina recorded by extracellular electrodes on the retinal, or more usually, corneal surface.

Embodied cognition Embodied cognition is an interdisciplinary branch of cognitive science that argues that cognitive processes emerge from the unique manner in which an animal's morphological structure and sensorimotor capacities allow it to successfully engage with its environment. It aims to capture the way in which an animal's brain, body, and world act in concert to produce adaptive behavior, and, as such, is closely allied to the concept of distributed cognition.

Emergence When a behavioral response to a multimodal signal is entirely different from responses elicited by any single component.

Emergency life history stage A syndrome of physiological and behavioral traits triggered by perturbations of the environment that are designed to allow the individual to cope with the perturbation in the best condition possible until it passes.

Emergent phenomenon Complex biological event that itself is not the target of natural or sexual selection, but which arises as the collective result of many simpler events that are under direct selection pressure.

Emergent relations Relations between classes or class members that arise through a process of association, generalization, or inference.

Emigration Dispersal or migration of organisms away from an area.

Emotion A physiological and psychological state that functions to increase the survival of the organism. Basic emotions include anger, disgust, fear, happiness, sadness, and surprise.

Emotional contagion Automatic state matching as a result of perceived emotions in others.

Empathy The ability to recognize or understand another's state of mind or feelings (i.e., emotions).

Empirical Evidence that can be observed.

Emulation Recreation of the results of the efforts of another animal.

Encapsulation A physiological immune response in host insects where a parasitoid egg, or other foreign body, is coated or engulfed by specialized cells called plasmatocytes resulting in the death of the parasitoid egg.

Encoding The process of endowing signals with information.

Endemic Native or restricted to a certain area.

Endocrine disruptor A compound that interferes with the endocrine system, typically by binding to a receptor and either stimulating the effects of the receptor's hormone or blocking those effects, rendering the receptor inert. A compound produced for use as insecticides, herbicides, fungicides, or industrial applications as well as plant-produced chemicals with biological activity in living systems due to similarities in the structural and functional characteristics of native hormones, resulting in interference of endocrine systems.

Endocrine gland A ductless gland from which hormones are released into the blood system in response to specific physiological signals. These signals can result from internal or external stimuli.

Endogenous Phenomena arising within an organism, such as a biological rhythm.

Endogenous metabolic marker An endogenous indicator of changes in metabolic activity within a cell.

Endogenous oscillator An oscillator that is reset by internal stimuli. An endogenous oscillator is self-sustaining (i.e., periodic output continues after the termination of periodic input).

Endogenous pyrogens Endogenous refers to inside the body and pyrogen refers to the generation of heat, in this case the increase in body temperature associated with a fever. Endogenous pyrogens, now commonly referred to as cytokines, evoke sickness

behavior along with fever. Endogenous pyrogens are released in the body upon exposure to bacteria, bacterial cell-wall lipopolysaccharides, and viruses.

Endogenous rhythm Internally generated, and not dependent on (but may be modified by) an external stimulus. Usually applied to seasonal processes, such as gonad growth, and migration, or diurnal processes, such as sleep.

Endoparasitoids A parasitoid with a life-history strategy where the larva develops within the host body.

Enemy-free space A habitat (e.g., host plant) where the herbivore is exposed to reduced rates of predation and parasitism.

Enemy release hypothesis Hypothesizes that nonnative species become invasive because they are free from the predation and parasitism pressures of their native region.

Energy balance Physiological adjustment of energy intake and expenditure resulting in precise maintenance of body mass; also known as 'energy homeostasis.'

Enrichment Any aspect of enclosure design or husbandry practice that increases behavioral opportunities and promotes physical and psychological well-being in captive animals.

Enterocytes Epithelial cells comprising the innermost layer of the gut.

Entrain (entrainment) To adjust a rhythm so that it synchronizes with an external cycle, for example, the entraining of the internal rhythm of an organism to a light/dark cycle.

Entropy The average amount of information encoded by signals of a system, less than or (rarely) equal to the channel capacity.

Environmental signaling The signaling effects of environmental chemicals that directly or indirectly lead to changes in physiological functions or behaviors through interference with endocrine or exocrine mechanisms.

Environmental task specialization Task threshold is primarily determined by the environment. Workers vary in their behavior on the basis of the environment they have experienced particularly during larval feeding.

Eph–ephrin receptors Eph and ephrin receptors are components of cell signaling pathways involved in animal development and axon guidance. Eph receptors are classified as receptor tyrosine kinases (RTKs) and form the largest subfamily of RTKs.

Epidermis The outermost layer of cells acting as the organism's major barrier against the environment.

Epigenetic Originally, the term 'epigenetic' was used in a broad sense to refer to the processes of development as an interaction of genes and their products to produce the

phenotype. This original definition did not imply heritability. Its definition became narrower with epigenetic being viewed as any aspect other than DNA sequence that influences the development of an organism. Modern usage of the term in molecular biology refers to the heritability of a trait over cell generations in an individual or across generations of individuals without changes in underlying DNA sequence. Epigenetic changes are preserved during the cell cycle and remain stable over the course of an individual's lifetime. For example, methylation of DNA at a Cytosine followed by a Guanine (CphosphateG or CpG site) can epigenetically switch off the adjacent gene, which may then stay 'off' in ensuing generations.

Episodic memory The ability to remember and reexperience specific personal happenings from the past.

Epistasis Where multiple genes interact to influence a trait.

Epistemic acts Acts which serve to change the cognitive demands of a task so as to make it easier to solve, but which do not move an animal closer to task completion.

Epistemic engineering The manner in which animals change their environments in order to alter the nature of the informational environments, as a means of either reducing its own cognitive load or increasing that of its enemies and rivals.

Eradication An attempt to completely remove exotic fauna or flora from an area.

ER α KO Knockout mice lacking a functional estrogen receptor α .

ER β KO Knockout mice lacking a functional estrogen receptor β .

Eruption In migration studies, a massive emigration from a particular region.

Estivation (Aestivation) A period of dormancy over the summer that allows animals to survive an extended period of high temperatures or drought.

Estradiol An estrogen (hormone) secreted by the ovary; it binds to estrogen receptors in many tissues including the brain.

Estradiol 17 β The most important circulating estrogen in both teleost fishes and mammals, produced in the ovaries but also other tissues including brain through the action of the enzyme aromatase.

Estrogen A steroid hormone with 18 carbons and an aromatic ring, so named because of their estrus-generating properties in female mammals. Examples include estradiol, estriol, and estrone. Estrogens are synthesized from androgens with the help of the enzyme aromatase.

Estrus (estrous) The period during which a female is sexually attractive, proceptive, and receptive to males and is capable of conceiving.

Ethnic marker A seemingly arbitrary cultural element that signals membership of a particular ethnic group.

Ethnopharmacology The study of the pharmacologically active compounds in plants used by traditional societies pertaining to the health care of humans and their animals.

Ethogram Inventory of behaviors of a species, with definitions.

Ethology Approach to the study of behavior developed by European zoologists that emphasizes, but is not limited to, the study of the naturally occurring behavioral patterns of free-ranging animals with particular emphasis on evolution and adaptive significance but not to the exclusion of development and immediate causation.

Ethopharmacology The study of the effects of drugs on the neurochemical mechanisms of behavior. According to some authors, ethopharmacology should include the biological variability and adaptive significance of behavior, thus explicitly relying on an evolutionary approach. Ethopharmacological studies of host–parasite interactions attempt to unravel the neuromodulatory mechanisms that underlie the behavioral alterations of a host induced by a manipulative parasite.

Euphotic zone Upper water layer of a lake or ocean to which 1% sunlight penetrates.

Euryhaline The ability to tolerate various salt concentrations, that is, describes water organisms that tolerate a wide range of salinity.

Eusocial A classification of social organization with (1) reproductive suppression, (2) overlapping generations, and (3) cooperative care of young (e.g., naked mole rat).

Eusocial (eusociality) Colonies of animals structured around in which the generations overlap and there is a division of reproductive labor with members of the older generation producing most or all of the offspring of the colony. In primitively eusocial species, the differentiation between the parental generation (queens) and their daughter workers is weak and the daughters may have the potential to reproduce. In highly eusocial species, the queen and workers are highly differentiated and workers typically lack the physical and physiological attributes required to mate and reproduce.

Eutherian mammals Eutheria are a group of mammals consisting of placental mammals plus all extinct mammals that are more closely related to living placentals (such as humans) than to living marsupials (such as kangaroos). They are distinguished from noneutherians by various features of the feet, ankles, jaws, and teeth.

Evaluator Any organism that evaluates a cue bearer and makes a decision regarding that cue-bearer's identity.

Evo-devo Evolutionary developmental biology, a field of biology that integrates studies of genetics, development, and evolution in order to understand the evolution of morphology and developmental processes.

Evolutionarily stable strategy (ESS) A strategy that, if adopted by a population of players, cannot be invaded by any alternative strategy that is initially rare.

Evolutionary algorithms Several computational techniques that use iterative progress to solve problems. Inspired by evolutionary processes, such as reproduction, mutation, recombination, and selection, the techniques are based on a population that evolves in a guided random search until the individuals who use the best solution or strategy take over.

Evolutionary game theory Evolutionary game theory is an application of the mathematical theory of games to evolutionary biology contexts, arising from the realization that frequency-dependent fitness introduces a strategic aspect. A game defines fitness of players, which reflects not only strategy of the protagonist player but also strategy of other ones. Evolutionary game theory analyzes transition of strategists' frequency in the population according to the expected fitness of each strategist, which reflects the current relative frequencies of the strategists and the game rules.

Evolutionary psychology The application of evolutionary principles to human behavior in which behavior is regarded as the product of mechanisms that evolved early in human history, possibly in the Pleistocene epoch, and may not be adaptive in the present environment. Thus, behavior need not be adaptive in the present environment. Often behavior is viewed as the product of relatively specialized modules in the brain.

Exogenous Phenomena arising outside of an organism, such as the light–dark cycle.

Exogenous metabolic marker An exogenous substance that, when introduced to an animal, can indicate changes in metabolic activity within a cell.

Exotherm An animal that depends on external sources of heat to maintain its body temperature in a viable range, as contrasted with *endotherms*, which have physiological mechanisms to generate heat and reduce heat stress.

Exotic species A species that was accidentally or deliberately transported to an area far from its native distribution range.

Expected group size The group size that is predicted on the basis of a given hypothesis for the advantage to being in groups.

Explicit In memory research, equivalent in meaning to declarative; contrasts with implicit; see declarative.

Exposure Process or situation in which a substance in the environment, such as a chemical, gains entrance to an organism (through ingestion, inhalation, dermal, or injection).

Expression component The production or acquisition of identity cues by a cue bearer.

External validity How well results of a study can be generalized to other situations or conditions.

Extinction Withholding or preventing reinforcement of a previously reinforced behavior with the goal of reducing the frequency of the behavior to baseline or eliminating it altogether.

Extracellular fluid One of the major fluid compartments of the body comprising all fluid residing outside cells.

Extracellular recording Monitoring the electrical activity of neurons with an electrode outside the cells; normally records the activity of many neurons simultaneously.

Extractive-foraging Behavior aimed at accessing food embedded in a protective matrix (such as shells or spines), or that is otherwise inaccessible (such as termites in nests or insect larvae in tree holes).

Extra-pair copulations (EPCs) Copulations with individual(s) other than a mate or social partner.

Extra-pair fertilizations (EPFs) Fertilizations that occur when females copulate with males other than their social mate.

Extra-pair offspring (EPO) Offspring obtained by extra-pair copulations.

Extra-pair paternity (EPP) Occurs when a socially paired female reproduces with a male, who is not the social mate.

Extrinsic isolation Low fitness of hybrids because of hybrid phenotypes not being adapted to the resources of either parental population.

Extrinsic marker Tag or band affixed to an animal at the time of capture that yields data only when an individual is re-sighted or recaptured later on.

Extrinsic mortality Mortality caused by extrinsic agents such as predators, diseases, and accidents independently of any risks taken for reproduction.

Exudate An escape of fluid as a consequence of increased vascular permeability and inflammation.

Exuviae The remains of a molted arthropod exoskeleton.

Facial nerve The seventh (VII) of twelve paired cranial nerves. It emerges from the brainstem between the pons and the medulla, and controls the muscles of facial expression, and taste to the anterior regions of the tongue.

Facultative Applies to organisms that can adopt alternative ways of living. More specifically, individual facultative migrants have the choice of whether to migrate or not.

False belief A belief is a mental state representing knowledge about the state of the world, for example that food is hidden in a particular container. A false belief is a mental state that is contrary to reality, for example the food may have been moved without an individual witnessing the change, and therefore it will have a false belief about the location of the food. Understanding that others can have false beliefs has been suggested as the key test for theory of mind in children.

False workers In termites, the majority of the individuals within a colony of wood-dwelling termites. They differ from the (true) workers of foraging termites as they are totipotent larvae that lack morphological differentiations. Correspondingly, they are less involved in truly altruistic working tasks, such as foraging, brood care, or building behaviors. Therefore, they may rather be regarded as large immatures that delay reproductive maturity ('hopeful reproductives').

Family group A group of individuals that repeatedly interact, composed of one or both parents and their direct offspring; may or may not include other relatives as in 'extended family group.'

Fast mapping A type of inference by exclusion used by psycholinguists to denote the ability of children to form quick and rough hypotheses about the meaning of a new word after only a single exposure.

Fear effects Another term for nonconsumptive effects. This term should be avoided except in cases where it has been established that antipredator responses are driven by fear.

Fear scream Loud, harsh auditory call emitted after being captured by a predator that may serve one or more functions, including mobbing, startling the predator, warning kin of danger, calling for help from conspecifics, and attracting other nearby predators to distract the captor (also called: distress call).

Feature learning (In the process of categorization) The use or abstraction of common features; in contrast to feature analysis, this process is characterized by a continuous adaptation of the feature set or the feature weights in order to cope with the actual categorization task.

Fecundity The reproductive capacity of an organism; the quantity of eggs, sperm, or offspring produced by an individual.

Fecundity selection Selection generated by variation in the number of offspring produced among individuals of a population.

Feeling A brain construct, involving at least perceptual awareness, associated with a life-regulating system, which is recognizable by the individual when it recurs and may change behavior or act as a reinforcer when learning.

Felid Species that are docat-like, classified within the family Felidae in the order Carnivora.

Female control Refers to the idea that in species with internal insemination and fertilization that females are likely to control the fate of sperm and the likelihood of fertilization by particular sperm.

Female resistance Describes behavior, physiology, and morphology of females that decreases the likelihood that males will attempt to force them to copulate.

Fertility The number of reproductive bouts for an individual female over a season or a lifetime.

Fertilization Occurs when sperm enters an egg.

Fidelity Faithfulness, usually applied to a locality or mate.

Finder's advantage In the context of group feeding, it is the part of a clump of food that a finder gets to eat before the arrival of any other individuals at the patch.

Finder's share The fraction of the total food patch that makes up the finder's advantage.

Fisher's sex-ratio theory Sex-ratio argument predicted for diploid species that sex ratios should stabilize at 1:1 (female:male) because each offspring derives from the pairing of a female and a male, and each sex, thus, produces overall the same total number of offspring; any deviations from an even sex ratio are unstable because negative frequency-dependent selection gives the rarer sex a reproductive advantage over the more common sex, ultimately leading to equal sex ratios at the population level.

Fission Mode of colony multiplication in which new colonies are founded by one colony dividing into two relatively equal halves.

Fission–fusion society A society in which members belong to a single, permanent social group, but in which all group members are rarely observed together concurrently. Instead, individuals form temporary subgroups that change frequently in their size and composition, often in response to ecological variation.

Fitness The relative capacity of an organism to survive and transmit its genotype to reproductive offspring.

Fixed threshold model A model of task allocation in insect colonies that holds that individual workers vary in the level of stimulus required to undertake a particular task. Workers with a low threshold are likely to engage in the task. High-threshold workers will not.

Flank marking A behavior in which an animal rubs its flanks on objects to deposit contact pheromones from scent glands located on or near the flanks.

Flexible individual phenotypes Phenotypes that are induced by environmental variation; these often appear to enhance the instantaneous fitness of the individual.

Flight boundary layer The narrow layer of the atmosphere closest to the surface within which the self-powered flight speed of an individual exceeds the mean wind speed; thus within this layer, the individual can control its direction and make headway against the wind.

Flight initiation distance Distance separating a prey and an approaching predator when the prey begins to flee; synonyms: approach distance, flight distance, flush distance.

Flight zone It is the animal's personal space. The size of the flight zone is determined by how wild or tame the animal is. Animals that are trained to lead have no flight zone.

Fluctuating asymmetry Difference between the values of bilateral symmetric traits of the same individual which can be of either sign with respect to the body axis and is assumedly the product of problems during development.

Fluffing The act of shaking and loosening the feathers.

Fluorescence resonance energy transfer (FRET) also known as Forster resonance energy transfer

A phenomenon in which nonradioactive transfer of energy occurs between donor and acceptor molecules when the two are in close proximity. The most common donor and acceptor pair used in molecular biology are CFP and YFP, respectively. When FRET occurs, CFP transfers its excited energy to YFP. As a result, YFP is observed instead of CFP fluorescence emission. An example of FRET application in neurobiology is using Cameleon, a genetically engineered protein, to detect temporal calcium activity inside a living cell.

Flyway A flyway is the entire range of a migratory bird species (or groups of related species or distinct populations of a single species) through which it moves on an annual basis from the breeding grounds to nonbreeding areas, including intermediate resting and feeding places as well as the area within which the birds migrate.

FM bats Bats that emit a brief pulse for echolocation where the frequencies of the emitted call sweep from high to low throughout the duration of the pulse.

Focal sampling Observational method in which an observer focuses on a single individual during a sampling period.

Follicle-stimulating hormone (FSH) Gonadotropin that supports spermatogenesis and oocyte development in the gonads; also responsible for production of the hormone, inhibin, by the gonad.

Food aversion learning A form of associative learning in which an animal associates sensory cues from a food with some deleterious consequence of eating that food and subsequently avoids the food.

Forced copulation Contrasts with copulation that individuals seek or freely accept. Most investigators infer that copulation is forced when it is preceded by aggression or the threat of aggression, including 'violent restraint.'

Forward genetics A phenotype-driven mutant screen.

Forward masking Reduction of perceptual sensitivity over a given time interval following the perception of a specific stimulus.

Foundress/cofoundress Foundresses are females that are initiating a nest, or living, on a newly established nest before the emergence of the first offspring. If more than one foundress is present in a nest, they are called cofoundresses.

Fourier analysis A type of time series analysis that involves fitting a series of sine waves to data. The analysis identifies the amount of strength or power associated with a set of periods.

Fovea Specifically, a depression in the center of the retina of many vertebrates, providing high-resolution vision. More generally, areas of high visual acuity in vertebrate retinas are called 'area centralis' or 'visual streak.'

Framework A simplified conceptual structure used to solve complex problems.

Frass The waste product from an animal's digestive tract expelled during defecation (also known as fecal material, or feces).

Free choice profiling An experimental methodology in which observers have complete freedom to choose their own descriptive terms and apply them to the observed behavior of animal subjects.

Free-running rhythm Free-running rhythm refers to fluctuations in physiological or behavioral responses, with a period of about 24h, that recur in the absence of environmental cues.

Freeze tolerance The ability of an animal to survive freezing of tissues.

Freezing Remaining motionless upon detection of a predator in hopes of avoiding detection by the predator either through cryptic morphology or habitat cover.

Frequency-dependent selection Selection that varies depending on trait frequency in the population.

Frequency of sound The number of cycles of vibration per second of a sound-producing object, expressed in Hz (Hertz, or cycles per second). A good set of human ears can detect frequencies of 20 Hz–20 kHz (a kHz is a kilohertz, or 1000 cycles per second). This physical property of sound is the primary determinant of our psychological experience of sound pitch.

Frequency modulation Cyclic changes in the frequency composition of a sound over time. The process of modulation produces extra frequencies in the sound, called sidebands.

Frontal cortex A brain region that (among other functions) plays a key role in long-term planning, executive decision-making, and impulse control.

Functional activity mapping An analysis of the patterns of neural activity, or its correlates, during the performance of a behavior or in response to a stimulus.

Functional class A class defined by a common (inherent) function of its members.

Fundamental frequency (f_0) The lowest frequency component in a harmonic sound.

Future planning The ability to imagine and preexperience specific personal scenarios that might occur in the future.

GABA- γ Aminobutyric acid is the chief inhibitory neurotransmitter in the mammalian CNS. The binding of GABA to its receptors causes the opening of ion channels to allow the flow of either negatively charged chloride ions into the cell, or positively charged potassium ions out of the cell, to produce an inhibition of the cell. Receptors to GABA are found in both the central and peripheral nervous systems of several invertebrate phyla. Insect GABA receptors show some similarities with vertebrate GABA receptors.

Gametes A cell that fuses with another gamete during fertilization.

Game theoretic models These are mathematical calculations of an individual's success (fitness) in making choices when their choice depends on the choices of others.

Game theory A mathematical technique for choosing the best strategy given the likely choice of others.

Ganglion The CNS of insects and other invertebrates comprises a ganglion – a processing center ('brain') – for each body segment connected to the ganglia of adjacent segments by bundles of axons called 'connectives.'

Gap junctions Specialized intercellular complexes that directly connect the cytoplasm of two cells. Gap junctions allow various molecules and ions to pass freely between cells. Between two neurons, gap junctions form electrical synapses.

Gasterosteidae Latin name for the family of stickleback fish.

Gating neurons A type of *command neuron* that must be active during the whole time while a behavior takes place. This term was coined in the study of leech swimming activation to distinguish these neurons from *trigger neurons*, a class of command neurons that is active only for a short time when a behavior begins.

Gene chip A commercial microarray.

Gene flow The transfer of alleles of genes from one population to another.

Gene regulation Relating to the activation (expression) of genes, including both transcription and translation.

Genetically effective population size The number of reproducing individuals in a randomly mating population; actual population size is usually larger than its genetically effective size owing to the presence of sexually immature or nonbreeding individuals.

Genetic complementarity The potential for traits on both sides of an ecological interaction to respond evolutionarily to reciprocal selection.

Genetic diversity The level of biodiversity within a species, in reference to its total existing number of genetic characteristics, which, importantly, provides the raw material for evolution and is critical for long-term sustainability of a population.

Genetic drift Chance variations in gene frequencies that result from random sampling error.

Genetic monogamy An exclusive mating relationship between a male and a female resulting in all offspring being genetically directly related to both partners.

Genetic polymorphism A portion of the genome that is represented by numerous distinct versions in the population. The more polymorphic a given locus is, the greater the number of distinct versions that will exist in the population. Genetic polymorphisms are based on sequence variation at specific loci.

Genetic relatedness The fraction of genes identical by descent between two individuals. Only the fraction of genes shared above background count. See piece on relatedness.

Genetic structure The array of alleles and genotype combinations in a population.

Genetic subdivision Reduced gene flow between populations allows them to differ in the presence and/or frequency of alleles as a result of random genetic drift or natural selection.

Genetic task specialization Task threshold is genetically influenced. Workers of particular parentage are more likely to engage in particular tasks.

Genic selection Selection within individual bodies between alleles at a locus.

Genomic imprinting Form of inheritance in which the expression of a gene depends upon the parent from which the gene is inherited. Because imprinting allows genes to be silenced when inherited from one sex and not the other, it provides a potential mechanism for achieving sex-specific expression. The imprint alters the chemical structure and hence the expression of the gene, but not its nucleotide sequence. Thus, the imprint can be erased and an active gene can be passed down in the next generation.

Genomic library A collection of fragments of genomic DNA that have been inserted into host cells, typically bacteria or viruses, so that the individual fragments can be replicated in high numbers.

Genotype The genetic constitution of an organism or one of the loci within that organism.

Geocentric cue A cue based on information external to the organism.

Geographic mosaic Ecological interactions vary across space because of the specifics of biotic and abiotic local environments, leading to a spatial mosaic of coevolutionary intensity. Hotspots, where reciprocal selection is strong, and coldspots, where reciprocal selection is weak or absent, characterize the geographic mosaic.

Geolocator A daylight-level recorder affixed to an animal at capture that can be recovered at recapture up to one year later to estimate the latitude and longitude for each day the device was attached.

Geomagnetic field Magnetic field associated with the Earth. It is essentially dipolar (it has two poles), the northern and southern magnetic poles on the Earth's surface. Away from the surface, the field becomes distorted.

Geophagy The ingestion of soil particles which can reduce the potency of ingested toxins.

Geotaxis Directed movement with respect to Earth's gravitational field. Movement away from Earth is 'negative,' movement toward Earth is 'positive.'

Germinal vesicle breakdown Dissolution of the nuclear membrane that signals continuation of meiosis.

Ghost experiment An experiment in which the model who would normally produce some effect in the world is absent, the effect being produced instead by surreptitious ('ghostly') means, such as pulling fine fishing line, allowing a test of how much an observer will learn from this component of the display alone.

Gill operculum The hard flaps covering the gills of a fish.

Gilliam's rule The prediction that animals favor using patches that minimize the ratio of predation risk to either expected growth or foraging rates.

Giving-up density and time (GUD and GUT) Giving-up density is the amount of food or prey items still remaining in the patch, when a forager leaves it. Giving-up time is the length of time a forager will go without encountering a food item before it leaves a patch. Both are important metrics for testing predictions of the marginal value theorem.

Glossopharyngeal nerve The ninth (IX) of twelve pairs of cranial nerves. It exits the brainstem from the medulla, just rostral (closer to the nose) to the vagus nerve. The glossopharyngeal nerve is mostly sensory and is involved in tasting, swallowing, and salivary secretions.

GLU Glutamic acid (glutamate) is the most common excitatory neurotransmitter in the mammalian brain. Receptors to GLU are found in both the central and peripheral nervous systems of several invertebrate phyla. Insect GLU receptors show some similarities with vertebrate GLU receptors.

Glucocorticoids (Glucocorticosteroids) (1) A class of steroid hormones released from the adrenal gland, particularly in response to stress; these include cortisol and corticosterone; (2) a class of synthetic steroid hormones; these include prednisone, dexamethasone and triamcinolone.

G-matrix A square and symmetrical matrix in which the main diagonal consists of the additive genetic variance for a series of traits, and the other elements are additive genetic covariances between pairs of traits. Additive genetic variances have values between 0 and +1, whereas additive genetic covariances can range between −1 and +1.

Gonadotropin-releasing hormone (GnRH) One of several neuropeptides synthesized in the brain.

Gonadotropins Peptide hormones released from the pituitary in response to gonadotropin-releasing hormone from the brain; they stimulate growth of the gonads and synthesis of gonadal steroids.

Gonochorism A sexual pattern in which individuals mature as one sex and remain that sex.

Good genes hypotheses Refer, collectively, to explanations of mate preferences based on information or cues about the genes in potential mates. Good genes hypotheses can refer to complementarity (dissimilarity), relative individual heterozygosity, or to traits that indicate the possession of particular genes.

Granivorous A diet of mostly seeds.

Gravid Ready to lay eggs, for example carrying ovulated eggs in the ovarian lumen or oviduct.

Green-beard gene A gene that affects copies of itself via three effects: production of trait, recognition of the trait in others, and differential treatment based on that trait. Sometimes not considered as part of kin selection because benefits go not to relatives but to actual bearers of the gene.

Green leaf volatiles A suite of chemicals released from many plants upon mechanical damage.

Gregarious Tending to aggregate actively into groups or clusters.

Gregarization Density-dependent behavioral phase change in locusts from mutual repulsion to attraction and aggregation.

Ground-reaction forces The forces that are developed as an animal or robot walks by pushing against a substrate (positive) or absorb momentum (negative, braking forces).

Group foraging The searching, handling, and consumption of food by animals in close spatial proximity, whether or not there are social interactions between them.

Group memory Information that is stored in the properties of an entire group, rather than encoded in the nervous system of an individual animal. The distribution of honeybee waggle dancers across food sources, for example, encodes the colony's ranking of the value of these sources.

Group selection Selection between assemblages of individuals.

Group size effect The phenomenon that individual vigilance declines as group size increases. This is most often explained by individual adjustments to a reduced perceived predation risk.

Gustation Sense of taste.

Gustatory receptor protein (GR) 7-transmembrane protein located on the dendrite membrane of a gustatory neuron; detects and binds specific chemicals such as sugars or minerals.

Gustatory receptor Sensillum that houses gustatory neurons; usually a tip pore *sensillum trichodeum*.

Gymnotiform Electric knifefish of the New World order Gymnotiformes comprising five families. All gymnotiforms are electrogenic. 'Gymnotid' refers to members of the family 'Gymnotidae' including the weakly electric genus *Gymnotus* and the strongly electric *Electrophorus* (electric eel).

Gyne Gynes are young females who have the potential to become egg-laying foundresses.

Habituation Often considered the most basic form of learning that is defined as a response decrease in the presence of repeated stimulation.

Hamilton's rule Named after W.D. (Bill) Hamilton, it is an inequality ($rb - c > 0$) that predicts when a trait is favored by kin selection, where c is the fitness cost to the actor of performing the behavior, b is the benefit to the individual to which the behavior is directed, and r is a measure of the genetic relatedness between those individuals. An altruistic act by definition has positive c and positive b and so is more likely to be favored by natural selection when r is high, and requires r to be positive. A selfish act, such as cannibalizing a member of the same species, has negative c and negative b and so is more likely to be favored by natural selection when r is low, and especially when r is zero.

Handicap A trait whose expression incurs a cost, such that the degree of trait expression reflects the quality or condition of the bearer, in the sense that only an individual of high quality or condition can afford the cost of expressing the trait. Handicaps are one type of indicator mechanism and comprise a subset of the various indirect benefit hypotheses for the evolution of sexual dimorphisms via mate choice.

Handicap principle A hypothesis to explain honest signaling that proposes that reliable signals must be costly to the signaler in a manner that an individual with less of that trait could not afford.

Haplodiploidy A genetic system in which females come from fertilized eggs and are diploid, while males come from unfertilized eggs and are haploid.

Haplometrosis The founding of a eusocial insect colony by a single queen.

Haplotype A set of alleles of closely linked loci that are usually inherited together.

Harassment Occurs when males attempt repeatedly to copulate and in so doing impose costs on females that supposedly induce females to submit to copulation attempts.

Harderian gland A gland found within the eye's orbit, which occurs in vertebrates that possess a nictitating membrane. In some animals, it secretes fluid that lubricates movement of the nictitating membrane.

Hardy–Weinberg law The foundation of population genetics; the law shows that in the absence of evolutionary forces genotype and allele frequencies are stable and related to each other algebraically.

Harmonic An integer multiple of the fundamental frequency of a sound (e.g., 2*f*, 3*f*, 4*f*).

Harmonic sound A complex sound consisting of multiple frequencies (sine waves), all in integer relation with each other.

Hawk–dove game A game theory analysis of alternate strategies hawk (attack immediately) and dove (display and retreat if attacked).

Helpers/helpers-at-the-nest Individuals, especially birds that provide care for conspecific young that are not their own offspring.

Hematophagy The habit of feeding on blood.

Hemimetabolous Having no pupal stage in the transition from larva to adult.

Hemoglobin Oxygen-carrying component of red blood cells.

Hemolymph The circulatory fluid of insects and other invertebrates, comparable to vertebrate blood.

Herbicides Chemicals produced to kill plants/weeds; generally used in no-till agricultural operations where the previous planting and weeds are not removed prior to seeding the new crop.

Heritability A measure of the proportion of phenotypic variation that is due to genetic variation in a population.

Hermaphroditism A condition in which individuals have gonads of both sexes (testes and ovaries) either simultaneously or sequentially.

Heterochrony hypothesis Proposes that an early step in the evolution of eusociality is based on simple evolutionary modification of the timing of expression of maternal care behaviors, from postreproductively towards offspring, to prereproductively, towards sibs (see reproductive groundplan hypothesis).

Heterospecific An individual of a different species.

Heterozygosity The proportion of genetic loci in an organism that have different alleles.

Heuristic Is a 'rule of thumb,' educated guess or a general way to solve a problem. Often used to describe a method that rapidly leads to a solution that is good in most situations. In phylogenetics, heuristic procedures are common because exact solutions are either mathematically impossible or nearly so.

Hibernation Dormancy during the winter. The seasonal occurrence of profound physiological changes that include strongly reduced basal rates of metabolism, heartbeat, and respiration.

Hidden Markov model Extension of the Markov chain concept to the modeling of nonhomogeneous data. The model combines a hidden variable driven by a Markov chain and an observed variable. A different distribution of the visible variable is associated with each possible value of the hidden variable.

Hiding time Latency between entering and emerging from refuge; synonym: emergence time.

Higher-order conditioning This Pavlovian learning process has two phases. First-order conditioning results in the conditioned stimulus predicting the occurrence of the provocative unconditioned stimulus. Second-order conditioning involves exposing the animal to the first conditioned stimulus, which has now acquired provocative properties, in temporal association with a second, emotionally neutral conditioned stimulus. The second conditioned stimulus then becomes a predictor of both the first conditioned stimulus and the unconditioned stimulus (not employed in the second-order association) and acquires its emotionally provocative properties at even a lower level of intensity.

Highly eusocial Eusocial society in which there are developmentally distinct specializations where some individuals are specialized for reproduction, and others have developmental differences that preclude mating and make them totally/effectively sterile under normal circumstances.

High-speed video Allows very high time resolution for analyzing fast behaviors by using high frame rates (commonly 500–2000 frames per second); frame rate for normal video is 30 frames per second.

Hippocampus A brain region that (among other functions), plays a critical role in learning and memory, especially spatial learning.

Historical contingency Evolutionary changes in a characteristic are dependent on what is inherited from evolutionary ancestors and the extent to which a characteristic diverges from that historic phenotype in response to selection.

Holarctic The northern continents of the world.

Holometabolous Insects that undergo complete metamorphosis involving four life stages: egg, larva, pupa, and adult.

Homeostasis The ability of or tendency for an organism or a cell to maintain ideal internal equilibrium by adjusting its physiological processes.

Homeostatic sleep regulation A sleep regulatory mechanism that aims to keep sleep amounts unchanged over a certain period of time; for example, after an overnight sleep loss, the activation of homeostatic sleep-promoting mechanisms induces sleepiness and compensatory increases in sleep next day.

Home range The geographic space that an individual or group utilizes over the course of a year or longer.

Homing The ability of an animal to return to its specific territory, or home range.

Hominization The process of human evolution. Humans (*Homo sapiens*) are a member of Hominoids, that is a group of primates, which include humans, chimpanzees, gorillas, orangutans, and gibbons.

Homolog A gene that shares ancestry, and hence DNA sequence composition with a gene from another species.

Homology Biological similarity due to ancestry. For example, bat wings and mammalian forelegs are homologous.

Homoplasy Biological similarity not due to ancestry, such as convergence or parallelism, for example bat wings and insect wings.

Honest signal A structure or behavior that conveys reliable information to a receiver.

Horizontal social influence Social influence on behavior that occurs within a generational cohort; for example, among juveniles.

Hormone A chemical signal produced by one gland or tissue in the body that influences the physiology of a remote tissue.

Host An organism harboring another parasitic organism that provides nourishment and shelter for the developing parasite.

Host plant A plant species naturally used by a herbivore for its life activities.

Host range The suite of host plant species used by a herbivore.

Host record Documentation from field observation that a particular herbivore naturally uses a particular plant as a host.

Host shift An evolutionary change by a herbivore lineage from using one host plant to using another; implies the abandonment of the ancestral host.

HPG axis Hypothalamo–pituitary–gonadal axis.

Hybridization Nucleic acid hybridization, the annealing, or binding, of two complementary, single-stranded, nucleic acid molecules.

Hybrid vigor The tendency of a crossbred individual to show qualities superior to those of both parents.

Hydrozoan A class of cnidarians that includes colonial polyps such as *Hydractinia*, individual polyps such as *Hydra*, and a diverse array of jellyfish with complex life cycles that include an attached polypoid and swimming medusoid phase.

Hyperosmolarity An abnormally high osmolarity. The osmotic concentration of a solution, normally expressed as osmoles of solute per liter of solution.

Hyperparasitoids A type of parasitoid that uses other parasitoids as host insects (also known as secondary parasitoids).

Hyperphagia Seasonal occurrence of excess eating to build up fat reserves.

Hyperpolarization A change in a nerve cell's membrane potential that makes it more negative.

Hypertrophy Growth and enlargement of tissues and organs without cell division.

Hypokinesia Abnormally slow or diminished movement of an animal.

Hypophysectomy Removal of the pituitary gland.

Hypothalamus A small region in the forebrain, containing various substructures (nuclei, including the arcuate nucleus) that collectively play a role in hunger, satiety, thirst, temperature regulation, hormone release, autonomic control, and circadian rhythms.

Hypothetico-deductive method Hypothesis testing in which a scientific hypothesis could be falsified by a test of a prediction of that hypothesis.

Hypoxia The presence of a low oxygen environment.

Hysteresis The dependence of a physical system's performance on its history, apparent in some emergent collective properties of animal groups. For example, the ability of a group of ants to form a

pheromone recruitment trail may depend on whether it reached its current size by growth from a smaller size or reduction from a larger one.

Hysteria Uncontrollable and potentially violent episodes of extreme nervousness.

Ideal despotic distribution Expected spatial distribution of organisms that have perfect information on the relative quality of all available habitats and current residents of habitats can exclude others from entering.

Ideal free distribution (IFD) Expected spatial distribution of organisms that have perfect information on the relative quality of all available habitats and can move freely among these habitats.

Idiobiont A parasitoid life-history strategy where host development is arrested upon parasitism. Idiobiont parasitoids are typically ectoparasitoids that attack host eggs or pupae.

Imitation The reproduction of the form of a behavior produced by another animal.

Immediate early genes The first genes transcribed in a cell during a response to a stimulus; their protein products regulate the transcription of other genes.

Immigration The arrival of new individuals from elsewhere.

Immunocompetence The ability of the body to produce a normal immune response (i.e., antibody production and/or cell-mediated immunity) following exposure to an antigen, which might be an actual virus itself or an immunization shot. Immunocompetence is the opposite of immunodeficiency or immuno-incompetent or immuno-compromised.

Imposex A form of sexual abnormality in gastropods where male sex organs such as the penis and vas deferens develop in ('imposed upon') a genetic female as a result of exposure to organotin.

Impulsivity A preference for the less delayed outcome.

In situ hybridization A process in which labeled DNA or RNA probes are used to localize specific DNA or RNA sequences in sections of tissue.

In vitro Literally, 'in glass,' meaning a reaction, process, or experiment in a metaphorical test tube rather than in a living organism. As opposed to *in vivo*: Literally, 'in life,' meaning a reaction, process, or experiment in a living organism.

Inadvertent social information Information generated as a by-product of the behavior of other individuals.

Inbreeding Mating among close relatives.

Inclusive fitness Calculated from an individual's own reproductive success plus his/her effects on the

reproductive success of his/her relatives, each one weighted by the appropriate coefficient of relatedness.

Inclusive fitness theory A synonym of kin selection theory emphasizing inclusive fitness.

Independence from irrelevant alternatives Principle of rational choice behavior. It describes the expectation that preference between a pair of options should be independent of the presence of inferior alternatives.

Independent founding Initiation of a new colony by reproductives without the help of workers.

Independent variable A variable that is presumed to affect or control the value of a dependent variable.

Indeterminate growth Growth that is not terminated in contrast to determinate growth that stops once a genetically predetermined structure has completely formed.

Index A signal whose reliability is maintained due to some physical constraint on their performance.

Indicator models A subset of indirect benefit hypotheses proposing that extravagant traits evolve via mate choice because their expression indicates the quality or condition of the bearer, which is assumed to be heritable. A handicap is an example of an indicator mechanism.

Indifference point A set of options between which agents are indifferent; that is, in preference tasks, they choose the options equally.

Indirect benefits Genetic benefits of mate choice that accrue indirectly to the choosing individual in the form of improved genetic quality of its offspring.

Indirect environmental maternal effect Indirect environmental effects occur when the mother's environment influences her own and in turn her offsprings' phenotype. With regard to hormone-mediated maternal effects, differences in the environment the mothers live in result in differences in hormonal signaling to the offspring.

Indirect fitness Indirect fitness is one component of inclusive fitness. The effects of an individual on the fitness of other individuals weighted by their genetic relatedness.

Indirect genetic maternal effect Indirect genetic maternal effects are influences on offspring phenotype due to differences in the genetic background of mothers. With regard to hormone-mediated maternal effects, genetic differences between mothers would result in, for example, the expression of certain genes that regulate hormone secretion.

Indirect reciprocity An observer C witnesses an altruistic act by A toward B, and as a result, cooperates with A in the future.

Individual comparison Direct comparison of two or more options by a single animal, allowing it to determine which option is best. Individual comparison is not necessary for a

collective decision, which can emerge from interactions among individuals who have each assessed only some of the available options.

Individual- or agent-based models Computer simulations which can be used to describe and predict the global (group or population) consequences of the local interactions of individuals.

Individual recognition The ability to learn the phenotypes of other individuals in a population and to use that information to shape individual-specific behavioral responses during interactions.

Induced ovulation Occurs when ovulation is tied directly to copulation or some other stimulus associated with copulation. It may have evolved as a guard against forced or coerced copulation.

Inducible defenses Defenses that occur only when predators are present.

Induction of preference When past experience with a plant increases the degree of preference for that plant relative to others.

Inequity aversion An aversion to unequal distributions of resources.

Infanticide Killing a young, relatively defenseless, member of the same species.

Infectious coryza Acute or subacute bacterial respiratory infection in chicken, pheasant, and guinea fowl caused by *Avibacterium paragallinarum*.

Inference (In the field of *logic*) The act of passing from one proposition, statement, or judgment considered as true to another the truth of which is believed to follow from that of the former.

Inference by exclusion Choice of an undefined stimulus (i.e., a stimulus that does not already have a learned association with a category) over a defined one (i.e., a stimulus that is already associated) by excluding (logically rejecting) the latter, which leads to the emergence of an untrained association between the undefined stimulus and the category.

Inferential reasoning The ability to associate a visible and an imagined event.

Inferior colliculus The midbrain auditory nucleus where the projections from most lower centers converge and are integrated. The inferior colliculus is the nexus of the auditory system.

Infinitesimal model A genetic model in which it is assumed that traits are determined by a large (infinite) number of loci, each with a very small (infinitesimal) effect.

Inflorescence A group or cluster of flowers arranged on a stem.

Information Data that, when acquired, reduces an animal's uncertainty about environmental or social conditions. A quantity in the mathematical theory of communication expressed in bits.

Information sharing A foraging system in which all group members are instantly informed of each other's food discoveries as they search for their own food.

Information transferred The average variety conveyed by a communicative act, less than or (commonly) equal to the entropy.

Initial phase The first sexual phenotype seen in many protogynous species, often characterized by relatively drab colors and relatively low displays of aggression and courtship behavior.

Inka cell Endocrine cells near the insect spiracles that secrete pre-ecdysis-triggering hormone and ecdysis-triggering hormone.

Innate behavior A behavior that is not learnt, but inherited.

Innovation (sensu process) A process that introduces novel behavioral variants into a population's repertoire and results in new or modified learned behavior. The introduction of a novel behavior by social learning is not considered innovation.

Innovation (sensu product) A new or modified learned behavior not previously found in the population.

Insectivorous A diet of mainly insects.

Insemination Occurs when males ejaculate inside the copulatory organ of a female.

Insight The view that problem solving occurs by sudden recognition of a solution, or 'ah-ha' experience, rather than by trial-and-error learning. It is characterized by a sudden shift in behavior with a smooth and error-free transformation, a shift before the reward is obtained, long-term retention, transfer to other, similar problems, and to appear based on a perceptual restructuring of the problem.

Instantaneous (point) sampling Observational method in which an observer records behavior of an individual at preset intervals.

Instar The growth stage between two successive molts.

Insulin resistance A state in which fat cells and muscle become insensitive to insulin's signal to take up glucose from the circulation, thereby producing high blood glucose levels (hyperglycemia). This is often seen in obesity and can be a precursor to diabetes.

Integument All components of the outer layer of an organism – includes skin, hair, feathers, scales, nails, horns, wattles, warts, etc.

Interaural time difference When sound comes from one side of the body, it reaches one ear before the other. This creates an interaural time difference (ITD) which is used to localize sound in the horizontal plane. When the ITD is zero, the source appears at the midpoint between the ears. When ITD is varied, the source shifts toward the ear at which the signal arrives earlier. ITDs depend upon head size and in some cases on an interaural canal. In general, animals with large heads have larger time differences available to them.

Interference A reversible decline in fitness with increasing competitor density.

Interleukin-1 This is one of the earliest described endogenous pyrogens or cytokines. IL-1 is also known as lymphocyte activating factor and mononuclear cell factor. IL-1 is actually composed of two distinct proteins, IL-1 α and IL-1 β .

Intermediate host A host which is used by a parasite during its life cycle, in which it may multiply asexually but not sexually.

Internal validity Suitability of the study design to answer the question. The extent to which an effect seen in a study can be attributed to a specific cause.

Interneuron A neuron which connects neurons to other neurons in neural circuitries and whose cell body lies in the CNS.

Interobserver reliability The extent to which two or more observers consistently score behavior in the same way.

Interommatidial angle The angle between the viewing directions of two neighboring ommatidia in compound eyes.

Intersex An individual carrying the sexual characteristics of both sexes.

Intersexual selection Selection arising from variance in mating success due to interactions between males and females, such as female preference for males with a particular trait or resource.

Interspecific competition Competition between individuals of two different species.

Intertemporal choice A choice between outcomes that yield benefits at different points in time.

Intimidation A type of male aggressive response to females' refusals to mate. It may increase the likelihood that a female will mate with a male in the future.

Intracellular fluid One of the major fluid compartments of the body comprising all fluid within cells.

Intracerebroventricular administration Injection of a substance into one of the cerebral ventricles. Drugs and hormones injected this route have a relatively direct access to the brain tissue.

Intraguild predation An interaction in which predator and prey compete for basal resources (e.g., top predators eating mesopredators as well as smaller prey eaten by mesopredators).

Intralocus sexual conflict A form of genomic conflict that occurs when males and females differ in their fitness optima for a shared trait that is coded by the same locus or set of loci. Intralocus sexual conflict arises from intrasexual genetic correlations that constrain sex-specific expression of the shared trait and it is resolved by the evolution of sex-linked inheritance or sex-limited gene expression and the subsequent evolution of sexual dimorphism.

Intraobserver reliability The extent to which an observer consistently scores behavior in the same way at successful time intervals.

Intrasexual selection An evolutionary process that favors traits which improve an individual's competitive ability against members of the same sex for access to mates. Selection arising from variance in mating success due to competitive interactions within one sex, such as male-male combat or territory defense for access to females.

Intrinsic isolation Low fitness of hybrids because of genetic incompatibilities.

Intrinsic markers Genetic material, stable isotopes, or other markers that are carried within the animal itself and require only a single capture to yield data.

Intromittant organs Male copulatory organs, which deposit sperm and other seminal fluids into the female reproductive tracts. In mammals, a very few birds (only 3% of species), lizards, and snakes, males have an intromittant organ called 'a penis.' In insects, a male's intromittant organ is called 'an eadeagus.'

Introspection Self-observation based on private mental processes; often thought to be limited to consideration of one's own conscious thoughts, feelings, and perceptions.

Invariant feature A feature (quantity or property or function) that remains unchanged under a transformation.

Invasion In migration studies, the same as irruption. More generally, the colonization of an area by a species formerly absent there.

Invasive species A nonnative species that spreads rapidly once established, with the potential to cause economic or environmental harm.

Inverse square law A mathematical formula describing the attenuation of sound as it propagates through an ideal environment. By the inverse square law, sound amplitude decreases by 6 dB per doubling of distance.

Ionospheric circulation Large-scale convection in the inner magnetosphere and the conjugated ionosphere.

Irruption In migration studies, a massive immigration to a particular region. More generally, a form of migration in which the proportions of individuals that participate, and the distances they travel, vary greatly from year to year.

Isodar The set of points on a plot of density of one species in different habitats at which the fitness payoffs for choosing between habitats are equal.

Isogamy Refers to eggs and sperm that are similar, or approximately more similar, in size than is usually the case.

Isoleg The set of points on a plot of densities of different species at which the fitness payoffs for using both (or multiple) habitats and using only one habitat are equal.

Isoleume A level of constant light intensity in the water column that is commonly represented as a line of points on a plot.

Iterated game Contestants play a game such as the prisoner's dilemma many times, thus allowing a strategy to be contingent on past moves.

Iteroparity The repeated or iterated cycles of reproduction, production of young, throughout the life cycle of an organism before it succumbs.

Jack In salmon, a male that matures precociously and typically does not spend any time at sea; jacks are typically much smaller.

Juvenile hormone A sesquiterpenoid insect hormone known to regulate many functions across insect taxa, including larval development, reproduction, and behavior.

Kairomone Chemical signal molecule that is produced by one species and perceived by another species, resulting in altered physiology or behavior in the species perceiving the cue that benefits that species.

Kappa coefficient An index of concordance that measures agreement between two observers in behavioral observation, taking into account the probability of agreement by chance alone.

Kendall's coefficient of concordance A nonparametric method for measuring agreement among more than two observers in behavioral observation.

Kinematics The characterization of a behavior in terms of the movements of the body. Most commonly, such studies involve a frame-by-frame analysis of films or videotapes of the behavior. Kinematic studies are often carried out to determine which muscles produce the movements underlying a behavior, so they are often accompanied by recording the tension or electrical activity generated by active muscles.

Kinesis Behavior in which the organism does not move in a particular direction with reference to a stimulus but instead simply moves at an increasing or decreasing rate, or rate or turning, until it ends up farther from or closer to the object. (Contrast with taxis.)

Kinocilium A special structure on the apex of hair cells located in the sensory epithelium of various vertebrate sensory receptors including electroreceptors.

Kin recognition The ability to discriminate kin from nonkin, or the ability to make discriminations among kin based on degree of relatedness.

Kin selection The process of selection as it acts through effects on relatives. Sometimes viewed as co-extensive with inclusive fitness, but sometimes viewed as excluding green-beard effects. See Hamilton's Rule.

Kleptoparasitic spiders Spiders that live in webs of other species and steal prey from the host.

Koinobiont A parasitoid life-history strategy where hosts continue to grow and develop after parasitism.

Labellum Bottom part of the proboscis in flies, equipped with fine grooves to assist ingestion of liquid food.

Lag-sequential analysis Method used for the identification of the most likely sequences of successive events appearing in a time series.

Lairage European term for the stockyards that hold animals at a slaughter plant.

Larviposition The act of depositing living larvae instead of eggs.

Larynx A musculoskeletal structure that functions as a vocal organ among amphibians, reptiles, and mammals.

Laser ablation In biology, a process of killing cells by irradiating them with a laser beam.

Latency The amount of time until a behavior occurs. The delay between the onset of the stimulus and the beginning of the response (neural or behavioral).

Leaf swallowing The slow and deliberate swallowing, one at a time without chewing, of whole leaves that are folded between tongue and palate, and pass through the gastrointestinal tract visibly unchanged. The behavior is known to occur in apes, some monkey species, other mammals and some birds.

Leapfrog migration Where northern wintering populations breed in the southern portions of the breeding range and southern wintering populations breed in the northern parts of the range.

Leghorn Breed of egg-type chickens that produce white-shelled eggs; named after the city of Leghorn, Italy, where they are considered to have originated; leghorns have provided the genetic foundation of most modern egg-type chicken strains.

Leishmaniasis Caused by protozoan parasites in the genus *Leishmania* that are transmitted by sandflies. They can affect the skin, mucus membranes, or internal organs.

Lek Is an aggregation or cluster of male territories into arenas used for attracting, courting, and mating with females. Males that form leks provide only sperm and no other resource to the females. No lasting bonds are formed and males do not engage in any parental care.

Lek paradox The persistence of strong directional selection for exaggerated sexual ornaments or display despite the apparent lack of benefit for such choice, particularly in lek mating systems.

Lek polygyny A mating system in which individual males mate with multiple females during a breeding season and in which males aggregate at small, nonresource-containing display sites to attract females.

Leptin A type I cytokine secreted by fat cells that regulates food intake. Leptin acts on the brain to signal when the body has sufficient energy stores, thus inhibiting appetite (i.e., it is an 'adipostat'). However, leptin and its receptor are widely expressed, suggesting that leptin is much more than an 'adipostat,' and likely plays diverse roles in animal development.

Levels of organization A complex behavioral system can be broken into a hierarchy of components or networks based on their physical size and functional complexity. Causal influences operate in both a top-down and a bottom-up fashion with one-way causation characterizing the simplest interactions and two-way causation operating across multiple levels. The lowest level of organization for predator recognition is sensory input from the environment, followed by the processing of predator features in a down-stream hierarchical integration of predator features, yielding higher-order predator recognition and mediation of antipredator behavior.

Lexical syntax Structured rules for ordering semantically meaningful sound units such that their ordering carries additional meaning beyond that reflected in the units alone.

Life cycle of chemicals The passage of a compound through the environment beginning with the source of production and release; consideration of the physical/chemical properties and the migration of the chemical in various media including soil, water, and air including the production of metabolites and their activity in living systems.

Life cycle of organisms Consideration of all stages in the life of an individual with ontogeny, maturation, adult, and aging including reproductive strategy and lifespan as well as unique species characteristics.

Life-for-life relatedness Relatedness including a concept of relative sex-specific reproductive value. $\text{Life-for-life relatedness} = \text{Regression relatedness} \times (\text{sex specific reproductive value of the recipient/sex-specific reproductive value of the actor})$.

Life history Characteristics of the growth and development of an organism, such as its length and timing of gestation, maternal dependency, sexual maturity, reproductive period, and lifespan.

Life history stage (LHS) A syndrome of morphological, physiological, and behavioral traits associated with a specific process (e.g., reproduction, nonreproduction).

Life-history traits Features of the life cycle, with particular reference to survival and reproduction (e.g., age at first reproduction, fecundity, etc.)

Lignified When something has been made hard like wood as a result of the internal deposition of *lignin*, a substance related to cellulose that provides rigidity to plant cell walls.

Linear timing The hypothesis that psychological estimates of time are linearly related to physical time.

Linkage A phenomenon whereby two genes are spatially located close to each other on a chromosome so that crossing over rarely occurs between them during meiosis. Thus, two variants in the corresponding genes are said to be in 'linkage disequilibrium' when they tend to be coinherited. If one variant is in a gene that encodes a phenotype, the linked variant acts as a marker. This is the basis for linkage studies.

Lipophilic Having an affinity for, tending to combine with, or capable of, dissolving in lipids (fats).

Lipopolysaccharides (LPS) Large molecules consisting of a lipid and a polysaccharide that are found in the outer membrane of some bacteria. The molecules, referred to as endotoxins, cause the release of endogenous pyrogens that evoke a fever, resulting in sickness behavior in the animals exposed to them. An integral component of Gram-negative bacterial cell walls that induces an acute phase response in most vertebrates.

Local enhancement Attention drawn to the location where another animal is performing a response.

Local mate competition Theory that competition for mates is stronger between related males than between related females, reducing the relative value of males; thus, sex-ratio interests of queens and workers become more closely aligned and female-biased sex ratios are considered optimal for both parties.

Local resource enhancement hypothesis The idea that related females cooperate synergistically to enhance their joint reproduction, increasing the relative value of females; thus, sex ratios should be female-biased.

Locomotor system The way an animal moves from one location to another. In primates, locomotor systems include brachiation, vertical clinging and leaping, quadrupedality, knuckle-walking and bipedality.

Logistic A logistic function or logistic curve is the most common sigmoid curve. The initial stage is approximately exponential; then, as saturation begins, the rate of increase slows and approaches an asymptote.

Log-linear model Model for the analysis of multiway contingency tables. The principle is to first consider all possible associations between a finite set of categorical variables, and then to remove nonsignificant associations.

Longitudinal Correlational research study that involves repeated observations of the same items over long periods of time – often many decades.

Lophotrochozoa A major subdivision of protostome animals that includes molluscs, annelids, bryozoans, brachiopods, and other less conspicuous animal phyla. The group is named for the presence fan-like feeding structures called ‘lophophores’ (in the bryozoans, phoronids, and brachiopods) and trochophore larval stages found in many of the group’s members. The Lophotrochozoa can be contrasted with the other group of protostomes called the ‘Ecdysozoa,’ which includes arthropods, nematodes, and other animal phyla.

Lordosis A female receptive behavior exhibited by many rodents and birds, highlighted by an immobile posture with arched back and raised rump and head.

Lumen The space within the intestinal tube.

Luminance An indicator of brightness.

Luteinizing hormone (LH) Gonadotropin that stimulates gonadal production of steroid hormones and supports gamete production.

Lymphatic filariasis A tropical parasitic disease caused by thread-like filarial nematode worms that live in the lymphatic system and cause lymphedema. The worms are transmitted by mosquitoes.

Lymphocyte This type of white blood cell makes up 25–30% of white blood cells. Lymphocytes are concentrated in central lymphoid organs and tissues, such as the spleen, tonsils, and lymph nodes. Lymphocytes determine the specificity of the immune response to infectious microorganisms. The two broad categories of lymphocytes are the large granular lymphocytes and the small lymphocytes. Large, granular lymphocytes are known as the natural killer cells and the small lymphocytes are the T cells and B cells.

Macrocyst The sexual, diploid stage of the *Dictyostelium* life cycle.

Macroevolution Evolutionary change that is observed as differences between species, genera, or higher taxa.

Macronutrient Those nutrients that are needed by the body in large amounts and potentially can be used as a source of energy (proteins, carbohydrates, and fats).

Macroparasite A parasite that does not multiply inside its definitive host.

Macrophages Literally meaning ‘big eaters,’ in actuality these are white blood cells dwelling within tissues that phagocytose or engulf cellular debris and bacteria.

Macrophytes Aquatic vegetation with roots.

Magnetic compass A compass that provides a direction bearing, or reference, based on the polarity or inclination of the Earth’s magnetic field.

Magnetic inclination angle The angle at which field lines of Earth’s magnetic field intersect the surface of the Earth.

Magnetic intensity The strength of a magnetic field.

Magnetic map A map based on geographic variation in the Earth’s magnetic field, which could be used to determine geographic position.

Magnetite (Fe₃O₄) One of several types of biogenically produced iron oxides. Lustrous black, magnetic mineral, Fe₃O₄. It occurs in crystals of the cubic system. A cubic mineral and member of the *spinel* structure type.

Magnetoreception The sensory detection and use of magnetic fields, particularly the Earth’s magnetic field.

Magnetoreceptor A sensory neuron that transduces magnetic stimuli into a neural (i.e., bioelectric) signal.

Major histocompatibility complex (MHC) A genetic region (containing > 150 genes in humans) that plays an important role in autoimmunity and immune diversity in jawed vertebrates. MHC genes products mediate self/nonself recognition in vertebrate immune systems and are involved in tissue compatibility (histocompatibility).

Male harassment of females A type of coercion that may not be immediately associated with copulation attempts.

Mandibular gland A salivary gland on either side of the mouth, inside the lower jaw, that discharges saliva into the oral cavity.

Mantle Soft extensions of the body wall that in many mollusks secrete a shell. It also forms a cavity that shelters the gills.

Marginal costs The change in costs with a change in behavior. (In economics, marginal is synonymous with the derivative from calculus.)

Marginal value theorem (MVT) A model within optimal foraging theory that predicts whether an animal should continue to exploit a given patch based on its current (marginal) value relative to the expected gain from moving to another patch.

Marker A trait that signals a particular genotype.

Markov chain Stochastic process in which the value taken by a random variable X at time t is explained by the values observed for the same variable at time $t-1$ (first-order model) and possibly at times $t-2$, $t-3$, ... (high-order model). Transition probabilities between different values are summarized as a transition matrix.

Mark-recapture method A method commonly used to estimate population sizes which relies on recording

individually distinctive traits or making individuals, and later using these traits or marks to recognize them in future encounters. In a closed population, the proportion of animals resighted in relation to newly encountered animals allows a calculation of population size. A set of methods for estimating one or more of abundance, survival, and recruitment by recording repeated sightings or captures of animals, some of which are identifiable from marks previously placed on them. Increasingly, natural marks are used, identified from photographs or DNA fingerprinting.

Masculinization A component of the sexual differentiation process during which the capacity to display male-typical behaviors is acquired or enhanced.

Mate A social associate and need not refer to an individual with which one copulates.

Mate assessment Results from the process of evaluating potential mates; mate assessment determines an individual's preference function.

Mate choice The decision made by an individual in selecting a partner for reproduction.

Mate-choice copying A form of nonindependent mate choice whereby an individual chooses the same mate that it previously observed being chosen by another individual.

Maternal effects Nongenetic influences of the mother's phenotype (including behavior) on an individual's phenotype, especially those with evolutionary consequences.

Maternal inheritance Maternal inheritance describes the maternal inheritance of DNA and is distinct from maternal effect.

Maternal rank inheritance The process by which juveniles (e.g., cercopithecine primates, spotted hyenas) attain positions in the dominance hierarchy adjacent to those of their mothers.

Mating system The demographic pattern of breeding individuals within a group.

Matrigene In diploids, the allele inherited from the mother.

Matriline Individuals of two or more generations that are descended from the same female.

Matrotrophic A form of gestation in which the developing offspring take nutrients directly from the mother's blood through specialized embryonic structures throughout the gestation period.

Maxillary palps Sensory structures on the outer surface of the maxillae used for detecting food.

Mechanisms of heredity Ways in which information physical or otherwise – are transferred between generations. Such mechanisms include genes, culture, learning, developmental systems, and epigenetics.

Mechanisms of sexual selection Include behavioral and physiological interactions between individuals, whether male–male, female–female, or male–female that result in within-sex variance in some component of fitness.

Medulla (medulla oblongata) The lower half of the brainstem. It contains the cardiac, respiratory, and vasomotor centers and deals with autonomic functions, such as breathing, heart rate, and blood pressure.

Melanin A pigment that underlies the rusty coloration of the ventral feathers of the barn swallow and many other birds. Melanins are produced endogenously rather than acquired through diet like carotenoid pigments that add red and orange colors to the feathers of many other birds like house finches.

Melanophores A pigment cell that contains melanin.

Melatonin Melatonin is a hormone secreted by the pineal gland. Plasma levels of melatonin are low in the day and high in the night. It enables an organism to detect changes in the seasons because its expression mimics changes in day length.

Memory The retention of information from prior experience.

Memory monitoring The process of tracking or evaluating the contents of one's own memory.

Mental representation The process of internalizing a referent (external stimulus) into specific mental content. The term can also be used to refer to the content itself.

Mental state An unobservable, internal or cognitive representation of 'things' in the world (e.g., the perception of objects), the actions or plans required to interact with those objects (e.g., intentions and desires), and information about those objects' current structure, location, properties, etc. (e.g., knowledge). In theory of mind research, David Premack suggested that there are three important categories of mental states: Perceptual, Motivational, and Informational.

Mental time travel The ability to travel backwards and forwards in the mind's eye in order to reminisce about the past and imagine future scenarios.

Mentalistic psychology An approach in which the scientist attempts to understand the mental life of the animal. One posits experiences in the animal mind that are similar, at least in some respects, to those of human experience.

Mesoconsumer Intermediate consumers (i.e., herbivores and mesopredators).

Mesocosm experiments Experiments that achieve highly controlled manipulations by working at small spatial scales (e.g., experimental plots are a few square meters or smaller and invertebrate consumers often comprise the

highest trophic level). They often test general principles that potentially apply to large spatial scales where experimental tests are logistically more difficult (e.g., large vertebrates in vast landscapes).

Mesopelagic Associated with the midwater oceanic zone between 200 and 1000 m depth, a zone characterized by dim light and a steep persistent thermocline.

Mesopredator A carnivore occupying a mid-trophic level and at risk of predation from carnivores at higher trophic levels.

Message A decodable collection of signals transmitted as a unit; also the meaning of a communication.

Metacognition Thinking about thinking; the ability to reflect on or think about one's own thoughts, feelings, and knowledge.

Metamemory Knowledge of the contents and function of one's own memory; memory monitoring.

Metamorphic climax The final and most rapid phase of morphological change when thyroid activity is at its peak.

Metamorphosis The change in form that occurs during the postembryonic lives of insects as they transition from early feeding stages to the adult reproductive stage.

Metapopulation A group of semi-isolated populations that are linked through exchange of individuals such that the dynamics of each subpopulation are asynchronous. A series of populations connected by dispersal; the dynamics of metapopulations involve extinction and recolonization events.

Methylation The addition of a methyl group to a molecule; in DNA methylation, methyl groups are attached to cytosine residues and can lead to changes in gene expression including gene silencing.

Microarray A series of microscopic spots of DNA that are attached to a solid surface; the microarray is hybridized with cDNA or RNA in order to measure differences in gene expression between two samples.

Microevolution Evolutionary change that takes place within a population. The direct or indirect genetic response to selection or drift.

Microparasite A parasite that reproduces inside its host.

Microsatellites Neutral segments of DNA consisting of repeating base pairs that show a high degree of intra- and inter-specific polymorphism.

Microspectrophotometry Measurement of the spectral composition of light that is reflected or transmitted by materials, at a microscopic scale.

Microvilli Microscopic cellular membranous protrusions that increase the surface area of epithelial cells and are

involved in a wide variety of functions, including absorption and secretion.

Migration A seasonal, usually two-way, movement from one habitat to another to avoid unfavorable climatic conditions and/or to seek more favorable energetic conditions.

Migration syndrome The suite of coadapted morphological, physiological, and life-history traits that enable migration and that is underlain by a genetic complex that controls the development and expression of these traits.

Migratory connectivity Geographic linking of populations between different periods of the annual cycle, including breeding, migration, and wintering.

Miracidium (plural: miracidia) A small free-living larval stage of the Trematoda which swims using cilia and does not feed, relying on glycogen stores to enable it to find and infect the subsequent parasite host, often a mollusc.

Mirror neurons Brain cells that react similarly during one's own motor actions as those observed in others.

Mitochondrial DNA An abundant single-stranded circular DNA molecule occurring in mitochondria and containing a few genes; the control region where DNA replication begins has especially high mutation rates and is valuable for population genetics studies.

Müllerian mimicry Mimicry of body coloration, body patterning, and/or behavior of a toxic prey species by a nontoxic, coexisting species.

Müllerian ring A group of species that are Müllerian mimics and have converged on the same aposematic signal.

Mobbing A coordinated effort by a group (three or more) of prey in response to a predatory attack in which the prey approach, observe, harass, attack, and sometimes injure or kill the predator before it is able to attack.

Modal action pattern An innate, relatively invariant series of behaviors, common to all members of a species, that are dependent on an external signal (sign stimulus) to trigger the sequence. Originally termed 'fixed action pattern,' George Barlow argued that because the motor pattern is not performed identically each time it is elicited 'modal action pattern' would be a more appropriate term for a recognizable motor pattern elicited by a sign stimulus.

Modules Phenotypic units, often occurring in a repeating series that develop more or less independently of each other, which come together to form a larger whole.

Molt The process of shedding the outer covering of the body.

Molt cycles Replacement of skin, hair, feathers, scales, etc. usually is cyclic and occurs during restricted periods called 'molts.' There may be one to several molt cycles each year depending on the species.

Monoamines Important neural signaling molecules characterized by having an amino group connected to an aromatic ring. Important examples include serotonin, dopamine, and norepinephrine.

Monocularly With one eye only.

Monocytes This type of white blood cell changes into a macrophage. While they make up only 3–8% of all white blood cells, monocytes have two important functions related to the immune system; one is to replenish resident tissue macrophages that get used up engulfing bacteria and cell debris and the other is to move quickly to new sites of infection where they then differentiate into a new population of macrophages.

Monodomy An ant colony that occupies a single nest.

Monogamy Mating system in which males and females mate with a single partner during a particular breeding season. This typically reduces variance in mating success in both sexes, thereby limiting the opportunity for sexual selection.

Monogynous (monogyne, monogyny) Colonies having one queen.

Monomorphism Individuals of a prey species which are invariant in a specific trait, for example, color pattern.

Monophagous versus oligophagous versus polyphagous Whether a herbivore uses one versus several versus many plant taxa as hosts.

Moon watching A technique for studying nocturnal migration by observing through a 20–30× telescope birds as they pass before the disc of the moon.

Morgan's Canon States that we should not attribute behavior to higher cognitive abilities if it can be explained in terms of simpler processes.

Mormyrid African, weakly electric fishes of the family Mormyridae.

Morph A discontinuous class of morphological variation.

Morphological caste A mechanism for division of labor in which individuals vary in physical attributes, particularly size, with corresponding differences in the tasks they perform.

Morphological computation The idea that the physical body of an animal, interacting with its environment, can function in a manner that removes the need for direct neural control in the production of adaptive behavior.

Morphology The form, structure, and configuration of an organism. This includes aspects of outward appearance such as coloration as well as the form and structure of internal parts such as bones and organs.

Mosaic evolution The ability of selective pressures to produce independent changes in brain regions.

Mosquito control Many states have programs to control mosquitos, either with chemical spray or by altering habitat,

such as cutting ditches in salt marshes to drain them so there is no habitat for the mosquitos to breed.

Motion parallax Motion parallax is a monocular depth cue that results from motion of the object or observer. Closer objects move farther across the visual field than distant ones.

Motoneuron (or motor neuron) A neuron located in the CNS that project its axon outside the CNS to innervated and control muscles.

Motor imitation Performing an action after seeing another perform that action.

Mucopolysaccharide Class of polysaccharide molecules, also known as 'glycosaminoglycans,' composed of amino sugars chemically linked into repeating units that give a linear unbranched polymeric compound.

Mucosa The innermost layer of the gastrointestinal tract (gut) that surrounds the lumen, or space within the intestinal tube. This layer of epithelial cells, known as *enterocytes*, comes in direct contact with food, and is the primary site of nutrient absorption.

Multifunctional neurons Neurons, particularly interneurons, that are active in – and presumably contribute to – several different behaviors.

Multiharmonic A vocalization with a nearly constant pulse repetition rate or fundamental frequency, and several prominent harmonics.

Multilevel selection theory Also known as levels of selection theory. Describes how variation in fitness can be partitioned into selection at multiple levels (e.g., between and within groups) to provide insight into how selection affects phenotypic evolution. For example, for social evolution, the balance of selection between and within social groups explains the evolution of sociality (note this can equivalently be described in terms of inclusive fitness/kin selection theory).

Multimale groups More or less permanent social groups containing multiple, reproductively active adults of each sex.

Multimodal signal Signals produced in multiple sensory modes or channels at the same time.

Multiple messages When the individual components of multimodal signals each convey distinct information.

Multivalued Having more than two values; communication codes having three or more alternative signals.

Multivariate More than one-variable quantity; communication codes having two or more signals making up a decodable unit.

Mutant screen Organisms are exposed to a mutagenic substance and the offspring of the mutagenized organisms are then screened for mutant phenotypes.

Mutation Any change in DNA sequence, typically caused by errors during DNA replication.

Mutual benefit/mutualism A behavior performed by the actor that contributes to the lifetime fitness benefits of both the actor and recipient (evolutionary biology); mutualism refers to interspecies cooperation (evolutionary biology); a behavior that produces immediate benefits for both actor and recipient (social science).

Mutual gaze Eye-to-eye contact is an important characteristic of early mother–infant relationships. Mothers look into the eyes of their infants, while the infants look back into their mothers.’ This is called ‘mutual gaze.’ It is a truly unique feature shared by humans and chimpanzees.

Mutualism Intra- or interspecific social interactions in which both parties benefit.

Mycophagy Feeding on fungi.

Myelination The development of a myelin sheath around sensory or motor neurones. Myelination improves the conduction speed of nerve impulses, enabling fast reactions and skilled movements to occur.

Narrow-sense sexual selection Variance in fitness due entirely to variation in number of mates. It is often associated with exaggerated traits in males.

Nash equilibrium A combination of strategies for the players of a game in which each player’s strategy is the best response (i.e., one that maximizes expected payoffs) to the other players’ strategies. Equilibrium point in a game at which no player can improve its payoff by changing its tactic unilaterally.

Natal Related to one’s birthplace.

Natal dispersal The movement of an individual from birthplace to breeding place.

Natal homing Tendency for an animal to return to reproduce in the same geographic area where it began life.

Natriorexigenic That which provokes salt intake.

Natural selection Nonrandom differential preservation of traits across generations, leading to changes in the distribution of traits in a population over time.

Nature–nurture controversy Controversy over the relative importance of genetic factors (nature) and the environment (nurture) in the development of behavior. This is now regarded as supplanted by an epigenetic approach to development.

Necessity and sufficiency Criteria required to prove causation; for instance, if a behavior disappears when a specific neuron is killed, that neuron is necessary for the behavior; if stimulation of only that single neuron elicits the behavior, it is sufficient; necessity and sufficiency can occur separately.

Necrophagy (adj. necrophagous) Eating dead and/or decaying insects.

Necrophoresis Movement toward dead organisms.

Nectar corridor A series of populations of flowering plants that permit nectar-feeding bats to migrate from one area to another.

Nectarivore An animal that eats nectar produced by flowering plants.

Negative frequency-dependent selection A type of selection that favors rare polymorphisms in the population. Under this type of selection, the fitness of a given locus is inversely proportional to its prevalence in the population.

Negative punishment The removal of a desirable outcome, or the opportunity for reinforcement, coincident with a behavior such that the future probability of that behavior is decreased.

Negative reinforcement Increasing the future probability of a behavior by the removal of, or a decrease in the intensity of, an aversive stimulus.

Neighborhoods All the groups of individuals that live within one fragment of habitat, more likely to interact with each other than with individuals from other areas; technically called a deme of a population.

Nematocytes The stinging cells of cnidarians. These cells contain organelles called nematocysts, among the most complex intracellular structures known in animals. Nematocysts serve a variety of functions including feeding, defense, and locomotion. Nematocytes are found only in the phylum Cnidaria, although a few other noncnidarian groups possess superficially similar cells.

Nematodes (or roundworms) Phylum of worms with an unsegmented body. Abundant in marine and freshwater habitats, in soil, and as parasites of plants and animals. Nematode species are very difficult to distinguish; over 80 000 have been described, of which over 15 000 are parasitic.

Nematomorpha Commonly known as ‘Horsehair worms’ or ‘Gordian worms,’ parasitic animals that are morphologically and ecologically similar to nematode worms, hence the name. They range in size from 1 cm to 1 meter long, and 1–3 mm in diameter. The adult worms are free living, but the larvae are parasitic on beetles, cockroaches, Orthoptera, and crustaceans. About 326 species are known and a conservative estimate suggests that there may be about 2000 species worldwide.

Neonatal smiling Human newborns are known to smile spontaneously with their eyes closed, a behavior known as ‘neonatal smiling.’

Neophilia A form of nonassociative learning in which novel things become more acceptable.

Neophobia Fear of novelty. A form of nonassociative learning in which novel things become less acceptable.

Neotenic reproductives In termites, wingless reproductives that develop within the natal colony *via* a single molt from any instar after the third larval instar. At this neotenic molt, their gonads grow and they develop some imaginal characters while maintaining an otherwise larval appearance; some characters, like wing pads, may regress. Neotenic reproductives are characterized by the absence of wings and usually by the lack of compound eyes. The cuticle is less sclerotized than in primary reproductives. They are subdivided into: (i) *replacement reproductives* if they develop after the death of the same-sex reproductive of a colony or (ii) *supplementary reproductives* if they develop in addition to other same-sex reproductive(s) already present within a colony.

Neoteny Persistence of juvenile characteristics into adulthood.

Neotropics An ecozone that includes Central and South America, the Mexican lowlands, the Caribbean islands, and southern Florida.

Nepotism The preferential treatment of relatives.

Nervous system maps A physical organization of neurons that corresponds to locations in the external world; analogous to a road map that depicts the locations of the real roads; can be sensory as in the mapping of touch sensation onto a body representation in the primate cortex or can be motor.

Nest defense Behavior by a parent that reduces the probability that a potential predator will hurt the parent's offspring; the parent may incur some cost of defense, including increased probability of injury or death.

Neural tracer Any substance that, when injected into brain tissue, is taken up by one part of a neuron and is transported to another part and can be used, therefore, to determine connections among brain regions.

Neuroendocrine General interactions between the nervous and endocrine systems; specific production of endocrine signaling molecules by neurons.

Neurohemal organ The enlarged endings of neurosecretory neurons that serve as a distinct storage and release site.

Neurohormone A hormone that is released into the blood from a neuron rather than from endocrine tissue.

Neuromast Functional unit of the lateral line, consisting of a cluster of hair cells with surrounding support cells, and an overlying gelatinous mass called 'a cupula.'

Neuromodulator A chemical messenger, typically a peptide, which is released from presynaptic terminals and acts on the postsynaptic membrane to modulate the responsiveness of the postsynaptic cells to the effects of the neurotransmitter.

Neuro-muscular junction Synapse between the motor neuron terminals and the muscle. In vertebrates, the signal passes through the neuromuscular junction via the neurotransmitter acetylcholine. In invertebrates, the transmitter is Glutamate.

Neuropeptide Peptides found in neural tissue acting as chemical signals to communicate information (such as endorphins, or some hormones like oxytocin and vasopressin).

Neurosteroids Some regions of the brain, especially those involved in territorial aggression, express all the enzymes needed to synthesize sex steroids such as testosterone and estradiol-17beta *de novo* from cholesterol. These neurosteroids are thought to act locally on neurons associated with aggressive behavior.

Neurotoxin A toxin that acts specifically on neurons usually but not exclusively by interacting with membrane proteins such as ion channels.

Neurotransmitter Chemicals (monoamines, ions, gases, hormones) that relay and modulate signals between a presynaptic neuron and a postsynaptic cell.

New York epigeneticists A group of animal psychologists that developed around T. C. Schneirla and was located primarily at the American Museum of Natural History and the Institute of Animal Behavior. They generally favored nurture over nature and a 'levels' view of evolution according to which only very limited generalizations can be made across well-defined taxonomic levels.

Niche conservatism Closely related species tending to occupy similar environments.

Niche displacement The removal of a species from its ecological and functional space in the environment. It is most often caused by a natural catastrophe, or by interspecific interactions like predation, competition, or mating interference.

Niche (ecological niche) The features of the environment that characterize an organism's position in the ecosystem, such as diet, preferred habitat, location within the habitat, and activity pattern. The ecological role of a species in an ecosystem encompassing abiotic, biotic, and geographical dimensions.

Nocturnal Active at night.

Nomenclature As subdiscipline of taxonomy, it is the naming of taxa, including species and higher level groups. In phylogenetic systematics, nomenclature must be tied to phylogeny. Formal rules governing the naming of animals are codified by the International Code of Zoological Nomenclature (ICZN).

Nonconsumptive effects The effect of a predator's presence on the survival and reproduction of prey, not due to direct killing. In essence, nonconsumptive effects are the costs of antipredator behavior.

Nonelemental learning Associative forms of learning in which individual events are ambiguous and only logical combinations of them can be used to solve a discrimination problem.

Nongenomic effects of steroids Effects of steroids on behavior or physiological responses that are not mediated by their binding to their well-characterized cognate intracellular receptors that normally results in a change in gene transcription. These effects are rather thought to come about via an interaction of the steroid with the cell membrane including the binding to membrane receptors of various sorts. These nongenomic effects are observed with much shorter latencies than the traditional genomic effects and by definition do not involve the induction of their biological effects via changes in gene transcription but via changes in protein state and second messenger systems.

Nonlinear timing The hypothesis that psychological estimates of time are nonlinearly related to physical time.

Nonrapid-eye-movement sleep One of the two basic forms of sleep in mammals and birds; in adult humans, it constitutes about 75% of total sleep time. It is characterized by high-amplitude, low-frequency brain waves, suppressed muscle tone, and decreased metabolic rate.

Nonredundant signals When component modes in a multimodal signal contain distinctly different kinds of information, indicated by different responses of receivers to each mode.

Norm enforcement The infliction of harm (including gossip, shunning, and ostracism as well as physical harm) on another individual for violations of social rules and conventions (social science).

Novelty response Sudden acceleration of the rate of EOD emitted by a pulse-type electric fish caused by the sudden appearance of a novel sensory stimulus of any modality.

Noxious Harmful or poisonous.

Nuclear species A species that plays an important role in the formation and maintenance of a mixed-species group, usually leading the group.

Numerical ratio effect When comparing a set of numerical values, one's ability to discriminate the values is based on both their magnitude and the difference between them (also known as Weber's law).

Nymph Generally, a nymph is the juvenile stage of any hemimetabolous insect; it appears similar to an adult except it is smaller and lacks wing structures and developed reproductive organs. In termites, it refers to the preadult instars that perform nonreproductive tasks in the nest. However, since they are juveniles, they can later develop into either reproductive members of the colony or into sterile adult workers. Sometimes, this term is used interchangeably with larvae; however, there is some contention to this dichotomy.

Object Something perceptible by one or more of the senses, especially by vision or touch; also a focus of attention, feeling, thought, or action.

Object movement reenactment Reproducing the movement of an object manipulated by another animal.

Obligate Applies to organisms that have to behave in a particular way to survive and whose behavior is innate. More specifically, individual obligate migrants migrate every year, and do not have the option of migrating or not, their behavior being genetically fixed.

Observational conditioning Facilitation of the acquisition of a response due to the association between an object and secondary reinforcement (the observation of the other animal making contact with the object and obtaining a reinforcer).

Occasion setting A learning situation in which a stimulus, the occasion setter, sets the occasion for when or where a predictive relationship applies. Contextual learning is closely related to occasion setting.

Occipital nerves One or more nerves that originate in the brain and exit the posterior end of the skull through a foramen to innervate muscles that develop from occipital somites; considered a homolog of the hypoglossal nerve of tetrapods.

Occipital somites Embryonic segments of mesoderm in all developing vertebrates that give rise to several skeletal muscles in the head including vocal/sonic muscles associated with the larynx, syrinx, and swimbladder.

Octavolateralis system The group of sensory systems related to the eighth, and lateral line cranial nerves. It includes the sense organs of the inner ear, the lateral line, and the electrosense.

Octopamine A neurotransmitter found in the CNS and elsewhere in all major classes of invertebrates. Its vertebrate equivalent is considered to be noradrenaline. It has been suggested that it plays a crucial role in the flight or flight reaction in insects. In particular, OA has been suspected of having a general effect on insect arousal.

Odiferous Producing a pungent smell, often unpleasant.

Odometry The measurement of distance traveled.

Odorant receptor A protein molecule situated on the membrane of the sensory neuron that recognize a particular odorant (or a class of similar odorants).

Offspring viability A measure of the relative health of offspring and/or their survival probability.

Offspring viability selection Occurs when variation in the number of offspring surviving to reproductive age (productivity) differs between constrained and unconstrained parents.

Oil droplets Lipid globules located in the inner segment of the cone photoreceptor of many birds and reptiles that filter light at different wavelengths and decrease the overlap in sensitivity between cones.

Olfaction Sense of smell.

Omnivorous A diversified diet of plant and animal materials.

One-way migration Movement of an organism from a location where it develops to where it breeds without returning to the natal habitat before succumbing.

One-zero sampling A time sample that produces a proportion of periods in which the behavior occurred.

Ontogeny The development of an organism from fertilization through maturity and adulthood, also used to refer to the development of a particular trait over the same time.

Oocyst A zygote stage in the sporozoan life cycle that sporulates to form sporozoites.

Oogenesis Production of eggs.

Oogenesis-flight syndrome A kind of migration syndrome described by C. G. Johnson, and found in many insects, in which migratory activity is limited to the brief period of sexual immaturity of the adult stage that immediately follows metamorphosis to the adult form.

Ootheca An egg case; in cockroaches, a double row of eggs enclosed by a protective outer shell.

Opaque imitation A form of imitation in which the observer cannot see its own reproduction of the behavior that is observed (e.g., imitating a demonstrator who places his hand on his head).

Open diffusion An experimental design for studying the social diffusion of information, in which one or more individuals proficient in a novel action pattern is introduced into, or reunited with, a group of individuals and the potential spread of the action tracked.

Operant conditioning Associative forms of learning in which an individual learns the consequences of its own behavior. It is a form of conditioning in which the desired behavior or increasingly closer approximations to it are followed by a rewarding or reinforcing stimulus.

Operational sex ratio (OSR) The sex ratio among individuals ready to mate (i.e., being in operation).

Opportunistic breeder An organism that can breed at any time of year, as long as specific environmental conditions exist (can thus also be a continuous breeder under correct circumstances).

Opportunistic foragers Animals that feed on whatever is available, and can make use of new and novel food sources.

Opportunity cost The cost of choosing one option and foregoing the opportunity associated with another option.

Opportunity for selection The upper bound on the rate of evolutionary change in the mean of all phenotypes in a population, which is equal to the variance in relative fitness among members of the population divided by the squared average in fitness of those individuals.

Opsin The membrane-bound G-protein-coupled receptor protein found in photoreceptors in the retina, which when combined to the chromophore, forms a visual pigment.

Optic lobe The portion of the insect brain that processes visual input.

Optic tectum A portion of the vertebrate midbrain, which processes sensory information from the eyes. In mammals, the optic tectum is called 'the superior colliculus.'

Optimal foraging theory A body of theory that predicts behavior relative to maximizing or minimizing one or a set of goals.

Optimal group size A group size for which the net benefits of group members are at a maximum.

Optimality The cost-benefit approach has been extended to model when the benefit-to-cost ratio is maximized so that an individual should maximize the benefit of the behavior while simultaneously minimizing any costs associated with the behavior.

Optimal outbreeding Mating with animals that share, due to identity by descent, favorable gene combinations, while avoiding matings with first or second degree relatives (parents, sibs, offspring) that might expose deleterious lethal genetic combinations.

Optimization and trade-offs *Optimization* is a mathematical concept in which a function is either minimized or maximized given a restricted set of alternative inputs into the function. In behavioral ecology, it applies to predicting or interpreting behavioral decisions that maximize net fitness (e.g., lifetime reproductive success) in the face of conflicting demands, such as avoiding predation, which reduces feeding rates, and foraging, which increases exposure and risk of death by predation. *Trade-offs* are the outcomes of these decisions, such as greater safety at the cost of poorer energy stores or better energy stores at the cost of higher predation risk.

Optomotor response Innate behavior used to stabilize a moving image through movements of the eyes, head, or body.

Organizational effects Permanent changes in morphology, physiology, and/or neural circuitry dependent on hormone exposure during development.

Oropharynx Region including the oral cavity and pharynx.

Ortholog A similar gene in different species, thought to be derived from a common ancestor.

Oscillator An oscillator is a process that repeats periodically.

Osmoregulation The homeostatic control (see homeostasis) of osmotic potential or water potential, resulting in the maintenance of a constant volume of body fluids.

Otolith Also known as ‘ear stones,’ these calcium carbonate structures are attached to the sensory epithelium of subdivisions of the vertebrate inner ear that are known as the lagena, saccule, and utricle. Each subdivision may serve either a vestibular (balance) and/or an auditory (hearing) function.

Oviposition Egg-laying.

Ovipositor The valved egg-laying apparatus of a female insect.

Ovipositor valve The blade-like paired structures comprising the ovipositor shaft.

Oxytocin A peptide produced almost exclusively within the hypothalamus that is released from the posterior pituitary and from neural projections to numerous intra- and extrahypothalamic brain sites. Involved in milk-let-down, mother–offspring, and pair-bond formation in females, and contraction of nonstriated muscles for example during parturition.

Paedomorphosis Reproductive maturity is attained while in a larval or branchiate form.

Pain An aversive sensation and a feeling associated with actual or potential tissue damage.

Pair bond The temporary or permanent association formed between a female and male, potentially leading to breeding.

Palps Lateral mouthparts of invertebrates.

Panmictic (panmixia) When mating between individuals in a population occurs randomly.

Pan-pipes A device designed to present a naturalistic challenge to a tool-using animal such as the chimpanzee (*Pan*). A blockage in the upper of two pipes traps a food item. In social learning experiments, the blockage is released by using the tool in either of two quite different ways, the spread of which through social learning can thus later be objectively recorded (see Whiten et al., 2005).

Paracellular solvent drag Movement of small molecules from interior of intestine (*lumen*) to circulatory fluids by passing between *enterocyte* epithelial cells of small intestine.

Paracrine agent A chemical messenger that is released into the extracellular fluid and diffuses to and acts on adjacent target cells without entering the systemic circulation.

Paradigm A combination of methods used to investigate problems, or an overall model of scientific conclusions regarding a given subject (e.g., how a contaminant affects the behavior of an animal, including humans).

Paralog A gene that duplicated from an ancestral gene.

Parasite Something that lives in, with, or on another organism (the host) and obtains benefits from that organism. A parasite is detrimental to the host in varying degrees.

Parasite manipulation The ability, shared by several parasite groups, to modify their hosts’ behavior to their own advantage, generally through increased probability of transmission in parasitic cycles.

Parasite propagules Life-cycle stages which enable dispersion, transmission between hosts and from which new organisms can develop.

Parasitic wasps A number of families of wasps which lay their eggs inside or outside of the larvae, pupae, or adult-host arthropods. The eggs hatch and the wasp’s larvae feed inside the host eventually killing it. The wasp’s larvae then pupate inside the host and emerge as adult wasps.

Parasitoid An organism that spends a significant portion of its life history attached to or within a single host organism that it ultimately kills.

Parasocial route Social grouping that originates in aggregations of individuals, usually around a rich resource.

Parathyroid glands Small endocrine glands in the neck which are involved in calcium homeostasis.

Parentage analysis Are studies or experiments that allow the investigator to determine the parents of any given individual offspring. In modern times, this is done using molecular techniques involving DNA analyses using mostly microsatellites.

Parental distraction display Any behavior by a parent that reduces the probability that a predator will harm the parent’s offspring by means of drawing the predator’s attention away from the offspring; may take the form of feigning injury, tail-flagging, explosive flight, or erratic or conspicuous running.

Parental investment (PI) Any investment by a parent that increases offspring fitness, at the cost of investing in other offspring.

Parental manipulation Proposes that offspring helping behavior, a fundamental characteristic of the evolution of eusociality, arises as a result of parents influencing offspring development and condition.

Parent–offspring conflict The disparity in selective pressures arising because optima in parental investment differ between parents and offspring.

Parr A juvenile salmon during the initial freshwater phase of life.

Parsimony The fundamental scientific principle that assumptions (especially process assumptions) need not be inflated beyond what is necessary to explain the phenomenon. In phylogenetics, the optimal tree is one that

summarizes the putative homologies in such a way that as many as possible are retained. That is, homology is maximized, and as a result, the minimum number of evolutionary changes necessary is preferred.

Parthenogenesis Development from an unfertilized egg.

Partial migration A situation in which some birds from a given breeding area migrate away for the nonbreeding season, while others remain in the breeding area year-round.

Passerine A bird belonging to the order Passeriformes, also referred to as 'perching birds.' Songbirds also belong to this group.

Patch A relatively homogeneous area that differs in some way from its surroundings.

Path integration Estimation of the current position relative to a starting location by integrating distances traveled and changes in direction throughout the journey.

Pathogen Any disease-causing agent, especially a microorganism.

Patience A preference for the more delayed outcome.

Patrigene In diploids, the allele inherited from the father.

Pavlovian conditioning This term is used interchangeably with the term 'classical conditioning.' It is a method of learning in which animals have inescapable exposure (one or more times) to an emotionally neutral stimulus, the conditioned stimulus, in temporal association with an innately provocative stimulus, unconditioned stimulus. Because of this association, the conditioned stimulus becomes a predictor of the occurrence of the unconditioned stimulus, and it typically acquires emotionally provocative properties similar to the unconditioned stimulus but at lower intensity.

Payoff matrix A mathematical description of the fitness benefits to one behavioral strategy when it plays other strategies.

PCR Polymerase chain reaction, a chemical reaction that utilizes a polymerase enzyme to replicate a target DNA sequence using primers that bind to the target DNA.

Pearson coefficient A measure of correlation between ordinal or ratio data; can be used as a measure of observer reliability.

Pecking The act of striking with the beak.

Pectoral girdle That part of the skeleton that connects the fins or limbs to the axial skeleton (homologous to the shoulder region in mammals).

Pelage Soft covering of a mammal such as hair, fur, or wool.

Penetrance A genetic term referring to the extent to which the effect of a gene is expressed.

Peptide hormones Small proteins, typically around 100 amino acids or shorter that are released from one tissue and have their action in another. These hormones differ slightly from species to species as the result of evolutionary changes in the DNA sequence, posttranslational processing, etc.

Perception Physical sensation interpreted in the light of experience; as a fundamental means of allowing an organism to process changes in its external environment it depends on, but is not equal, to *sensation* – the detection of a stimulus and the recognition that an event has occurred; it can be viewed as the process whereby sensory stimuli are translated into organized experience. In the human cognitive sciences, perception is the process of attaining *awareness* or understanding of sensory information.

Perception-action mechanism (PAM) Perception of another's state or situation activates neural representations of similar states or situations that the self has experienced.

Perception component The recognition and processing of cues and cue bearers by an evaluator.

Perceptual class A collection of items sharing perceptual properties, that is, arrays of features or elements defined in their own absolute values; thus class membership is solely based on similarity.

Period The amount of time taken to complete one cycle of a sinusoid is its period. Period is the reciprocal of frequency. Low-frequency sounds have long periods and high-frequency sounds have short periods. In chronobiology, period is the time it takes for a full oscillation or rhythm to occur.

Periodogram analysis A type of time series analysis that involves combining average response rate functions assuming different underlying periodic trends. The analysis identifies the underlying periods that minimize errors of prediction.

Perspective taking Being in a position to form a 'mental picture' of what another can see even when you cannot see it directly yourself.

Pesticides A range of chemicals produced to kill insects; many chemical forms exist some of which are endocrine active.

Pet A domestic or tamed animal that is individually identified, kept by a person or persons as a companion, and cared for with affection.

Phagocytosis The cellular consumption or elimination of foreign tissues, cells, or particles.

Phagomimicry Release of a chemical that induces feeding behavior toward the chemical (a false food stimulant) and not the animal that releases it.

Phagostimulant Anything that triggers feeding behavior.

Pharmaceuticals Chemicals produced for the treatment of biomedical conditions.

Pharmacology The science of the properties of drugs and their affects on the body.

Pharynx The part of the neck and throat situated immediately posterior to (behind) the mouth and nasal cavity.

Phase Temporal relationship between two rhythmic processes having the same frequency.

Phase angle Measurement of phase, expressed as the time delay between two rhythmic processes, divided by the length of the common period and multiplied by 360° .

Phase (in locusts-solitarious, gregarious, or transiens) A combination of traits defining morphological, physiological, and behavioral state of a locust.

Phase locking The auditory system uses phase-locked spikes to encode the timing or phase of the auditory signal. Phase-locked neurons fire spikes at, or near, particular phase angles of sinusoidal waveform. Physiological experiments measure this spike phase with respect to the stimulus period. Spike phase is plotted in a period histogram and is used to calculate the statistic vector strength (r). Each spike defines a vector of unit length with a measured phase angle. The vectors characterizing the spikes are plotted on a unit circle and the mean vector calculated. The length of the mean vector provides a measure of the degree of synchronization.

Phase shift A phase shift is a change in the timing, or phase, of an oscillation or rhythm in response to an external cue. A widely used manipulation in the study of biological rhythms. The event that is thought to reset timing (e.g., light-dark cycle in the case of circadian rhythms) is advanced or delayed. Gradual adjustment in response to a phase shift is a characteristic feature of an endogenous oscillator.

Phenology The repetitive sequence of events of the life cycle of plants and animals that are affected by environmental conditions.

Phenomenology One's subjective experience or the experience from the first-person point of view.

Phenotype Any characteristic of an organism that is the result of that individual's genotype and the interaction of the genotype with the environment during development.

Phenotype matching The ability to learn phenotypes of group members, such as littermates, and to extend that knowledge of phenotype to make discriminations among previously unmet animals.

Phenotypic flexibility See phenotypic plasticity.

Phenotypic interface of coevolution The traits that mediate ecological interactions between coevolving species, such as chemical defenses of prey and resistance to those compounds by predators.

Phenotypic plasticity The capacity of an individual organism to produce different phenotypes (morphology, physiology, behavior, etc.) in response to different environmental inputs.

Pheromone A chemical messenger produced by an organism that influences the behavior or physiology of another organism of the same species.

Phi coefficient A measure of correlation between nominal data; can be used as a measure of observer reliability.

Philopatric reproduction Breeding at the natal nest.

Philopatry The tendency of an individual to remain or return to its birthplace.

Phonological syntax Structured rules for constructing sequences of otherwise meaningless sound units.

Phonotaxis Locomotion towards or away from a sound source.

Photic zone The portion of the upper water column with sufficient light for photosynthesis to occur, typically reaches between 50 and 200 m depth in oceanic waters.

Photomechanic infrared receptor A receptor rapidly dissipating infrared energy into a micromechanical event (i.e., a brief increase in internal pressure in the core of the receptor) which is measured by a mechanoreceptor.

Photoperiod Length of day.

Photoperiodism Changes in reproductive physiology and behavior in response to changing day length.

Photorefractoriness A complete shutdown of the hypothalamic-pituitary-gonad axis that terminates the breeding phase.

Photorefractoriness in birds Physiological state in which photoperiodic birds terminate reproduction during long day lengths. Signals the end of the breeding season.

Photorefractoriness in mammals Physiological state in which photoperiodic mammals reactivate the HPG axis after prolonged exposure to short days. Spontaneous gonadal recrudescence occurs and the short days no longer inhibit reproduction.

Phototaxis From photos (light) and taxis (movement). It refers to movement toward or away from a light source (positive or negative phototaxis, respectively).

Phylogenetic Relating to, or based on, evolutionary history.

Phylogenetic signal The extent to which similarities among closely related species, such as the form of communication they use, is dependent on the phylogenetic relationships between those species.

Phylogenetic systematics (also, phylogenetics, cladistics) The particular method of systematics proposed by Willi Hennig. Phylogenetic systematics relies

on two fundamental precepts: (1) only whole character-state transformations, in the form of synapomorphies, count as evidence of relationship; and (2) taxonomic names must be applied only to natural evolutionary groups (i.e., nomenclature is united with phylogeny).

Phylogeny A genealogy of species that reflects their evolutionary relationships.

Physiological psychology The study of mechanisms internal to the animal that affect and are affected by behavior. Included are studies of the nervous system, endocrine function, and other internal processes.

Phytohormones Hormone-like chemicals produced by plants that have structural characteristics that allow them to interact with steroid hormone receptors in vertebrate physiological systems; for example soy phytoestrogens.

Phytophagous Plant eating.

Pied Piper effect The idea (now largely discounted) that in the northern hemisphere, northward movements of insects in the spring are facilitated by favorable winds, but that the progeny of these immigrants are then trapped at high latitudes as winter approaches, leading to mass fatality.

Piloerection This term derives from 'pilo,' meaning hair, and refers to the erection of the hair of the skin. Piloerection starts when a stimulus such as cold or a frightening stimulus causes an involuntary contraction of the small muscles that attach to the base of the hairs deep in the hair follicles. Contraction of these muscles elevates the hair follicles above the rest of the skin so the hairs seem to stand on end.

Planktivorous Feeding primarily on organisms that drift or possess insufficient motor capabilities to overcome currents (plankton).

Plant secondary metabolite See secondary plant compound.

Playback studies 'Playbacks' can be broadly defined as the use of broadcast signals in any sensory modality with an accompanying bioassay to address questions concerning communication and animal behavior.

Pleiotropic (see pleiotropy).

Pleiotropy When a gene affects multiple traits.

Pleometrosis The founding of a eusocial insect colony by several queens.

Poikilothermic Having a body temperature that varies with the temperature of its surroundings.

Point of balance It is a point at the animal's shoulder that handlers can use to control animal movement. When a person stands behind the point of balance, the animal

moves forward. When a person stands in front of the point of balance, the animal backs up.

Policing Repression of selfish or competitive behavior (evolutionary biology); in social insects, inhibition of worker reproduction by aggression or destruction of eggs (evolutionary biology); impartial intervention in conflicts (social science); enforcement of societal norms and laws (social science).

Polyandry One female has a breeding relationship with two or more males. In eusocial insects, a queen that has mated many times.

Polydomy Of colonies having more than one nest each.

Polyembryonic A form of reproductive in which one sexually produced embryo splits into many genetically identical offspring.

Polygamous Having more than one partner or spouse.

Polygenic Where several genes interact to influence a phenotype; each gene may have a varying degree of influence upon the phenotype.

Polygyny (polygynous) Mating system in which some or all males in a population mate with more than one female per breeding season. This typically increases variance in male mating success, thereby generating sexual selection on males. In eusocial insects, a colony that has two or more queens.

Polymorphism The existence of multiple forms within a population or species. The term can refer to morphology or alleles or physiology or behavior or any other kind of trait. In eusocial insects, size or shape variation in the worker caste.

Polymorphous class A class in which no single feature is necessary or sufficient to determine class membership, but several features contribute to this to some degree.

Polyphagy (adj. polyphagous) Eating many kinds of food, for example, many plant species from a range of families.

Polyphenism Within a population, different phenotypes that arise from environmental rather than genetic causes.

Polyspermy When more than one sperm enters the egg during fertilization.

Ponerine ants The Ponerinae is a subfamily of ants (Hymenoptera, Formicidae). Some species within the Ponerinae are queenless, having lost the queen caste. A colony is headed by one or more mated workers that fulfill the queen's role and are sometimes known as gamergates.

Population density The number of individuals within a specified unit of space.

Population dynamics Study of short- and long-term changes in the size and age composition of populations, and the factors influencing those changes.

Porphyropsin All visual pigments whose chromophore is 3,4 dehydroretinal.

Positional cloning A technique used in molecular cloning that utilizes a set of unique genomic elements called 'genetic markers' that flank the gene of interest.

Positive punishment The application of a stimulus immediately after a behavior which results in a reduction in the future probability of that behavior.

Positive reinforcement The application of a stimulus coincident with or immediately after a behavior which results in an increase in the future probability of that behavior.

Postconflict bystander affiliation Postconflict affiliative interaction between a conflict opponent and a bystander uninvolved in the conflict.

Postconflict quadratic affiliation Postconflict affiliation between two bystanders.

Postcopulatory sexual competition The term generally used to refer (somewhat imprecisely) to all events following the initiation of genital coupling.

Postmating-prezygotic isolation Barriers between species or populations that result from mechanisms that prevent zygote formation after mating.

Postzygotic compensatory mechanisms Flexible responses of constrained individuals of either sex that increase the likelihood that already produced zygotes will survive to reproductive age.

Postzygotic isolation Barriers between species or populations that result from low fitness of hybrids.

Potential conflict Differences in the reproductive optima of individuals or groups in a colony. For example, there is potential conflict over male production in a colony of eusocial Hymenoptera as each individual is more related to its own sons (0.5) than to the sons of the mother queen (0.25) or sister workers (full nephews 0.375, half nephews 0.125).

Potential reproductive rate (PRR) Offspring production per unit time when unconstrained by mate availability.

Praying mantis A predatory insect with prominent eyes and an elongated body; in the order Dictyoptera along with the cockroaches and termites.

Precedence effect Psychophysical phenomenon in which two or more stimuli separated by a brief time interval are perceived as a single stimulus originating from the source of the first one.

Precocial Mobile young (usually birds or mammals) that are dependent on parents for food and warmth.

Predation risk theory The framework used to predict or interpret antipredator behavior, risk effects, and the behavioral component of trophic cascades. Fundamental to

it is the assumption that prey maximize fitness (e.g., lifetime reproductive success) by making behavioral decisions that optimize trade-offs between predator avoidance and resource acquisition.

Predation sequence The sequence of events that is necessary for a predator to kill one or more prey individuals, including search, encounter, hunting, and killing. Each of these four stages can include distinct substages.

Predator inspection Alone or in groups, an approach toward a predator to observe and gain information about it that may function to deter attack by advertising that the predator has been detected; the behavior may also advertise ability to incur risk and escape.

Prediction Statement of results of studies that could be performed.

Preening The act of cleaning and trimming the feathers with the beak.

Preference function The order in which an individual ranks potential mates.

Preference hierarchies A ranking indicating the relative degree to which each of a set of alternative plants are preferred by a herbivore.

Premating isolation Barriers between species or populations that result from mechanisms that prevent mating.

Premetamorphosis Stage of amphibian larval development when the animal grows but little or no morphological change occurs; plasma thyroid hormone concentrations are low.

Preoptic area A region of the brain just rostral to the optic chiasma where steroid action plays a key role in the activation of male sexual behavior in many vertebrate species.

Prepubescent Prior to puberty.

Prezygotic compensatory mechanisms Flexible or facultative responses of constrained individuals of either sex that increase the likelihood that their offspring survive to reproductive age.

Price equation A mathematical statement of evolutionary change that partitions selection into a between- and within-group component.

Primary polygyny Polygyny that arises through pleometrosis.

Primary predator-prey behaviors Behaviors concerned with predators encountering prey, or prey avoiding predators, before any attack occurs.

Primary reproductive The winged, founding members of a termite colony. A winged reproductive male and female found a new colony as the primary reproductives.

Primitively eusocial Eusocial society in which all individuals are capable of mating and reproducing, though behaviorally specialized reproductives occur.

Prisoner's dilemma In its simplest form, it is a two-player game in which players decide whether to cooperate (C) or defect (D). The relative sizes of the payoffs define the game, in that mutual cooperation pays more than mutual defection, but defecting while your partner cooperates provides the highest payoff, and cooperating while your partner defects provides the lowest payoff. The game captures both the temptation to defect and the low payoff for being a 'sucker' (cf. the 'tragedy of the commons,' which arises in a multiplayer version of this game).

PRKO Knockout mice lacking a functional progesterone receptor.

Probability matching In the study of foraging behavior, this refers to an animal's tendency to match its proportion of visits to a feeding site with the proportion of times that site produced food.

Probing motor acts (PMA) Characteristic behaviors composed of a series of swimming movements in close proximity to an object under investigation.

Problem-solving The use of novel means to reach a goal when direct means are unavailable.

Proboscis Central trunk-like mouthpart of insects that feed on liquid food.

Proceptivity Feminine behaviors that are evoked by stimuli from the male and which serve to reduce the distance between the female and the male. The extent to which a female initiates mating (i.e., a female's willingness and motivation to mate).

Producer and scrounger Behavioral alternatives for group foragers when a resource, for example, food, is found by one individual, the producer, and then exploited by one or more animals in the group, the scroungers. The term also describes a game theory model that applies to the two alternatives.

Production learning Where a signal is modified in form as a result of experience of the usage of signals by other individuals.

Productivity The number of offspring that survive to reproductive age.

Progesterone Steroid hormone produced mostly in gonads and the brain.

Progressive molt A molt characterizing the gradual development from egg via several instars into an adult. Associated with progressive molts is an increase in body size and morphological development. This is the default developmental program in all hemimetabolous and holometabolous insects.

Progressive provisioning Type of larval provisioning in which the larvae are fed throughout their development. In contrast to mass provisioning, in which all of the food necessary for larval development is amassed before laying an egg.

Prohormone Precursor to the active form of a hormone.

Prometamorphosis Stage of amphibian larval development when metamorphosis begins. Hindlimb growth and development is evident externally. The thyroid gland becomes active and secretes thyroid hormone in response to increasing plasma concentrations of pituitary thyrotropin (TSH).

Propagules Any structure that can give rise to a new individual. This could include sexually or asexually produced zygotes, embryos, larvae, seeds, or fragments or buds.

Propolis Plant resins collected by honeybees and used for sealing gaps and cracks in their nest.

Proprioception The ability to sense the position and location and orientation and movement of the body and its parts.

Prosocial behavior Tendency to help others even if this provides no immediate reward to the self.

Prosociality The tendency to help another in a situation where there are no personal gains, and little or no personal cost.

Prostaglandins Fatty acid hormones, such as PGF2a, that are secreted by the reproductive tract and ovary.

Protandry A sexual pattern in which individuals mature as males and can then later change functional sex to become female.

Proteome The set of proteins expressed by the entire genome of an organism under given environmental conditions at a given time. Proteomics is the large-scale study of the structure and function of this entire set of proteins, generally in a particular cell, tissue-type, or organ (such as the brain).

Prothoracic gland The molting gland of the insect that secretes ecdysone, the precursor of the active form of the molting hormone, 20-hydroxyecdysone.

Protogyny A sexual pattern in which individuals can mature as females and then later change functional sex to become secondary males. In *monandric* ('one male') protogyny, all secondary males first pass through a female stage. In *diandric* ('two males') protogyny, individuals can mature as either males or females and both can change from the initial phase (IP) to become the larger and typically colorful and aggressive terminal phase (TP) males.

Prototype The 'best' or most typical example of a category that corresponds to the average, or central tendency, of all of the exemplars that have been

experienced; it serves as the basis or standard for other members of the same category.

Protozoan Unicellular microorganisms among eukaryotes. Comprises flagellates, ciliates, sporozoans, amoebas, foraminifers.

Proximal Closer to a body midline (opposite of distal).

Proximate causation Explanations of an animal's behavior based on internal and external mediators of behavior including genetic underpinnings, epigenetic forces, maternal effects on physiology, morphology, and development. Questions about proximate causes are sometimes said to be about how animal behavior is expressed or about mechanisms of animal behavior.

Proximate factors External stimuli (such as specific daylengths) which are used as cues by an animal to trigger preparation for breeding, migration, molt, or other events, or as time keepers to set their endogenous time programs at appropriate times of the year.

Pseudergate In termites, an alternative technical term that can be found which distinguishes workers with a flexible development and options for direct reproduction from workers with restricted developmental trajectories. Pseudergates are the 'workers' of many lower termites (including wood-dwelling and foraging species) that have broad developmental options, generally including progressive, stationary, and regressive molts. Current use of this term often lacks the precision of its original definition for individuals that develop regressively from nymphal instars to 'worker' instars without wing buds.

Pseudopregnant Reproductive condition in which a female shows external indicators of pregnancy but is not actually pregnant.

Pseudoreciprocity The act of increasing another individual's fitness to acquire or enhance the by-product benefits obtained from that individual.

Pseudoreplication A statistical error in which interrelated observations or measures are treated as though they are statistically independent.

Psychoneuroimmunology A relatively new field in medicine that explores the ability of the nervous system and psychological states to influence immune defenses, and the ability of the immune system to influence the brain and behavior.

Pterygoid teeth Small teeth on the roof of the mouth.

Ptilochronology The study of growth bands in feathers that indicate condition or problems during feather molt in birds.

PTT A platform transmitter terminal (PTT) sends an ultrahigh frequency (401.650 MHz) signal to satellites.

PTTs are attached to animals in order to track their movements.

Public good A resource that is costly to produce and provides a benefit to all the individuals in the local group. Public goods systems are often open to exploitation by cheats who benefit, but do not pay the cost.

Public information Cues produced by animals that can potentially be used by observer animals in making behavioral decisions.

Pulse repetition rate The rate at which individual sound pulses are produced within a single call.

Punishment A costly behavior that is negatively reciprocal (decreases harmful behavior in the recipient) (evolutionary biology); any stimulus that reduces the frequency of a behavior (social science); behavior correction and the enforcement of social norms, typically by impartial parties; see also Third-party punishment, Policing (social science).

Pupa A life stage in some insects that undergo complete metamorphosis that results in the transition between the larval and adult stage.

Purging selection Mechanisms eliminating deleterious genes from the population.

Pyrophilous insects Species strongly attracted to burning or newly burned areas, and species that have their main occurrence in burned forests 0–3 years after the fire.

Quality of life Well-being; a multidimensional, experiential continuum that comprises an array of affective states, broadly classifiably as relating to the states of comfort–discomfort and pleasure; often equated to welfare and well-being.

Quantitative trait A continuous trait such as body mass that is influenced by many genes and the environment.

Quantitative trait locus (QTL) A region of DNA that is associated with a particular quantitative trait, containing a gene or genes that influence that trait. Quantitative traits typically have continuous distributions rather than discrete states, and are influenced by several or many loci, each with relatively small or large effects on the expression of the trait.

Quasi-experimental design An experimental design where a treatment variable may be manipulated but subjects within groups are not equated or randomly assigned.

Quasiparasitism Occurs when the female that dumps eggs in another female's nest is the resident male's extra-pair partner and her dumping is assisted by that male.

Queen Reproductive female in a eusocial insect society. She is developmentally and/or behaviorally disposed towards performing all reproductive function for a colony.

Questing The behavior of ticks, involving an ascent on vegetation that allows for a maximum exposure of sensory receptors on the forelegs to stimuli from approaching hosts.

Quorum decision A minimum number of individuals required to perform a specific behavior (such as choosing a direction of travel) that results in all of the other members of a group adopting this behavior.

Quorum sensing A rule under which a social group member's execution of a particular act or behavioral transition is conditioned on the presence of a threshold number of fellow group members.

Radiotracking The location and tracking of a radiomarked individual from a signal emitted frequently by the radio.

Rape A legal term and includes other forms of sexual assault as well as forced copulation, including statutory rape, which may appear to be consensual copulation but with a minor; in this case women, not just men, can be rapists.

Rapid-eye-movement sleep The other basic sleep form in mammals and birds. It is often called 'paradoxical sleep' because the brain activity resembles that of the awake brain. It is characterized by the complete inhibition of muscle tone and suppressed autonomic regulation of most homeostatic functions such as thermoregulation and blood pressure.

Rate of return The ratio of the amount of food obtained to the time it took to procure the food.

Rationality A set of consistency principles that decision-makers are expected to follow if they are attempting to maximize some currency such as utility or fitness. Fitness maximization by natural selection is expected to yield rationality, but many instances of irrational choice are known in humans and other animals. Property of individual choice is used both to describe the process of making a choice and to describe the behavioral outcome of choice.

Rayleigh scatter Light scatter by particles smaller than the wavelength of light.

Reaction norm A reaction norm describes the production of a range of phenotypes by a single genotype in response to a range of an environmental parameter. Different genotypes may produce different response trajectories in response to a gradient of an environmental parameter. Reaction norms resemble dose-response curves in physiology, for example the effects of a gradient in hormone concentrations. Dose-response relationships are not necessarily monotonic but can include thresholds or show maximal (minimal) effects at low and high doses or medium doses.

Reasoning A form of logic-based thinking; the cognitive process of looking for reasons for beliefs, conclusions, actions, or feelings.

Receiver psychology Sensory capabilities of the signal receiver that affect the detectability, discriminability, and/or memorability of signals, and play a role in the evolution of signal design.

Receptivity Sexual behaviors that are necessary and sufficient for mating.

Reciprocal altruism Where individual A pays a personal cost to help individual B with the expectation that B will return the favor.

Reciprocal selection Positive feedback between selection by ecological enemies. Natural selection by predators on prey generates the evolution of increased defense, which in turn causes stronger selection by prey on predators to evolve greater exploitative abilities.

Reciprocity Delayed exchange of benefits between parties.

Recognition signals Signals that evolved to make a signaler distinctive.

Recombination In evolutionary algorithms, a process of crossover that combines elements of existing solutions in order to create at the next generation a new solution, with some of the features of each 'parent solution.' It is analogous to biological crossover.

Reconciliation Postconflict affiliative reunion between former opponents that restores their social relationship disturbed by the conflict.

Recruitment Entry of progeny into a population as reproductive adults.

Red queen Based on the quote from Lewis Carroll's Red Queen, 'It takes all the running you can do, to keep in the same place,' this metaphor describes a coevolutionary dynamic where frequencies of traits or genotypes of ecological enemies cycle through time so that as one type becomes common, it is disfavored and a rare type can spread through the population.

Redirected aggression Postconflict aggressive interaction directed from the original recipient of aggression to a bystander uninvolved in the conflict.

Redirected behavior The direction of some behavior, such as an act of aggression, away from the primary target and toward another, inappropriate target.

Redundancy reduction The reduction in the overlap of information encoded by neurons in the nervous system.

Referent The on model on which a signal is based.

Reflectance The ratio of reflected to incident light on a given area (e.g., colored patch in the plumage).

Refraction Change in direction of light caused by alteration of its velocity on obliquely entering a medium of different refractive index.

Refractive index A measure of the speed of light in a medium.

Refractive state The resting refractive state of an animal determines the point at which it is focused without having to expend any accommodative effort.

Regressive molt A molt that is characterized by a decrease in body size and/or regression of morphological development, generally a reduction of wing bud size in nymphal instars. This type of development is unique to termites.

Regularity A specific version of independence from irrelevant alternatives. It describes the expectation that the absolute preference for an option should never be increased by the addition of inferior options to the choice set.

Regurgitant A substance produced in the gut of an insect that is excreted from the mouth as a defensive secretion.

Reinforcement The evolution of premating isolation after secondary contact as a result of selection against hybrids or hybridization.

Reinforcement/supplementation Addition of individuals to an existing population of conspecifics.

Reintroduction An attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct.

Relatedness asymmetries A group of individuals are more closely related with a certain group of individuals than others within a colony.

Relatedness, r Genetic similarity between individuals, in comparison with randomly chosen individuals in the population, that have a mean relatedness of zero by definition.

Relational class A class defined by relations between or among its members and going beyond any perceptual similarities or functional interconnections.

Relative risk An individual's risk of predation given the abundance of its type.

Relaxed selection This occurs when the sources of natural selection engendering physical or behavioral traits that promote fitness diminish markedly or are no longer present in the environment. In the case of predators, prey species might be separated from their former predators by their isolation on islands. In another context, climate change tolerated by prey might diminish contact with their predators that are intolerant to climate change and eventually disappear.

Reliability The percentage of signals of a particular type X that are accurately associated with a stimulus (X').

REMI Restriction enzyme mediated integration (REMI) is an ingenious method of introducing single gene knockouts in a genome in a way that allows one to identify the actual gene that is knocked out. Used in *Dictyostelium*.

Repeatability Consistency between different measurements separated in time of a trait of a certain individual, used in population genetics as the upper limit of heritability.

Repertoire expansion A pattern of temporal polyethism in which workers increase the types of tasks they perform as they age.

Replication Using more than one observation per observational unit or subject per experimental treatment group.

Reproductive age The age at which an individual becomes receptive to mating the first time.

Reproductive character displacement The process of phenotypic evolution in a population caused by cross-species mating and which results in enhanced prezygotic reproductive isolation between sympatric species. Referred to as 'reinforcement' if postzygotic isolation is incomplete.

Reproductive compensation Refers to any flexible response of constrained individuals that increases the likelihood that their offspring will survive to reproductive age.

Reproductive division of labor Differentiation of individuals within a eusocial colony into those capable of reproducing, and functionally or physically sterile workers.

Reproductive effort The proportion of available time, nutrient or energy resources that an adult invests in current reproduction, usually detracting from those available for other functions.

Reproductive groundplan hypothesis (Originally described as ovarian groundplan hypothesis) Proposes that the evolution of eusociality is based on simple evolutionary modification of conserved reproductive and corresponding behavioral cycles so that during the course of social evolution, reproductive and nonreproductive behavioral and physiological components can be separated and used to build reproductive (queen) and nonreproductive (worker) phenotypes.

Reproductive isolation Reduced genetic exchange between populations via reduced interbreeding and lower fitness of hybrid offspring; speciation has occurred when reproductive isolation between populations is complete.

Reproductive skew Asymmetry in the distribution of direct reproduction among individuals within a social group.

Reproductive strategy An organism's relative investment, behaviorally and physiologically, in offspring, including reproduction and parental care.

Reproductive success (RS) Refers to the number of offspring an individual produces which survive and go on to reproduce in the next generation. Although 'life-time reproductive success' is the most accurate measure, logistically it is not always possible to obtain this measure.

Consequently, RS may be measured as number of eggs produced, number of young produced, number of young that fledge from the nest (e.g., birds) or survive to weaning (e.g., mammals), or number of young that survive to reproductive age.

Reproductive suppression A mature individual does not reproduce because of physiological mechanisms that inhibit production of gametes as a direct result of communication with conspecifics.

Reproductive value The expected reproduction of an individual from its current age onward, given that it has survived to that age. It changes with age, increasing at first and declining until death.

Residual reproductive value The number of offspring an individual is expected to produce during its remaining lifespan.

Resource competition A particular form of competition in which members of the same or different species compete for the same resource in an ecosystem (e.g., food, space).

Resource constraint hypothesis (Trivers–Willard effect) Colonies should invest more in the cheaper sex (i.e., males, which are generally smaller than females in Hymenoptera) when resources are limited.

Resource holding potential The relative fighting ability of a contestant.

Response blocking Also called *flooding* – The process of exposing a subject to constant, high levels of a distressing stimulus, while preventing escape from the situation, in an attempt to reduce or extinguish the distress produced by the stimulus.

Retinal disparity Difference between the images projected on the two retinas when looking at an object that serves as a binocular cue for the perception of depth.

Retinoscopy A technique used to obtain an objective measurement of the refractive state of the eye, in which a moving light is shone into an animal's eyes and the relative motion of the reflection is observed.

Reverse genetics A molecule-driven approach to understanding a phenotype.

Rheotaxis Orientation or response to current flow; moving upstream is positive and downstream is negative rheotaxis.

Rhinophores Tentacles in some gastropod mollusks that carry the olfactory organ.

Rhodopsin All visual pigments whose chromophore is retinal, but commonly (although erroneously) used to refer only to rod visual pigments.

$R_{\text{male-male}}$ Androgen responsiveness (i.e., the change in testosterone concentrations) during aggressive interactions between territorial males.

R_{season} Seasonal androgen response, reflecting the increase from breeding baseline testosterone concentrations to maximum concentrations during specific parts of the breeding life-cycle stage, that is, during the phase of territory establishment or mate guarding.

Riparian Interface between terrestrial and aquatic ecosystem. When intact, riparian ecosystems limit soil runoff and are characterized by high biodiversity and thus are an important buffer zone.

Risk effects Nonconsumptive effects of predators on prey, namely the lost foraging opportunities and lower levels of growth and reproduction experienced by prey investing in antipredator behavior (also known as nonlethal effects). This term avoids the complication that prey that are not directly killed by a predator may in fact be consumed.

Risk history The frequency, intensity, and duration of predation risk events experienced by prey in the past.

Risk threshold The level of risk that must be exceeded for the prey to start reducing its antipredator behavior under the risk allocation hypothesis.

Ritualization Communicative behaviors used in social interactions that evolved from other behaviors with different functions. For example, when attacked an ancestor of the wolf might have flattened the ears, crouched, and tucked the tail to avoid injury; over time these behaviors evolved to communicate submission. Evolutionary modification of a motor pattern used in communication that is thought to improve signal function, often through increased stereotypy and exaggeration.

RNA interference (RNAi) A technique of molecular biology in which expression of a particular gene is silenced by introducing double-stranded RNA into a eukaryotic organism. RNA interference can provide conclusive proof that a particular gene influences behavior.

Roosting The act of perching to rest or sleep.

Round-trip migration A subcategory of migration, with seasonal to-and-fro movements between regular breeding and wintering sites, typical of many birds but rare in insects.

RT-PCR Reverse transcription PCR, PCR that is performed on DNA that was synthesized from RNA by a reverse transcriptase enzyme.

Rule learning The ability to infer rule information from a number of different examples connected by a logical operation 'if \rightarrow then.'

Rules of thumb Simple measures that animals can use to approximate solutions to optimal foraging problems. An example would be using the number of prey items encountered to leave patches as predicted by the marginal value theorem.

Runaway selection A theoretical model for the evolution of extravagant traits based on female preference.

The model proposes that female preference for a male trait results in a genetic correlation between preference and trait, such that the trait evolves beyond the level favored by natural selection in a 'runaway' process fuelled by female preference. Also called the Fisher process in reference to Sir Ronald Fisher, who developed the theory.

Sacculus An otolithic subdivision of the inner ear in all vertebrates that has an auditory (hearing) function among many fishes.

Saprophagy Feeding on dead materials.

Satellite transmitters These tracking devices are larger than radio transmitters and emit signals that are detected by geosynchronous satellites; these devices carry substantial batteries or are solar powered and continue to transmit for relatively long periods of time (i.e., a year or more); they enable tracking to occur over substantial geographic distances.

Satiation The feeling of fullness at the end of a meal.

Satiety The persisting sensation of repletion that results from eating.

Scalar timing The dominant theory of timing which assumes that the coefficient of variability (i.e., the standard deviation of time estimates divided by the mean of time estimates) is constant across a broad range of temporal estimates (i.e., a specific proposal of the linear timing hypothesis).

Scale-free power-law A degree distribution described by $p(k) \approx k^{-\gamma}$; demonstrated by a straight line on a log-log plot.

Scan sampling A type of instantaneous sampling in which a group of individuals is scanned at specified intervals and the behavior of each individual at that instant is recorded.

Scanning Often synonymous to vigilance.

Scatter hoarding Hoarding of individual food items in many different locations.

Schistosomiasis (or bilharzias) A disease caused by a blood fluke of the genus *Schistosoma*, a type of flatworm parasite. The intermediate host is a snail, in which cercariae (larvae) develop and migrate out into water; the cercariae penetrate the skin of hosts which make contact with the water. Symptoms depend on species causing infection, but can include rash, fever, aching, cough, diarrhea, and liver and spleen enlargement.

Schnauzenorgan response A twitching movement of the elongated chin (Schnauzenorgan) of *Gnathonemus petersii*, an electric fish, evoked by the sudden emergence of a novel object near the animal's head, which is detected through the active or passive electric sense.

Schreckstoffe Chemical alarm signals released by aquatic injured conspecifics, which is used to warn animals about an imminent danger.

Sclerotized The hardening of tissue.

Scolopidium A multicellular sensory structure of arthropods used to detect stretch, vibration, or sound.

Scout A member of a social group, such as an ant or bee colony, that searches for food sources, nest sites, or other targets of interest. It may exploit its discoveries by itself or recruit other group members to help.

Scramble competition Organisms use up a common limiting resource but otherwise do not contest or harm each other.

Scrounging A behavioral strategy that consists of exploiting a resource uncovered by some other individual's efforts.

Seasonal breeder An organism that breeds only in specific seasons (i.e., not continuously).

Seasonal interaction When events in one period of the annual cycle, such as timing or condition, of an animal to influence events in subsequent periods.

Seasonality Changes in hormonal or behavioral status in response to change in seasons.

Secondary defenses Traits of the prey that influence the action of the predator, subsequent to prey detection, in ways that benefit the prey. Compare with primary defenses that act prior to the predator detecting the prey.

Secondary plant compound Molecules produced by plants, the presence of which is often characteristic of particular plant taxa and which appear not to be directly involved in primary metabolism.

Secondary polygyny Polygyny that arises from monogyny, generally through queen adoption.

Secondary predator-prey behaviors Behaviors concerned with predators capturing prey, or prey escaping from predators, during an attack.

Secondary reproductive These are produced by many termite species; they are sexually capable individuals who do not have wings, and are capable of superceding sick, injured, or absent parental primary reproductives.

Secondary sexual character A trait that differs between the sexes and is neither required for reproduction nor related to sex differences in ecology. Most such traits do not develop fully until sexual maturity, are expressed more strongly in males than in females, and are useless or costly for survival. Traits that do not differ between the sexes but share the other two qualities may also be referred to as secondary sexual characters (e.g., ornate plumage in sexually monomorphic birds).

Segregation distortion Within-individual selection for one or another allele of a diploid body.

Selective attention The cognitive processes of (selectively) concentrating on one aspect of the environment while ignoring others; consciously or unconsciously, the perceiving organism is focused on particular areas of the environment. This is determined by past experience and the skill being performed.

Selective differential The difference in fitness between two or more subsets of a population subjected to different selective pressures with resulting differences in fitness.

Selective sweep Recent and strong positive natural selection on a particular gene which leads to reduced variation in DNA sequence among individuals in a population.

Selective tidal stream transport (STST) Vertical movements of aquatic organisms relative to tides; provides a mechanism for zooplankton and small nekton to move horizontally within and between estuaries and coastal regions.

Self-awareness (self-recognition) Increased self-other distinction, oftentimes indicated by self-recognition in a mirror. Sensitivity to one's own thoughts and feelings; sometimes used to indicate the knowledge that one exists independent of other entities.

Self-control task Experimental situation in which decision-makers must choose between smaller-sooner and larger-later options.

Selfish-herd effect Bunching by foragers to decrease their relative domain of danger when facing predation threats.

Self-medicate The use by animals of secondary plant compounds or other nonnutritional substances in preventing or treating diseases.

Self-organization The idea that the development of complex structures and behaviors in a system can emerge from events taking place primarily within and through the system itself.

Self-propelled particle (SPP) models Models of collective motion in which each group member is treated as a particle that responds to other group members within interaction zones. An individual moves toward or away from other individuals, or aligns itself with them, depending on which zone they occupy.

Semantic memory The ability to acquire general factual knowledge about the world.

Semelparous (semelparity) Reproducing once during a lifetime.

Semiclaustral founding Colony founding procedure in which a founding queen or queens forage outside the brood cell to secure sufficient energy to rear the first generation of workers.

Semi-intact preparation A piece of an animal, along with its nervous system, that produces a behavior or a component of a behavior. Such preparations are normally used primarily to allow access to the nervous system, but can also be used to eliminate sensory input or confounding inputs from other parts of the nervous system.

Semisociality Social groups of same-generation adults and their offspring characterized by cooperative brood care (i.e., alloparental care occurs), and a reproductive division of labor, such that some individuals mainly reproduce while others mainly perform other tasks such as foraging and brood-care.

Senescence The combination of biological processes of deterioration of organismic function in a living organism approaching an advanced age.

Sensillum Hair-like structure that houses sensory neurons.

Sensitive phase A stage of life during which the ability to learn is enhanced. Occurs most commonly early in life.

Sensory drive The hypothesis that sensory systems and sensory conditions in the environment 'drive' evolution in particular directions.

Sensory environment Multiple types of information – signals and cues from other animals and the physical environment – that may be perceived by an animal on the basis of its unique sensory capabilities (i.e., 'umwelt').

Sensory mode The physical characteristics of signal production, on the basis of animal sense organs by which it is perceived (e.g., sound, patterns of light and color, vibration, etc.).

Sensory traps In attempts to induce certain responses in other individuals, the use of stimuli whose effectiveness in inducing these responses evolved in a different context. In a sexual context, the male can produce a stimulus that elicits a particular female response; this female response exists because previous natural selection in another context favored such a response to the same (or a similar) stimulus.

Sentience A general term for the ability to feel or perceive subjectively.

Sentinel An individual in a group that remains vigilant and stands guard while other group members forage or carry out other activities (also called: sentry or guard).

Sentinel cells A newly discovered cell that sweeps through a *Dictyostlium* slug mopping up toxins and bacteria, acting as a kidney, a liver, and an innate immune system.

Sequence divergence Changes in the sequence of DNA bases in different populations or different species. Comparisons of the degree of sequence divergence are used to estimate how long ago the populations or species began to evolve independently.

Sequestering Accumulation of a chemical in the integument or inner organs of an organism from an outside source (e.g., diet).

Serotonergic basal cells Round cells at the base of the taste bud, which are immunoreactive to serotonin.

Serotonergic medications Psychotropic medications that effectively increase the availability of the neurotransmitter serotonin in the brain.

Serotonin (5-HT) A monoamine neurotransmitter that is derived from tryptophan. It is synthesized in the gut, pineal, and CNS. In the brain, 5-HT influences learning and memory as well as appetite, sleep, and muscle contraction.

Sex allocation Sometimes used to refer to the process by, or the time at, which a parent bestows gender on offspring (see sex determination and sex allocation sequence, respectively), but more generally used to refer to how resources are apportioned to each gender (also referred to as *investment ratio*). Sex allocation can be thought of as an evolutionarily derived reproductive strategy of the parents and the sex ratio as one of its manifestations.

Sex allocation sequence The order in which offspring of different gender are produced by a parent. Nonrandom sequences can, but do not always, imply parental control and can influence sex ratio variance.

Sex determination The genetic basis of an individual's gender. There is an astonishing diversity of sex determination mechanisms among animals, often exerting a profound influence on reproductive behavior.

Sex-limited polymorphism Occurrence of several discrete forms or morphs within one sex, but not the other sex.

Sex ratio The proportion of individuals that are male, that is, males/(males + females). Sex ratios are sometimes given as the proportion females (this is not incorrect; there is no strict convention) and sometimes reported as the ratio of males to females, that is, males/females (termed sex ratio *sensu stricto*): this is not a recommended measure as it is not readily amenable to statistical analysis. The sampling unit may be indicated, for example, *population sex ratio*, *clutch sex ratio*, *parental sex ratio* (the sex ratio of offspring produced by a given parent or pair of parents). The developmental stage of offspring may also be indicated: *primary sex ratio* (the sex ratio at offspring production; this may be used to indicate the sex ratios at fertilization or at egg laying), *secondary sex ratio* (the sex ratio at some defined later stage of offspring development, for example, emergence or mating (adulthood)). Developmental mortality can mean that primary and secondary sex ratios are not equivalent.

Sex ratio variance A measure of the diversity of sexual composition in groups of offspring (e.g., clutches, litters, etc.). Heterogametic sex determination (e.g., the XY system

in mammals, the WZ system in birds) leads to the null expectation that distributions of group sex ratios conform to binomial variance. Deviations from the binomial expectation can, but do not necessarily, imply sex ratio control. Under haplodiploid sex determination, there is no particular null expectation of variance, but subbinomial variances have been observed in many haplodiploid species.

Sex-ratio conflict Conflict between queens and workers over the investment into male versus female reproductives produced by the colony.

Sex role reversal Occurs when males provide the majority of parental care, resulting in sexual selection on females, who can increase their reproductive success by obtaining additional mates.

Sex-role reversed species Are those in which females compete for males and males choose among females. Typically, males take care of the young.

Sexual behavior Behavioral interactions that facilitate the union of eggs and sperm.

Sexual coercion Occurs when one sex, usually males, use force or the threat of force – forced copulation, harassment, intimidation, restriction of the movement of the other – to increase the probability that mating will occur.

Sexual conflict Occurs whenever the fitness interests of individuals of different sexes conflict.

Sexual dialectics hypothesis The idea that whenever the behavior and physiology of one sex decreases the fitness of the other, flexible individuals adaptively modify their behavior or physiology to resist the deleterious effects of interaction(s) with the other sex. Because control and resistance interactions are likely to be dynamic, changing during the lifetime of an individual, the sexual dialectics hypothesis predicts that individuals flexibly adjust resistance behavior in contemporary time.

Sexual dichromatism A subset of sexual dimorphisms in which males and females of a species differ systematically in coloration or color pattern.

Sexual differentiation In ontogeny, the anatomical and behavioral differentiation of males and females.

Sexual dimorphism Refers to differences in morphology, behavior or physiology between males and females. Generally, more intense sexual selection results in greater sexual dimorphism.

Sexually antagonistic selection A type of selection that is characterized by dynamic interactions – actions and reactions – between individuals of different sexes that can lead to a coevolutionary arms race.

Sexual reproduction Reproduction involving gamete formation by meiosis and gamete fusion to form new individuals.

Sexual selection Selection for traits that make individuals of one sex better able to compete for individuals of the opposite sex. As a consequence, some individuals have a mating advantage over other individuals of their own sex, such that there is nonrandom differential reproductive success among these individuals.

Sexual signals Advertise the signaler's genetic or phenotypic quality in order to attract mates and deter rivals. Examples include conspicuous traits, such as bright colors and elaborate songs. Signals can be visual, acoustic, olfactory, tactile, or electric.

Sexual size dimorphism (SSD) A subset of sexual dimorphisms in which males and females of a species differ systematically in body size.

Shaping The procedure of reinforcing successive approximations of a desired behavior.

Short day breeder An organism that enters full reproductive capability during short days of winter.

Sibling species Anatomically similar species that are nonetheless reproductively isolated; in herbivorous insects, such species often use different host plants.

Sickness responses The suite of adaptive behavioral and febrile reactions among vertebrate animals associated with the acute phase immune response that includes fever, iron withholding, reduced motivated behaviors such as food and water intake, and lack of sexual, parental, or other social interactions. These responses are critical to survival.

Sign A signal; also anything that gives evidence or trace of something else; also a physical object, usually fixed in space, that is a signal when encountered by a receiver.

Sign stimulus An external stimulus that elicits a specific motor pattern (modal or fixed action pattern).

Signal A character or behavior that has evolved so as to provide information to other organisms.

Signal detection theory A general model of the discrimination of signals from background noise that can be applied to data from psychophysical studies with animals and to situations where an animal must make a discrimination under conditions of uncertainty.

Signal dominance When a multimodal signal generates a response in only one of its component modes in relation to other modes.

Signal enhancement When receiver responses to redundant multimodal signals are increased in their intensity compared to unimodal signals.

Signal equivalence When receiver responses to redundant multimodal signals are the same or equal to unimodal signals in their intensity (equivalence).

Signal independence When the response to a multimodal signal includes the (different) responses to each of its unimodal components.

Signaling mode The physical characteristics of a signal that enables it to be received by a specific type of sensory neuron in a receiver. Signaling modes include chemical, electric, sound, light, and vibration.

Signal parasite An individual that exploits an existing communication system in a way that benefits itself at the expense of a signal giver or a signal receiver.

Signal redundancy When individual components of a multimodal signal presented separately elicit the same response from a receiver and likely contain the same or similar kinds of information about the sender.

Significance level/criterion In statistical analyses it is a criterion of probability below which a statistical test value is said to indicate a significant difference between populations.

Silkie Asiatic breed of chickens characterized by fur-like plumage and dark blue flesh.

Simultaneous hermaphroditism A sexual pattern characterized by individuals possessing both mature ovarian and spermatogenic tissue within the same functional gonad.

Single nucleotide polymorphism (SNP) Variation in a DNA sequence that occurs when a single nucleotide – A, T, C, or G – varies between individuals of the same species.

Sinus gland A neurohemal organ associated with the crustacean X-organ.

Siphon Cylinder created by curling the edges of the mantle in some mollusks. It can be used to forcibly discharge the contents of the mantle cavity.

Sister groups A pair of evolutionary lineages that share their most recent common ancestor and thus are necessarily equal in age.

Site fidelity (see philopatry).

Size constancy The ability to determine the true size of objects despite viewing them at different distances when their images subtend various angles on the retina.

Skylight polarization Due to scattering by particles in the earth's atmosphere, sunlight becomes polarized, with the light wave's electric field oscillating in one direction. The degree of polarization is maximal at 90°, relative to the direction of incident light.

Sloughing behavior Specific behavior associated with sloughing off skin and associated structures such as hair, feathers, and scales. Often, this involves rhythmic movements to lift off old skin layers (e.g., in snakes), or movements allowing abrasion of skin with substrate (many birds and mammals) to break up and shed skin and its components.

Smoltification The transformation or metamorphosis of anadromous salmonids from the parr to smolt stages, including changes in morphology, endocrinology, and behavior in preparation for saltwater entry. Some of these include increased plasma, thyroid hormone, and cortisol levels, as well as the deposition of guanine in the skin, giving the fish a silvery appearance. This impedes water loss, and with the increase of Na⁺-ATPase pumps in the gills and gut, the osmoregulatory function improves as the fish enters the hyperosmotic conditions for seawater. Behaviorally, smolts leave the natal streams and migrate to open water.

Sneak spawning Male reproductive behavior where an individual will attempt to fertilize eggs that are released during the courtship and spawning episode of another male–female pair; the individual is usually unable to defend a territory and court a female independently, and spends most of the time hiding to avoid agonistic encounters with territory-holding males.

Social cognition Knowledge about group mates and social interactions.

Social (cooperative) spider Spiders that share a nest, feed together, and have cooperative breeding.

Social cues Products of the behavior of others that convey inadvertent social information.

Social dominance The state of having high social status relative to other individuals, which react submissively during dyadic agonistic encounters. Dominant individuals have priority of access to resources over subordinate individuals.

Social eavesdropping The extraction of social information by an individual (the eavesdropper) from a signaling interaction between other individuals (usually conspecifics) in which the eavesdropper takes no direct part.

Social facilitation or social enhancement The effect of the mere presence of another animal on the production of a target response. The increase or initiation of a behavior already in one's behavioral repertoire when in the presence of others engaged in the same behavior.

Social foraging theory A body of game theoretic models designed to analyze foraging decisions made under conditions of frequency-dependent payoffs.

Social hymenoptera Meaning the eusocial Hymenoptera. Eusociality has evolved approximately nine times in the Hymenoptera, once in ants, three times in wasps, and approximately five times in bees.

Social influence The effect of another animal on the production of a target response (e.g., contagion or social facilitation) that does not involve the acquisition of information about the to-be acquired response (e.g., imitation).

Social information Information obtained by an individual from other animals in its social group.

Social insects (see eusocial) Insects that live in groups in which some group members rear offspring that are not their own.

Social intelligence An influential theory developed by Alison Jolly, Nick Humphrey, and others to explain the superior intelligence of primates, including humans. The theory is based on the idea that living in a complex social world requires cognitive abilities related to learning from others, forming social relationships in order to gain dominance, and deceiving others to gain resources normally unavailable to them. This extreme form has been named Machiavellian Intelligence.

Social interaction A dynamic, changing sequence of social actions between individuals that modify their actions and reactions according to those of their interaction partner(s).

Sociality Associations and interactions of individuals within a social group.

Social learning Any process whereby the behavior of an individual is altered as a result of it either observing the behavior of another individual, interacting with it, or being exposed to its products.

Social learning strategy An evolved psychological rule specifying under what circumstances an individual learns from others and/or from whom it learns.

Socially mediated learning Learning that is influenced by presence and activity of conspecifics, also referred to as socially biased learning; the process by which social context contributes to learning.

Social mimicry Imitation between species that associate among each other.

Social monogamy A type of mating system in which one male and one female form a bonded pair for the purposes of reproduction. Typically, the pair will stay together and raise young together. However, both the male and/or the female may engage in copulations with other individuals from outside the bonded pair (EPCs).

Social network Pattern of social connectedness, either through behavioral interactions or spatial proximity, between individuals in a population.

Social norm A pattern of behavior that is accepted as being the normal way of behaving for a particular group of people, and to which all the group members are expected to conform.

Social organization The size, demographic composition, and spatiotemporal coordination of individuals within a group.

Social (other-regarding) preferences Behavior motivated out of concern for the effects it has on other individuals over and above material self-interest; these can be positive or negative (social science).

Social parasitism The coexistence in the same colony of two species of social insects, one of which parasitizes the other.

Social selection A type of natural selection characterized by nonrandom, differential reproductive success of individuals bearing some trait relevant to social interactions (either competitive or cooperative) for access to resources such as food, territories, allies, and mates.

Social structure The pattern of relationships among individuals within groups, groups within demes (subpopulations), and demes within a population of a given species.

Social transmission Transfer of information among individuals in a group or population, both within and between generations, through social learning or teaching.

Social transport A form of recruitment used by certain ant species, in which one ant carries another to a destination, typically in a stereotyped posture. This is most commonly seen when colonies emigrate from one nest site to another.

Sociobiology An extension of Darwinian theory and the evolutionary synthesis that developed during the 1960s and 1970s. The core principles were that natural selection works at the level of the individual or gene, not the population or species (still contested) and that the representation of one's genes in future generations could be achieved by facilitating the reproductive success of close relatives.

Sociomatrix For a group with n members, an $n \times n$ matrix with each group member along the vertical and horizontal axes and each entry in the grid as the weight of the social relationship, if any, between the two intersecting individuals.

Soldier Similar to workers, these are nonreproductive members of a colony (sometimes known, especially in ants, as 'major workers'). Unlike normal workers, however, they are generally larger, with specialized head structures, and primarily perform nest-defense tasks.

Solitary Living singly or in pairs; the term refers to behavioral, morphological, and physiological traits (especially for the solitary phase of locusts).

Somatic Pertaining to the body.

Somatic fusion The process by which the nonreproductive tissues of two individuals join to form a single individual with a shared body (soma). In many taxa, this can occur either between clones or closely related individuals. Fusion between allogeneic (nonclonemates) organisms produces a genetically chimeric individual.

Somatic recombination The process by which regions of the genome are physically edited in the nucleus, giving rise to novel genetic elements. Accounts of this process are rare and are known from a few systems where genetic diversity is of primary importance.

Somatic rejection The process by which two individuals reject each other, often involving the formation of a physical barrier between them and the preservation of genetic individuality.

Somatosensory system A diverse sensory system comprising the receptors and processing centers to produce the sensory modalities such as touch, temperature, proprioception (body position), and nociception (pain). The sensory receptors cover the skin and epithelia, skeletal muscles, bones and joints, internal organs, and the cardiovascular system.

Somatotropic axis A group of hierarchically regulated hypothalamic, pituitary, and peripheral tissue hormones which are involved in the regulation of somatic growth.

Song Loud, often complex sound usually produced by males of a species in defense of a breeding territory and/or to attract females.

Song control nuclei Interconnected regions of the brain in songbirds that regulate the production and learning of song.

Sore footed A type of lameness which is caused by pain in the animal's hoof.

Sparse coding The representation of information in the nervous system by the activation of a relatively small set of neurons.

Spatial contrast sensitivity function Plot of the contrast required to detect gratings of different spatial frequencies.

Spatial resolution (acuity) The ability of an animal to perceive spatial detail.

Spawning Oviposition, or the deposition of eggs, in water.

Spearman coefficient A measure of correlation between ranked data; can be used as a measure of observer reliability.

Spectral sensitivity The differential sensitivity of photoreceptors to different wavelengths of light.

Spectrogram A display of the frequency components of a sound over time.

Speed/accuracy tradeoff A fundamental decision-making constraint that captures the cost in time that must be paid to improve the accuracy with which the best available option can be chosen.

Sperm allocation Refers to situations in which males that are running low on sperm will vary the amount of sperm in an ejaculate, so as to provide more sperm for some females and less for others. Generally, it is assumed that males will provide more sperm for females that are of higher quality or status.

Spermatheca A small sac associated with the median oviduct of the female, in which sperm are stored following copulation.

Spermatophore A sac produced by accessory glands of male insects and directly or indirectly transferred to the female, containing sperm and often proteinaceous material.

Sperm capacitation Changes the spermatozoa undergo to become ready to interact with the ovum and hence able to fertilize.

Sperm competition A type of sexual selection that can occur if a male or his seminal products directly reduce the changes that the sperm of other males which have mated with the same female have of fathering her offspring. This is the postcopulatory equivalent of male–male battles.

Sperm depletion Refers to the fact that males may be limited in the number of sperm that they can produce per unit time and eventually they may run out of sperm. In such cases, males need a period of time to rebuild their sperm supplies.

Sperm precedence An individual male's share of paternity when females mate with multiple partners.

Spherical aberration Optical imperfection caused by light striking a refractive surface at different points being focused in different planes.

Spite A behavior that reduces the lifetime fitness of the recipient while also reducing the fitness of the actor (evolutionary biology); harming behavior resulting from a desire for the suffering or misfortunes of another individual (social science).

Split sex ratios Population-wide bimodal sex-ratio distributions with co-occurring colonies that specialize in the production of either male or female reproductives.

Sporozoites A stage in the life cycle of apicomplexan protists that is produced by sporulation and invades host cells.

Stabilizing selection A form of selection in which deviations from a main phenotype, such as changes to a conspecific call type, are selected against maintaining the same phenotype over evolutionary time. Contrast with directional selection.

Stable group size A group size at which no individual can gain by unilaterally leaving or joining the group.

Stable isotopes Nonradioactive forms of an element having an extra neutron; stable isotopes of carbon, nitrogen, and hydrogen, among others, are very useful for ecological and behavioral studies.

Stable supine posture The ability of infants to lie on their backs on the ground or another surface is uniquely human. Chimpanzee and other non-human primate infants are unstable when they are laid on their backs – they move their limbs in an attempt to grasp and cling to something. From a developmental perspective stable supine posture enabled humans to become by far the most versatile and proficient tool users in nature. The stable supine posture provides the basis of tool use, face-to-face communication, and vocal exchange.

Stage 4 sleep The deepest stage of NREMS. It is characteristic of the first half of the night in humans; our ability to enter this stage diminishes with aging.

Startle signal See deimatic signal.

Starvation–predation risk trade-off Animals must balance the time or effort they spend feeding to prevent themselves from starving, with the time or effort they spend looking out for predators to prevent themselves from being eaten. Any animal that spends all its time looking out for, or avoiding predators will starve to death. Any animal that spends all its time feeding may not ever starve, but is more likely to be caught by a predator.

State-dependent model Models that use the techniques of stochastic dynamic optimization to predict animal behavior. Often used to model tradeoffs that animals face when having to decide between competing factors such as getting food and avoiding predators.

Stationary molt An intermittent molt that is associated with a lack of increase in body size and morphological development. This type of development occurs in several insect species and is frequently associated with periods of food shortage, when a larva or nymph is not capable of passing a critical mass threshold in an instar. In some termites, it might also be linked to the wear of mandibles.

Statocyst Inertial balance organ of aquatic invertebrates, consisting of a heavy mineral body (statolith) resting on a bed of mechanoreceptors that register the displacement of this body whenever its orientation relative to the direction of gravity changes.

Stereocilia Nonmotile tufts of secretory microvilli on the free surface of cells. Thought to be a variant of microvilli and characterized by their length (distinguishing them from microvilli) and their lack of motility (distinguishing them from cilia).

Stereotypic behavior Behavior that is repetitive, relatively invariant, and has no obvious goal or function.

Steroid hormone A class of molecules that include the sex hormones and stress hormones from the adrenal cortex that share a common biosynthetic pathway.

Steroid receptors Steroid hormones act largely through intracellular steroid receptor proteins that bind hormone and then function as 'ligand activated transcription factors' to regulate gene expression in target cells. Teleosts have multiple forms of both the estrogen and the androgen receptors.

Stimulant A substance that quickens and enlivens the physiological and metabolic activity of the body.

Stimulus (In physiology) Something that can elicit or evoke a physiological response in a (sensory) cell, a (sense) organ, or an organism; it can be internal or external; (in psychology)

something that has an impact or an effect on an organism so that its behavior is modified in a detectable way.

Stimulus enhancement The facilitation of an observer's response (e.g., through approach and manipulation) resulting from the pairing of an object with reinforcement.

Stimulus generalization and discrimination When prey respond to the olfactory, auditory, or visual cues of a species which are similar to those of another species, prey are said to generalize their species recognition to these cues. If prey fail to respond or respond weakly to these cues because they are dissimilar, they are said to discriminate these cues from those of another species. Therefore, stimulus generalization and discrimination are reciprocal effects, with higher stimulus generalization indicating lower stimulus discrimination.

Stochastic dynamic optimization A mathematical technique that predicts optimal behavior by having computers examine every possible set of behaviors. This produces a numerical rather than an analytical solution as found by the marginal value theorem or Gilliam's rule.

Stop-over habitats Habitats along the migration routes of animals that allow them to feed and replenish fat stores before moving on.

Stotting Vertical jumping in ungulates during flight away from a predator in which all four legs leave the ground at the same time, the legs being held straight while the animal is in the air; similar behaviors include pronking, spronking, bounding, and leaping; may function to deter further attack by a predator or distract the predator's attention away from vulnerable offspring.

Strategic design Aspects of signals relating to its function, for example, brightness of plumage conveying male quality.

Strategy A set of behavioral decisions that are highly heritable, associated with a particular genotype within the gene pool of a species.

Stratified squamous epithelium An epithelium characterized by multiple layers of flat, scale-like cells called 'squamous cells.'

Stress A descriptive label with varying meanings for the biological processes involved when an animal perceives a threat that challenges internal homeostasis (both motivational and physiological 'set points') and the behavioral and physiological adjustments that the organism undergoes to avoid or adapt to the stressor and return to homeostasis. An environmental effect on an individual that overtaxes its control systems and results in adverse consequences and eventually in reduced fitness.

Stress response The physiological and behavioral responses to a sudden emergency situation.

Stressor A challenge (whether physical or psychological) to homeostatic balance (see 'homeostasis').

Stress-response The array of neural and endocrine adaptations that occur in the body in response to a stressful challenge.

Stretch activation In some muscles, physical elongation by mechanical means can lead directly to contraction of the muscle, counteracting the induced stretch.

Striated muscle Also known as 'skeletal muscles,' these muscles have alternating bands of overlap and nonoverlap between thick (myosin) and thin (actin) filaments, giving them a striated appearance.

Stridulation The rubbing of skeletal elements against one another that is a common form of sound production in fishes and many insects.

Strong inference A method in the cognitive structure and logic of scientific discovery in which investigators attempt to identify and test simultaneously alternative hypothetical-deductive hypotheses with crucial predictions. Crucial predictions are predictions about a phenomenon that are in opposite directions. If tested well with a crucial experiment, two hypotheses can be tested simultaneously and one hypothesis supported and another rejected.

Strong reciprocity A propensity to reward others for cooperative, norm-abiding, behaviors coupled with a propensity to punish others for norm violations.

Stunning A method that renders animals insensible to pain before slaughter.

Sublethal effects Effects that are negative, but do not immediately kill the organisms, such as decreased ability to stand, walk, eat, or avoid predators.

Submission Behavior that indicates a low probability of initiating aggressive behavior. A submissive individual, however, may respond to injurious aggression with aggression. Submissive individuals often terminate interactions by physical distancing.

Subordinance The state of having low social status in a group, often because the individual was defeated in an aggressive encounter.

Subordinate A low-ranking individual within the group that does not usually get access to resources. Subordinate individuals tend to be smaller and weaker and do not form close social networks.

Subsociality Family groups consisting of parents and immature offspring, and are characterized by brood defense or brood provisioning by parents.

Subsocial route Social grouping that originates from an extended family and restricted, or no dispersal of, young.

Suprachiasmatic nucleus (SCN) The suprachiasmatic nucleus (SCN) of the hypothalamus is a bilateral structure that sits at the base of the mammalian brain. It serves as a central pacemaker and acts to synchronize the body with the environment. It also synchronizes endogenous circadian

rhythms. The SCN can be divided into two areas, a ventral area containing cells that receive direct input from the retina, and a dorsal area which contains highly rhythmic cells that serve in output processes. Input from the ventral SCN synchronizes the rhythmic cells of the dorsal SCN.

Surprisal In the mathematical theory of communication, the entropy or information associated with a particular signal.

Survivorship cost Reduction in fitness in the form of decreased probability of survival.

Swimbladder An anatomical structure comprising connective tissue, filled with a mixture of oxygen, carbon dioxide, and nitrogen (hence, also known as a 'gas bladder') that has multiple functions among fishes including control of buoyancy, sound production, and sound reception.

Symbol Something – such as an object, picture, written word, a sound, or particular mark – that represents (or stands for) something else through association, resemblance, or convention, especially a material object used to represent something invisible.

Sympathetic nervous system The branch of the peripheral nervous system, regulated by epinephrine and norepinephrine release, that orchestrates the immediate responses to a stressor.

Sympatric Geographically overlapping; for example, populations on the same island with no barrier to movement between them.

Sympatric speciation The development of isolating mechanisms while incipient species are within the same geographic area, specifically when individuals from each population are within cruising range of one another.

Synanthropic (synanthropy) Describes a population of wild animals that lives near or within human settlements or anthropogenic habitats; usually implies some degree of dependence on humans or exploitation of human-derived resources.

Synapomorphy A shared, derived character; the only valid character type for revealing phylogenetic affinities.

Synapse The gap or junction between nerve cells.

Synaptic pruning The reduction in the number and connectivity of synapses that may accompany development.

Synaptic transmission The transmission of an electrical signal from one cell to another which occurs at the point of connection between these two nerve cells called synapse.

Syrinx Musculoskeletal structure that functions as a vocal organ found among birds.

Systematics The general field of researching inferring, and proposing the evolutionary relationships of organisms. One of the oldest fields of biology, its relevance today is stronger than ever, including multiple sources of data and methodological techniques.

Tachycardia An increase in heart rate.

Tactical design Aspects of signals relating to its effectiveness in transmission, for example, male songs with higher amplitude signals in certain frequencies get more female attention.

Tactics A set of behavioral decisions for which the phenotype develops as a result of any combination of learned mechanisms (genetic heritability is unspecified).

Tail streamer The elongated outer tail feathers (rectrices) of the swallow tail, giving the tail its forked appearance.

Tandem run A form of recruitment used by certain ant species, in which one ant leads a single follower to a destination. The pair remain in contact by the exchange of pheromone signals from the leader and tactile signals from the follower.

Tangled bank theory The idea that the world, and the challenges that it poses to organisms, is variable and complex. In such a world, the production of genetically variable offspring increases the chances of at least some of them being able to survive and reproduce.

Tapetum Reflective layer in either the retinal pigment epithelium or choroid that reflects light not absorbed by the photoreceptors back through the retina, thus improving sensitivity in animals in low light levels.

Task A behavior or set of behaviors that contribute to the work necessary for the function of a social group.

Task specialization When an individual within a social group preferentially performs one task over other tasks being performed by that group.

Task threshold The level of stimulus required to make a worker engage in a task.

Tastant Chemical molecule that induces the sensation of taste, such as sugars or salts.

Tautologous A circular logical argument in which the conclusion is included in the propositions.

Taxis The movement of an organism in a particular direction with reference to a stimulus. A taxis usually involves the employment of one sense and a movement directly toward or away from the stimulus, or else the maintenance of a constant angle to it. (Contrast with kinesis.) See phototaxis and geotaxis as examples.

Taxonomy The scientific discipline concerned with studies of taxa, including the subdisciplines of systematics and nomenclature.

Teaching Behavior modified by an experienced individual in the presence of a naïve individual, such that the naïve individual learns the behavior more quickly than it would otherwise and at some cost to the teacher.

Tegmen (pl. tegmina) A leathery, hardened forewing (usually of Orthopteroids).

Teleost Fish infraclass Teleostei within the ray-finned, bony fishes, excluding gars and bowfins. One of three infraclasses of ray-finned fishes (Actinopterygii) that includes most common fish.

Template The neurological or physical model against which cue bearers are compared and evaluated.

Temporal caste discretization A form of age-related division of labor in which workers form distinct age groups that have roles composed of sets of nonoverlapping tasks.

Temporal contrast sensitivity function Plot of the contrast required for detection of a light flickering at different frequencies.

Temporal discounting A decrease in the subjective value of a delayed benefit.

Temporal information Of, relating to, or involving an awareness of time.

Temporal information processing The sequence of computational steps that are hypothesized to occur while processing events that unfold in time.

Temporal polyethism A pattern of division of labor in eusocial insect colonies in which task performance is associated with worker age.

Temporal representation The internal format of stored information about events that unfold in time.

Temporal structure Describes the amplitude and frequency modulations of an acoustic waveform over time.

Tergal glands Glands on the dorsal surface of the abdomen; usually referring to those on males that entice females into position for copulatory engagement.

Terminal investment strategy Is a term sometimes used to refer to species in which the male usually, or always, is killed and cannibalized by the female during, or immediately after, copulation. The term implies that the male may be investing in its future offspring by providing food and nutrients (its own body) to the female.

Termites, higher Comprises only the termite species of the family Termitidae. They have bacterial gut symbionts only.

Termites, lower All termites with the exception of the Termitidae. Lower termites harbor bacteria and flagellates in their guts.

Territory Any defended space; can be for breeding, foraging, caring for young, or a combination.

Test of congruence A central component of phylogenetic systematics; it is the result of simultaneous analysis of characters. Given sufficient evidence, true synapomorphies will tend to reinforce one another guiding tree inference, and characters that do not in fact reveal phylogeny will be revealed as such. The test of congruence is therefore the primary tool in testing homology and identifying homoplasy, and it flows logically from the recognition that there is but one optimal phylogeny for a group of taxa.

Testosterone (T) Important androgenic steroid hormone in all classes of vertebrates; critically, this steroid often functions as a biosynthetic intermediate in estradiol or 11-ketotestosterone production.

Tethered flight A laboratory technique in which an insect is suspended by a wire or stick attached to its dorsal surface; with a wind blowing on the head, removal of foot (tarsal) contact triggers sustained flight.

Thanatosis An antipredator behavior in which the organism feigns death.

Thelytokous automixis A kind of parthenogenesis in which two gametes produced by meiosis fuse to produce a diploid female.

Thelytoky A form of parthenogenetic reproduction in which only female offspring are produced.

Theory of mind The ability to attribute mental (cognitive) states to others.

Thermocline A zone of rapidly changing temperature.

Thermolability See poikilothermic.

Thermoneutral ambient temperature An ambient temperature where the activities of heat-producing and the heat loss mechanisms are at a minimum level; the animal needs the least thermoregulatory effort to maintain its normal body temperature.

Thermoregulation The ability of an organism to keep its body temperature within certain boundaries, even when the temperature surrounding is very different. The regulation of body temperature.

Thiamine A water-soluble vitamin of the B complex (vitamin B₁), whose phosphate derivatives are involved in many cellular processes.

Third-party punishment Imposition of sanctions by an impartial observer on an individual for actions directed toward a third party; see also Policing punishment (social science).

Third-party relationships Relationships or interactions among conspecific group members in which the observer itself is not directly involved.

Threshold The lowest stimulus strength that reliably elicits a response; a low threshold means high sensitivity; the exact criterion for threshold differs among studies.

Thyroid hormones Iodinated tyrosine residues produced in the thyroid gland. The gland mostly secretes thyroxine (T4) that is then converted in the blood or in target organs by deiodinases to tri-iodothyronine (T3). T3 is regarded as being the biologically active form. Biological effects of thyroid hormones include regulation of metabolism (temperature regulation), development, and behavioral effects.

Thyrotropin (TSH) Glycoprotein hormone comprising two subunits produced by the anterior pituitary gland that stimulates the production of thyroid hormone by the thyroid gland.

Thyrotropin-releasing hormone (TRH) Tripeptide produced in the hypothalamus and extrahypothalamic sites that stimulates the release of TSH by the anterior pituitary gland.

Time perception The experience of time.

Time sampling Behavior is sampled periodically at a specified sample point at the end of a specific sample interval.

Time series analysis Events that unfold in time may be characterized by the periodic trends that make up the temporal structure of the events.

Timing The general ability to keep track of time.

Tonotopy The orderly mapping of frequency along the cochlea. The orderly arrangement of frequency is then preserved in each of the successively higher nuclei of the auditory system up to and including the auditory cortex.

Tool-use Directing an unattached object towards one's self or another object (animate or inanimate) in order to achieve a goal.

Tool-user A species that regularly uses tools in its natural environment.

Totipotent In eusocial insects, having the ability to express either the reproductive queen or the nonreproductive worker phenotype.

Toxic Substances that are poisonous and injurious or lethal to predators that attempt to consume it.

Toxicological effects Direct effects of chemicals that interfere with physiological processes resulting in the deterioration of function and may ultimately cause organ and system failure.

Trade-off The cost–benefit approach has been extended to model when this benefit-to-cost ratio is optimal, and states that an individual should maximize the benefit of the behavior while simultaneously minimizing any costs associated with the behavior. In other words, the benefit of any particular behavior should be considered with the costs associated with the behavior.

Trade-off theory A theory to explain the emergence of symbolic representation in humans. At a certain point in human evolution, brain capacity reached a limit and in order to accumulate new functions, old functions needed to be lost. Consequently, humans may have lost much of their ability for olfactory processing and developed instead highly sensitive visual, auditory, and crossmodal functions. A similar scenario may be applied to the trade-off between memory and symbol use, where human memory capacity may have been sacrificed in exchange for enhanced symbolic capabilities.

Tradition An enduring behavior pattern shared among members of a group that depends to a measurable degree on social contributions to learning.

Tragedy of the commons A situation in which individuals would do better if they all cooperate, compared to them all defecting, but in which cooperation is unstable because each individual gains by selfishly pursuing their own short-term interests (cf. Prisoner's dilemma).

Trained losing and winning The learning processes whereby an animal either acquires a stronger tendency to submit or yield to other individuals after losing previous agonistic encounters, or acquires a stronger tendency to attack or dominate other individuals after winning previous encounters. Modification of the tendency is in relation to other individuals generally, not limited to opponents involved in previous encounters.

Transcellular diffusion Substances travel through the cell, passing through both the *apical membrane* and the *basolateral membrane*.

Transcription factor A gene that directly affects the expression of another gene or genes.

Transcriptional Relating to transcription, the process by which DNA is converted into messenger RNA.

Transcriptome The set of all messenger RNA (mRNA) molecules produced in one cell or a population of cells, or in a given organism, under particular environmental conditions at a given time. Transcriptomics is the large-scale study of gene expression level (mRNAs) in a given cell population (such as brain cells), often using high-throughput techniques based on DNA microarray technology.

Transduction mechanism In a sensory neuron the odorant receptor-ligand complex induces a series of cellular reactions that ultimately release action potentials in the axons.

Transiens Transitional locust phase, from the solitary to gregarious or vice versa.

Transition matrix Squared matrix in which each row is a probability distribution. This is the fundamental element of a Markov chain.

Transitive inference A form of reasoning in which given prior information a subject deduces a logical conclusion.

Specifically, the ordinal relation between two elements in a series must be inferred from information that establishes the relations of those two elements to a third.

Transitivity A fundamental principle of rational choice behavior that applies specifically to binary choices. Preferences are transitive between the three options A, B, and C if A is preferred to B, B is preferred to C, and A is preferred to C.

Translational Relating to translation, a process by which mRNA is converted into protein.

Translocation Technique used in wildlife conservation, wherein wild individuals are captured from one location and transported and introduced to another part of their range, often with the purpose of re-establishing a local population which has become extirpated.

Transmission distance Refers to the change of sound intensity with increasing distance relative to a reference point.

Transposable element A mobile piece of DNA that can insert itself into the genome.

Trematodes Groups of parasitic worms, commonly referred to as 'flukes.' Almost all trematodes infect mollusks as the first host in the life cycle, and most have a complex life cycle involving other hosts. Most trematodes are monoecious and alternately reproduce sexually and asexually. The two main exceptions to this are the Aspidogastrea, which have no asexual reproduction, and the schistosomes, which are dioecious. The Trematoda are estimated to include 18 000–24 000 species.

Triadic mother–infant–object relationships It is also called 'social referencing.' Human infants often manipulate objects within a social context. Suppose that a human infant encounters a new toy. She may look up at the mother *before* touching it. The mother may nod or smile, and only then will the infant actually start manipulating the object. While playing with the toy, the infant may often show it to the mother while smiling. The mother may smile back at her child and give social praise.

Trigeminal nerve The fifth cranial nerve in vertebrates, which is known to be both sensory and motor in function. The ophthalmic branch of the trigeminal has been shown to be sensitive to magnetic fields.

Trigger neurons A class of command neurons whose short-lasting activation (e.g., less than a second) produces a long-lasting behavioral response (e.g., for tens of seconds). This term was coined in the study of leech swimming activation to distinguish these neurons from *gating neurons*, a class of command neurons that must be active during the whole time while a behavior takes place.

Tri-trophic level interactions Interactions that take place between organisms at three different levels within a food chain, for example, a plant, herbivore, and a carnivore.

Trivial movement See Appetitive movement.

Trophic cascades The indirect effects of top predators on the population processes of plants and animal species at lower trophic levels, as mediated by the density and foraging behavior of intermediate consumers.

Trophic level An organism's feeding position in a food web, with primary producers occupying the lowest level, herbivores the second, and carnivores occupying higher trophic levels.

Trophallaxis Mouth-to-mouth transfer of food or other substances.

Tropic hormone A hormone that modulates the secretion of another hormone.

True workers In termites, workers in colonies of foraging termites. They can be considered altruistic individuals as they perform most tasks within a colony (e.g., foraging, brood care, and building behavior) except for reproduction and specialized defense. Although they sometimes, especially in lower termites, still have some reproductive options (for instance as neotenic reproductives), their morphological differentiations (especially their sclerotization) largely restrict their developmental capability. In functional terms, these true workers, often just called workers, are equivalent to the workers of the social Hymenoptera, even though the latter are imagoes, whereas the true workers here are preimaginal stages.

Trypanosomiasis The name given to several diseases of vertebrates, including man, that are endemic in parts of Africa and the American continents. They are caused by protozoan parasites of the genus *Trypanosoma*.

Tuber Enlarged area of a root (e.g., a sweet potato).

Two-action design An experimental design used in social learning studies, in which each of two different actions on the same object is modeled in either of two different experimental conditions, permitting measurement of the extent to which observers match their later behavior to the alternative they witnessed.

Two-action procedure The demonstration of a response in two distinctly different ways that results in the same effect on the environment (e.g., stepping on vs. pecking at a treadle).

Tympanum Eardrum; a thin membrane that vibrates in response to sound.

Type I error A statistical error in which the null hypothesis is rejected when it is, in fact, true.

Type II error A statistical error in which the null hypothesis is not rejected when it is, in fact, not true.

Ultimate causation Evolutionary explanations of animal behavior. Questions about ultimate causes of behavior are about why a behavior is expressed. Ultimate causes explain the adaptive significance of behavior.

Ultrasonic vocalization A vocalization consisting only of frequencies higher than 20 kHz, that is, higher than the range of frequencies audible to human ears. Many species hear very high frequencies, well above the frequency range of human hearing.

Ultrasound Sounds with frequencies above the limit of human hearing; normally considered to be 20 kHz and higher.

Unconstrained parents Individuals mated to partners they do individually prefer.

Undertaking behavior A behavioral routine found in social insects that involves collecting and removing the corpses of colony-mates from the nest.

Units In extracellular multichannel recordings, investigators use mathematical techniques to separate differently sized and shaped action potentials from each other, calling each one a 'unit.' It is thought that these represent recordings from individual neurons. Because of the properties of extracellular recording, however, one cannot be absolutely certain that these are unique neurons. Hence, people who work in this area often use the less specific term 'unit.'

Univoltine Having but a single generation a year.

Unpalatable Unable to be eaten due to an unpleasant/noxious taste or toxicity.

Usage learning Where an animal comes to use an existing signal in a new context as a result of experience of the usage of signals by other individuals.

Usurpation Take over or adoption of nest, brood, and/or workers produced by other queens.

Vacuum activities Behaviors, such as fly snapping, performed out of context, without an obvious stimulus.

Vagotomy The transection of the vagus nerve.

Vagus nerve The tenth of the 12 pairs of cranial nerves, which originates in the brain stem and sends nerve fibers to the head, neck and viscera, including the lungs, heart, liver, and gastrointestinal tract. Most of the nerve fibers in the vagus nerve are sensory and the remainder are part of the parasympathetic nervous system. It contributes to the innervation of the viscera and conveys sensory information about the state of the body's organs to the central nervous system. The vagus is also called the *pneumogastric* nerve since it innervates both the lungs and the stomach.

Value One of the alternative states of a variable; in communication, one of the alternative signals of a code.

Value of information The fitness of an animal with access to information, contrasted to the fitness of an animal without access to the information.

Variable reinforcement schedule In operant conditioning, the reinforcement of a desired behavior is given at random intervals.

Variance A measure of statistical dispersion obtained by averaging the squared distance of its possible values from the expected value (mean). Whereas the mean is a way to describe the location of a distribution, the variance is a way to capture its scale or degree of being spread out.

Variance in fitness A measure of deviation from mean fitness.

Variance in number of mates Refers to a measure of the variation (deviation around the mean) in the number of mates obtained by different individuals of the same sex within a population. For example, in any given population, variance in number of mates is low when all individuals of one sex are able to obtain more or less the same number of mates. Variance in number of mates is high when some individuals mate with many members of the opposite sex, while others mate with very few or none.

Variance in reproductive success Refers to a measure of the variation (deviation around the mean) in number of young produced by different individuals of the same sex within a population. For example, in any given population, variance in RS is low when all individuals of one sex produce more or less the same number of young. Variance in RS is high when some individuals produce most of the young, while others produce few or none.

Varroa mite The mite species *Varroa destructor*, originally a pest of *Apis cerana* and now found on *A. mellifera*. A serious pest of honeybees and the cause of substantial colony mortality in *A. mellifera*.

Vasopressin A peptide produced predominantly by magnocellular cells within hypothalamus, but also by centrally projecting neurons within the hypothalamus and amygdala.

Vasotocin Peptide hormone secreted by the posterior pituitary; also released in the brain where it affects many social behaviors.

Veliger One of the larval stages of some mollusks, including gastropods.

Venomous Substances that are toxic and injure or kill animals, in most cases injected by biting or stinging.

Vent External opening of the cloaca.

Ventricle A cavity within the brain that is filled with cerebrospinal fluid. The cerebroventricular system comprises four ventricles: two lateral ventricles, the third ventricle, and the fourth ventricle. Cerebrospinal fluid flows from the lateral ventricles, to the third ventricle, then to the fourth ventricle before leaving the brain and entering the central canal of the spinal cord or into the subarachnoid space.

Vergence eye movements Eye movements where the angle between the eyes changes.

Vertex A component of a network with known relationships to others in the graph model representing the network; in a

social network, this can be an individual animal or group; also called a *node* or *point*.

Vertical social influence Influence by an individual on another from a different generation, such as a mother's influence on her offspring.

Vesicle Knob-like structure on the terminal region of a nerve cell that stores and releases neurotransmitters. Also called synaptic vesicle.

Viability Capacity for survival, more specifically used to mean a capacity for living, developing, or germinating under favorable conditions.

Viability selection Selection generated by variation in survival among individuals of a population.

Vibrissae Specialized hairs usually used for tactile sensation (singular: vibrissa).

Vicarious (or social) sampling Gathering of information about the environment by observation of the behavior or products of the behavior of others.

Vigilance Visual or auditory monitoring of the surroundings aimed at detecting threats related to predation. Vigilance can also be aimed at rivals or mates within the group.

Viral vector A virus that is engineered to transport a specific DNA sequence into infected cells.

Viscera The organs in the cavities of the body.

Visual acuity Spatial visual resolution, the minimum angular separation between two objects that are perceived as different within the visual field.

Visual fields Volume of space around an animal from which visual information can be obtained.

Vitellogenesis Yolk deposition into the oocyte (egg).

Vitellogenin Egg yolk precursor protein involved in regulation of behavioral maturation in social insects.

Viviparous An animal giving birth to live young which have developed inside the body of the parent.

Vocal mimicry Imitation by one species of sounds produced by another.

Vocal muscle A vertebrate striated muscle used in sound production; also known as 'sonic muscle.'

Vocal production learning Signals are modified in form as a result of experience with those of other individuals, leading to signals that are either similar or dissimilar to the model.

Vomer nasal organ (Jacobson's organ) An accessory olfactory (odor-detecting) organ that is located in the roof of the mouth or nasal septum. The vomeronasal organ is particularly important for processing odors related to social signals.

Waders Used in Europe and refers to shorebirds but used in North America with reference to herons and egrets.

Waiting game A game in which both predator and prey need to decide for how long to wait when the prey entered a refuge that restricts its ability to collect information about the continued presence of the predator.

Wave refraction zone The shallow area of ocean adjacent to a coastline where waves approaching the shore at an angle are redirected by interactions with the sea floor so that they approach directly toward shore.

Wavelength The spatial distance between two consecutive cycles of a sine wave. Numerically, wavelength is the velocity of sound divided by its frequency. In a given medium, low-frequency sounds have long wavelengths and high-frequency sounds have short wavelengths.

Weakly electric fish Electric fish with electric organs that produce very weak electric organ discharges that function in electrolocation and communication, but that are too weak to function in stunning predators or prey.

Weaning The transition of young mammals from nursing to independent feeding, especially the parent's role in facilitating that transition.

Weber's law A psychological law stating that one's ability to discriminate two quantities or intensities depends on the ratio between them.

Welfare The health, happiness, and prosperity of an individual in its state as regards its attempts to cope with its environment; equated with 'well-being,' generally measured on a scale from very good to very poor.

Welfare illustrator grid The assessment and two-dimensional illustration of welfare, designed to account for a temporal component and the cause of the animal's suffering.

'When' strategy A social learning strategy specifying the circumstances under which individuals copy others.

'Who' strategy A social learning strategy specifying from whom individuals learn.

Wild-type The phenotypic composition of an organism as it occurs in nature.

Wing aspect ratio The ratio of wing length to wing width; high aspect ratio wings permit fast, agile flight; low aspect ratio wings permit slow, maneuverable flight.

Wing polymorphism Having more than one wing form within a population, for example, long-winged (migratory) and short-winged (nonmigratory) individuals may be found within the same population of many species of planthoppers (known as 'wing-dimorphic species').

Wintering area In migratory birds, the area where populations spend the nonbreeding season, usually at lower latitudes.

Wintering dispersal The distance between the wintering site of an individual in one year and its wintering site in another year.

Winter territory A home range that an individual occupies and defends its boundaries against others (usually conspecifics but sometimes other species as well). This territory/home range may be held exclusively by the individual or as a pair or as a small group.

Wiring costs The energetic costs associated with total length neural wiring (axons and dendrites).

Wisdom of crowds The principle that the collective performance of a group of decision-makers can exceed that of a randomly chosen individual acting alone.

Within-pair offspring (WPC) Offspring sired by the social father.

Within-sex variance in reproductive success An operational definition of sexual selection.

Worker Individual in a eusocial society that primarily performs all nonreproductive tasks in a colony. In primitively eusocial groups, this individual may be physically capable of reproduction; however, in highly eusocial groups, it is effectively sterile.

Xenoestrogens Chemicals that are produced for agricultural, private, or industrial use that have estrogenic activity in living organisms.

X-organ A group of neurosecretory neurons in the crustacean eyestalk that synthesize several peptide hormones.

Y-organ The molting gland of crustaceans that usually secretes ecdysone, the precursor of the active form of the molting hormone, 20-hydroxyecdysone.

Zeitgeber German word for ‘time-giver’; an exogenous cue that entrains an endogenous biological rhythm.

Zoological psychology A part of animal psychology that lies at the boundary between psychology and zoology. The approach is animal-centered in that the focus is primarily on studying the life of the animal rather than on asking arbitrary questions in a so-called animal model. The emphasis is often upon the natural behavioral repertoire of the animal rather than training the animal to engage in some arbitrary task.

Zoopharmacognosy The study of how animals use medicinal substances. Interchangeably used by some with the term animal self-medication.

Zooplankton Small pelagic organisms in aquatic ecosystems that form central part of the food web. They typically eat algae (phytoplankton) and are consumed by small (planktivorous) fish.

Zugunruhe Migratory restlessness (hopping or hovering) in caged migratory birds often oriented with respect to seasonal directions of migration (e.g., northward in spring and southward in fall).

Zygote A newly fertilized egg.