Abiotic factors: These are the environment's nonliving component, encompassing physical & chemical factors such as temperature, available energy forms, water, & nutrients. Climate, for example, is an abiotic factor that often determines the distribution of communities. Abiotic reservoirs: These are locations where chemicals accumulate or are stockpiled outside of living organisms within a biogeochemical cycle. Examples include the atmosphere for carbon & nitrogen, & soil for phosphorus & nitrogen. Absorption: In fungi, absorption is the process by which they acquire nutrients after secreting powerful enzymes to digest their food externally. Alternation of generations: This refers to the plant life cycle that involves an alternation of a haploid generation, which produces eggs & sperm, & a diploid generation, which produces spores within protective structures called sporangia. In this cycle, haploid & diploid stages are distinct, multicellular bodies. Amniotes: This clade includes reptiles (including birds) & mammals. Their major derived character is an amniotic egg with four internal membranes, allowing them to complete their life cycles entirely on land. Amniotic egg: This is the major derived character of amniotes, possessing four internal membranes. It contains a fluid-filled sac (amnion) surrounding the embryo, a yolk sac for nutrients, an allantois for waste disposal, & a chorion (with allantois) for gas exchange. Its waterproof shell allows vertebrates to complete their life cycles on land. Amoebocytes: These are cells found in sponges that wander through the middle body region & produce supportive skeletal fibers composed of flexible protein (spongin) & mineralized particles (spicules). They also pick up & digest food from choanocytes & distribute nutrients to other cells. Amphibians: These are tetrapods that include salamanders, frogs, & caecilians. They typically use their moist skins to supplement their lungs for gas exchange, often have poison glands, usually return to standing water to reproduce, & undergo metamorphosis from a larval to an adult form. They were the first tetrapods able to move on land. Angiosperms: These are flowering plants that include flowering trees & grasses. Their seeds develop within protective ovaries, which mature into fruits that aid in seed dispersal. About 90% of angiosperms use animals for pollen transfer. Annelid: This phylum (Annelida) refers to segmented worms. Their bodies are subdivided along their length into a series of repeated parts (segments). They have a true coelom that functions as a hydrostatic skeleton, a nervous system, & a closed circulatory system. Examples include earthworms, polychaetes, & leeches. Anterior: This refers to the distinct head end of an animal with bilateral symmetry. For example, the anterior end of a tapeworm is called the scolex. Anther: This is a sac at the top of each stamen in a flower that contains male sporangia & will eventually release pollen. Anthropoids: This group includes monkeys & apes. They began diverging from other primates about 55 million years ago. Apical meristems: These are growth-producing regions of cell division found near the tips of stems & roots in land plants. Arachnids: A group of chelicerates that includes scorpions, spiders, ticks, & mites. Spiders, a diverse group of arachnids, hunt insects or trap them in webs of silk. Arthropods: This phylum (Arthropoda) includes crayfish, lobsters, crabs, barnacles, spiders, ticks, & insects. Their diversity & success are attributed to their segmentation, a hard exoskeleton, & jointed appendages. They have an open circulatory system. Ascomycetes: Also known as sac fungi, they are named for their saclike structures called asci that produce spores in sexual reproduction. They include unicellular yeasts, morels, & cup fungi, & some are plant pathogens. Basidiomycetes: Also known as club fungi, these include common mushrooms, puffballs, & shelf fungi. They are named for their club-shaped, spore-producing structure called a basidium. Many are important forest decomposers & include destructive plant parasites like rusts & smuts. Behavior: An action carried out by muscles or glands under the control of the nervous system in response to an environmental cue. Collectively, it is the sum of an animal's responses to internal & external environmental cues. Behavioral ecology: This is the study of behavior in an evolutionary context. It investigates how animal behaviors develop, evolve, & contribute to an animal's survival & reproductive success. Bilateral symmetry: Animals with bilateral symmetry have mirror-image right & left sides & distinct anterior (head), posterior (tail), dorsal (back), & ventral (bottom) surfaces. This symmetry often facilitates mobility. Bilateria: This is a clade that includes the vast majority of animal species that possess bilateral symmetry. Biocapacity: This refers to Earth's capacity to renew resources. When human demand for resources exceeds Earth's biocapacity, it leads to resource depletion. Biodiversity: This term refers to the variety of living things. It encompasses ecosystem diversity, species diversity, & genetic diversity. Biodiversity hot spot: This is a relatively small area with numerous endemic species (found nowhere else) & a large number of endangered & threatened species. These areas are highly sensitive to habitat degradation. Biogeochemical cycles: These are chemical cycles in an ecosystem that include both biotic & abiotic (geologic & atmospheric) components. They describe the recycling of chemical elements essential for life. Biological magnification: This is the process where toxins become concentrated as they pass through the food chain. Top-level consumers are usually the most severely affected. Biomes: These are major types of ecological associations that occupy broad geographic regions of land or water. Terrestrial biomes are primarily determined by temperature & precipitation, while aquatic biomes are defined by salinity & availability of light & nutrients. Biosphere: This is all of Earth that is inhabited by life. It extends from the atmosphere several kilometers above Earth to the depths of the oceans. Biotic factors: These include all of the organisms in an area, representing the living component of the environment. Birds: Birds are a group of reptiles that have evolved adaptations for flight, such as feather-covered wings, large flight muscles, & features to reduce weight like lacking teeth. They are amniotes & endothermic. Bivalves: This group of molluscs includes clams, oysters, mussels, & scallops, & they have shells divided into two halves that are hinged together. Most are sedentary suspension feeders. Blastula: This is an early embryonic stage of animals, usually a hollow ball of cells, formed when a zygote divides by mitosis. Body cavity: In animals with three embryonic layers, this is a fluid-filled space between the digestive tract & outer body wall. It cushions internal organs & allows them to grow & move independently. A true coelom is completely lined by mesoderm-derived tissues, while a pseudocoelom is not. Bryophytes: These are seedless, nonvascular plants that include mosses, liverworts, & hornworts. They lack true roots, leaves, & lignified cell walls. Carpel: This is the female reproductive structure at the center of a flower. It includes the stigma, style, & ovary, which encloses the ovules. Centipedes: These are myriapods, a lineage of arthropods, characterized by having a pair of long legs per body segment. Cephalopods: This group of molluscs (e.g., octopuses & squids) are fast, agile predators with large brains & sophisticated sense organs, including complex image-focusing eyes. Their shell can be large, small & internal, or missing. Chelicerates: A major lineage of arthropods named for their clawlike feeding appendages. Their bodies consist of a cephalothorax & an abdomen, & they lack antennae. Horseshoe crabs & arachnids are examples. Chemical cycling: This refers to the transfer of matter within the ecosystem. Unlike energy flow, chemical elements are recycled within ecosystems. Chitin: This is a strong, flexible nitrogen-containing polysaccharide that makes up the cell walls of most fungi. It is identical to the chitin found in the external skeletons of insects. Choanocytes: These are flagellated "collar" cells that form the inner layer of cells in sponges & help to sweep water through the sponge's body, trapping food particles in mucus. Chondrichthyans: This group of jawed vertebrates includes sharks & rays. They have a flexible skeleton made of cartilage. Chytrids: These are thought to represent the earliest lineage of fungi to diverge. They are the only fungi with flagellated spores. Circulatory system: In molluscs, this system pumps blood throughout the body. It can be either open or closed. Closed circulatory system: In this type of circulatory system, blood remains enclosed in vessels throughout the body. Annelids & vertebrates have closed circulatory systems. Club fungi: This is an informal name for basidiomycetes. Clumped dispersion pattern: This is the most common dispersion pattern in nature, where individuals are grouped in patches. It often results from unequal distribution of resources or social behavior. Cnidarians: This phylum (Cnidaria) is characterized by radial symmetry & only two tissue layers (outer epidermis, inner layer lining digestive cavity). They exhibit two radially symmetrical body forms: polyp (sedentary) & medusa (mobile). They possess unique stinging cells called cnidocytes. Examples include hydras, sea anemones, corals, & jellies. Cnidocytes: These are unique stinging cells found in cnidarians that function in defense & in capturing prey. Each contains a fine thread coiled within a capsule that can sting or entangle prey when discharged. Coevolution: This is a series of reciprocal evolutionary adaptations in two species. It occurs when a change in one species acts as a new selective force on another, & the resulting adaptations of the second species in turn affect the selection of individuals in the first. Community: Defined as an assemblage of all the populations of organisms living close enough together for potential interaction. Ecologists define the boundaries of a community based on their research questions. Complete digestive tract: This refers to a digestive system that extends as a tube from a mouth to an anus. Food travels one way through the system, allowing for specialized regions for processing. Nematodes are an example of animals with a complete digestive tract. Complete metamorphosis: This is a type of insect metamorphosis where a free-living larva transforms from a pupa into an adult. The larval stage is specialized for eating & growing, while the adult is specialized for reproduction & dispersal. Conservation biology: This is a goal-oriented science that seeks to understand & counter the loss of biodiversity. It focuses on protecting populations of threatened species & sustaining entire ecosystems. Crustaceans: These are mostly aquatic pancrustaceans that include lobsters, crayfish, barnacles, crabs, & shrimps. Cuticle: In plants, this is a waxy covering on the aboveground parts that prevents water loss. In nematodes, it's a nonliving covering that protects the body & is periodically shed. In arthropods, it's a hard exoskeleton made of protein & chitin. Decomposers: These are consumers that derive their energy from detritus. They are mainly prokaryotes & fungi that secrete enzymes to digest organic materials & convert them into inorganic forms through decomposition. They link all trophic levels. Decomposition: The process by which decomposers break down organic materials into inorganic compounds that plants or phytoplankton can use. Density-dependent factors: These are limiting factors whose intensity is related to population density. Examples include intraspecific competition (for food or space), disease, & predation. Density-independent factor: This is a population-limiting factor whose intensity is unrelated to population density. Examples include abiotic factors like weather changes (e.g., hot & dry weather killing aphids, freezing temperatures killing adult insects) & disturbances like fire or storms. Detritivores: These are organisms whose diet is made up primarily of decaying organic material (detritus). Earthworms & millipedes are examples. Detritus: This refers to the dead material produced at all trophic levels, including animal wastes, plant litter, & the bodies of dead organisms. Deuterostomes: Animals with three tissue layers whose opening formed during gastrulation develops into the anus. Echinoderms & chordates are deuterostomes. Deuterostomia: This is a clade of bilaterian animals that includes echinoderms & chordates, all of which undergo deuterostome embryonic development. Dispersion pattern: This refers to the way individuals are spaced within their area in a population. Patterns can be clumped, uniform, or random. Disturbances: These are events that damage biological communities by removing organisms or altering the availability of resources. Examples include storms, fires, floods, droughts, overgrazing, or human activities. Dorsal: This refers to the back surface of an animal with bilateral symmetry. Dorsal hollow nerve cord: One of the four distinctive features of chordates, present in embryos & often adults, located on the dorsal side of the body. Ecdysozoa: A lineage of bilaterians that includes nematodes & arthropods, characterized by having external skeletons that must be shed (molting or ecdysis) for the animal to grow. Echinoderms: This phylum (Echinodermata) includes sea stars, sand dollars, & sea urchins. They are slow-moving or sessile, all marine, radially symmetrical as adults (though bilaterally symmetrical as larvae), & deuterostomes. They have spiny skin, an endoskeleton, & a water vascular system for movement. Ecological footprint: An estimate of the land & water area required to provide the resources an individual or a nation consumes (e.g., food, fuel, housing) & to absorb the waste it generates. Ecological niche: The sum of an organism's use of the biotic & abiotic resources in its environment. It encompasses everything a species needs for its existence. Ecological succession: A process where a disturbed area is colonized by a variety of species, which are gradually replaced by a succession of other species. It can be primary (begins in lifeless area with no soil) or secondary (disturbance clears community but leaves soil intact). Ecology: The scientific study of the interactions between organisms & the environment. It describes the distribution & abundance of organisms. Ecosystem: This level of ecological study includes both the biotic & abiotic components of the environment. Ecosystem ecologists study how chemicals cycle & energy flows within them. Ecotourism: This is travel to natural areas for tourism & recreation, which has become an important source of revenue for conservation efforts, especially in zoned reserves. Ectoderm: One of the three embryonic layers established during gastrulation in many animals; it forms an outer layer that will give rise to the skin & nervous system. Ectothermic: Animals that are ectothermic absorb external heat rather than generating much of their own body heat. This is a more appropriate term than "cold-blooded" for reptiles. Embryophytes: This term designates plants due to the fact that their fertilized egg (zygote) develops into an embryo while attached to & nourished by the parent plant. This multicellular, dependent embryo is a distinguishing feature of plants, separating them from algae. Endemic species: These are species that are found nowhere else in the world. Biodiversity hot spots are characterized by an exceptional concentration of endemic species. They are highly sensitive to habitat degradation because they are limited to specific areas. Endoderm: In animal embryonic development, the endoderm forms the lining of the future digestive tract. It is one of the three embryonic layers established during the gastrula stage. Endoskeleton: This refers to an internal skeleton. In echinoderms, such as sea stars, the endoskeleton is made of hard calcium-containing plates under a thin skin, which extend into prickly bumps or spines. In vertebrates, the endoskeleton is made of either flexible cartilage or a combination of hard bone & cartilage, & it can grow with the animal due to living cells that secrete the nonliving material. Endothermic: This term describes animals that use heat generated by metabolism to maintain a warm, steady body temperature. Birds & mammals are examples of endothermic animals. Energy flow: This is the passage of energy through the components of an ecosystem. It moves chemical nutrients & energy from producers up through the trophic levels in a community. Energy enters an ecosystem, often from sunlight, is transferred through organisms, & much of it is lost as heat, meaning the ecosystem would run out of energy without a continuous inflow. Errantians: One of the two major clades of annelids, most errantians are marine & have an active, mobile lifestyle, often crawling or burrowing in sediments or being free-swimming. Their heads are well-equipped with sensory organs, & many have paddle-like appendages with stiff bristles that aid locomotion. Eumetazoa: This clade, meaning "true animals," includes animals with true tissues, distinguishing them from sponges which lack tissues. Eutherians: These are mammals that bear fully developed live young. They are commonly called placental mammals because their placentas are more complex than those of marsupials, & the young complete their embryonic development in the mother's uterus attached to the placenta. Elephants, rodents, rabbits, dogs, cows, whales, bats, & humans are examples of eutherians. Exoskeleton: This is a hard external skeleton that covers the body of arthropods. It protects the animal & provides attachment points for muscles that move the appendages. This nonliving covering, a cuticle, is hardened by layers of protein & chitin. As an arthropod grows, it must periodically shed its old exoskeleton in a process called molting or ecdysis. Extinction: This refers to the irreversible loss of all populations of a species. It is a major concern in biodiversity loss. Extirpation: This is the loss of a single population of a species from a local ecosystem, even if other populations survive elsewhere. Flatworms (Phylum Platyhelminthes): These are the simplest bilaterians, characterized by bilateral symmetry & three tissue layers, but they lack a body cavity. They live in marine, freshwater, & damp terrestrial habitats, & can be free-living or parasitic. Most have a gastrovascular cavity with only one opening. Flukes: These are a group of parasitic flatworms. They have complex life cycles, often involving intermediate hosts like snails, & possess suckers to attach to their hosts. Food chain: This is the sequence of food transfer up the trophic levels in a community. It illustrates how chemical nutrients & energy move from producers to consumers. Food web: This is a network of interconnecting food chains . It provides a more realistic view of trophic structure, as consumers often eat more than one type of producer, & multiple consumer species may feed on the same producer. Foot: In molluscs, the foot is a muscular part that functions in locomotion. In bivalves, it may be used for digging & anchoring, while in cephalopods, it is drawn into several long tentacles for catching & holding prey. Fossil fuels: These are coal, oil, & natural gas, formed from the remains of ancient organisms. Coal, specifically, is black sedimentary rock made up of fossilized plant material from immense swamp forests during the Carboniferous period. The burning of fossil fuels significantly increases atmospheric CO_2 levels. Free-living flatworms: These are a group of flatworms, exemplified by planarians, that live independently in marine, freshwater, & damp terrestrial habitats, rather than as parasites. Fungi: These are absorptive heterotrophic eukaryotes that secrete powerful enzymes to digest their food externally. Most consist of a mass of threadlike hyphae forming a mycelium. Fungal cell walls are made of chitin. They are essential decomposers in most ecosystems. Gametangia: These are male & female structures in mosses & ferns that produce gametes, consisting of protective jackets of cells surrounding the gamete-producing cells. The egg remains in the female gametangium & is fertilized there by sperm that swim through a film of water. Gametophyte: This is the haploid generation of a plant that produces gametes (eggs or sperm) by mitosis. In mosses & other nonvascular plants, the gametophyte is the larger, more obvious stage of the life cycle. Spores grow into gametophytes. Gastropods: This is the largest group of molluscs, including snails & slugs, found in fresh water, salt water, & terrestrial environments. Most are protected by a single, spiraled shell. Gastrovascular cavity: This is a multifunctional compartment in cnidarians where food is digested. It serves in digestion & circulation, & its fluid pressure also acts as a hydrostatic skeleton to support the body. It has only one opening, serving as both mouth & anus. Gastrula: This is an embryonic stage formed when one side of the blastula folds inward & cells rearrange to establish three embryonic layers. Germinates: This describes the process when a seed begins to grow under favorable conditions, with the embryo using its food supply until it can photosynthesize. Also, a fungal spore that lands in a moist place with food will germinate to produce a new haploid fungus. Glomeromycetes: These are a group of fungi that form a distinct type of mycorrhiza where haploid invade plant root cells, branching into tiny treelike structures called arbuscules. They deliver phosphate & other minerals to plants in exchange for organic nutrients. Gross primary production: This is the total amount of solar energy converted to chemical energy by an ecosystem's producers through photosynthesis during a given time period. Gymnosperms: These are among the earliest seed plants, characterized by "naked seeds" that are not produced in special chambers. They include cone-bearing trees like pines, spruce, & fir, as well as ginkgo & cycads. Habitat: This is the specific environment an organism lives in, which includes both the biotic (living) & abiotic (nonliving) factors present in its surroundings. Habitat loss is the single greatest threat to biodiversity. Herbivory: This is the consumption of plant parts or algae by an animal. Plants have evolved numerous defenses against herbivores, such as spines, thorns, & chemical toxins. Heterokaryotic stage: In the sexual reproduction of many fungi, this is a stage where cells contain two genetically distinct haploid nuclei (one from each parent) that have fused cytoplasm but not yet fused nuclei. Hominins: These are species that are more closely related to humans than to chimpanzees, forming the human branch of the evolutionary tree. The oldest known hominin, Sahelanthropus tchadensis, lived about 7 to 6 million years ago. Hyphae: These are threadlike filaments that form the feeding structures of a fungus. They branch repeatedly to form a mass called a mycelium. Hyphal cells have a huge surface area to secrete digestive enzymes & absorb food. Imperfect fungi: This is an informal term for fungi in which asexual reproduction is the only known means of spore production. Molds & yeasts are often classified as imperfect fungi. Incomplete metamorphosis: In some insect species, this is a type of metamorphosis where the transition from larva to adult is achieved through multiple molts, but without forming a pupa. Juvenile forms may resemble adults. Ingestion: This is the process of eating food, which is how most animals obtain nutrients. This contrasts with fungi, which absorb nutrients externally. Interspecific competition: This occurs when populations of two different species compete for the same limited resource. It happens when the ecological niches of two populations overlap. Interspecific interactions: These are relationships between individuals of different species within a community. They greatly affect population structure & dynamics & can be categorized (e.g., competition, mutualism, predation, herbivory, parasitism). Intraspecific competition: This refers to competition between individuals of the same species for limited resources such as food or space. It is a density-dependent factor that can restrict population growth. Invasive species: These are organisms that have been introduced into non-native habitats by human actions & have established themselves at the expense of native communities. Their rapid population growth is often due to the absence of natural enemies. They are a leading cause of local extinctions & cause significant environmental & economic damage. Invertebrates: These are animals that lack a backbone. They comprise roughly 96% of all animal species & play critical roles in ecosystems. Keystone species: This is a species whose impact on its community is much larger than its abundance or total biological mass would indicate. Their niche holds the rest of the community in place, & their removal often results in lower species diversity. Lancelets: These are simple, bladelike chordates that live in marine sands. They are invertebrate chordates, meaning they do not have a backbone, & use their pharyngeal slits for suspension feeding. Landscapes: These are arrays of ecosystems, usually visible from the air as distinctive patches. Landscape ecology applies ecological principles to study the structure & dynamics of a collection of ecosystems. Larva: This is an immature individual that looks different from the adult animal. Larvae undergo a major change in body form called metamorphosis to become a reproductively mature adult. Lateral line system: This is a sensory system found in tadpoles (larval amphibians) that resembles that of fishes. Lichens: These are symbiotic associations of millions of microscopic green algae or cyanobacteria held within a mass of fungal hyphae. The fungus receives food from its photosynthetic partner, & the fungal mycelium helps the alga absorb & retain water & minerals. They are rugged pioneers on new land, helping to break down rock into soil. Lignin: This is a substance that supports the body of many land plants against gravity. The absence of lignified cell walls in mosses & other plants lacking vascular tissue limits their height. Fungi like basidiomycetes excel at breaking down lignin in wood. Lobe-fins: These are a group of fishes characterized by muscular pelvic & pectoral fins that are supported by rod-shaped bones. This lineage gave rise to tetrapods. Lophotrochozoa: This is one of the three main lineages of bilaterians, which includes flatworms, molluscs, & annelids. The name comes from a feeding apparatus (lophophore) found in some phyla & a ciliated larva (trochophore) found in molluscs & annelids. Mammals: These are amniotes that have hair & mammary glands, which produce milk. They are endothermic & have efficient respiratory & circulatory systems, as well as differentiated teeth. Mantle: In molluscs, this is a fold of tissue that drapes over the visceral mass & may secrete a shell. It often forms a water-filled mantle cavity that houses the gills. Marsupials: These are mammals that have a brief gestation & give birth to tiny, embryonic offspring that complete development while attached to the mother's nipples, often housed in an external pouch. Medusa: This is one of the two radially symmetrical body forms exhibited by cnidarians, characterized by a more mobile, umbrella-like shape with tentacles around the lower edge. Marine jellies are an example. Mesoderm: This is the middle embryonic layer that forms during gastrulation in most animals. It gives rise to muscles & most internal organs. Metamorphosis: This is a major change in body form that an immature individual (larva) undergoes to become a reproductively mature adult. It is a common feature in insect life cycles. Millipedes: These are myriapods (arthropods) that have two pairs of short legs per body segment & primarily eat decaying plant matter. Mold: This term refers to any rapidly growing fungus that reproduces asexually by producing spores, often appearing as furry carpets on aging fruit or bread. Molluscs (Phylum Mollusca): These are soft-bodied animals, most of which are protected by a hard shell. They typically have a muscular foot, a visceral mass, & a mantle. Many feed with a rasping radula. Molting: This is the complex process by which an arthropod periodically sheds its old exoskeleton & secretes a new, larger one to permit growth. Monotremes: These are egg-laying mammals. Living monotremes include the duck-billed platypus & echidnas. Mutualism: This is an interspecific interaction where both populations benefit . Examples include plants & mycorrhizae, or flowers & their pollinators. Mycelium: This is a mass of threadlike hyphae that makes up the feeding structure of most fungi. It grows extensively through a food source, providing a huge surface area for enzyme secretion & food absorption. Mycorrhiza (plural Mycorrhizae): This represents a symbiotic relationship between fungi & plant root cells. Mycorrhizal fungi absorb phosphorus & other essential materials from the soil & make them available to the plant, while the plant nourishes the fungi with sugars from photosynthesis. They are present in nearly all vascular plants & are thought to have been crucial to the colonization of land by plants. Myriapods: These are a lineage of arthropods that have similar segments over most of their body & jointed legs, including millipedes & centipedes, & are all terrestrial. Nematodes (Phylum Nematoda): Also known as roundworms, they are abundant & diverse, with bilateral symmetry, three tissue layers, & a nonliving cuticle covering their body. They have a pseudocoelom body cavity & a complete digestive tract with a mouth & anus. Many are free-living decomposers, while others are plant or animal parasites. Net primary production: This is the amount of new organic material added to an ecosystem in a given period. It represents the stored chemical energy available to consumers after producers have used some for their own cellular respiration. Nitrogen fixation: This is a process performed by some bacteria that converts atmospheric nitrogen gas (N_2) into compounds of nitrogen that can be used by plants, such as ammonia (NH_3) or ammonium (NH_4^+). Notochord: This is a flexible, supportive, longitudinal rod located between the digestive tract & the nerve cord in chordate embryos & often adults. In hagfishes & lampreys, it is the main body support in adults. Ocean currents: These are currents that influence coastal climate, along with landforms & prevailing winds. Open circulatory system: In this type of circulatory system, found in many invertebrates like most molluscs & all arthropods, fluid is pumped through vessels that open into spaces surrounding tissues & organs, rather than remaining enclosed in vessels. Operculum: is a corneous or calcareous anatomical structure like a trapdoor that exists in many groups of sea snails & freshwater snails, & also in a few groups of land snails Organism: At the organism level of ecological study, researchers examine how one kind of organism meets the challenges & opportunities of its environment through its physiology or behavior. Ovary: In angiosperms, the ovary is a unique adaptation that encloses the ovules. After fertilization, the ovary matures into a fruit, which aids in seed dispersal. Ovules: These are structures within the angiosperm ovary. Each ovule contains a sporangium that produces a female gametophyte & will eventually become a seed after fertilization. Ozone layer: is a region of Earth's stratosphere that absorbs most of the Sun's ultraviolet radiation. Paleoanthropology: This is the study of human origins & evolution, focusing on the history since the divergence of human & chimpanzee lineages. Paleoanthropologists unearth & study hominin fossils. Pancrustacea: A clade suggested by recent evidence to include crustaceans & insects. This group consists almost entirely of aquatic organisms, except for insects, which are terrestrial. Parasites: Organisms that live on or in a host from which they obtain nourishment. Examples include nematodes, tapeworms, mosquitoes, ticks, & aphids. About 30% of known fungi species are parasites or pathogens, mostly on plants. Some human parasitic nematodes include Trichinella spiralis_(causing trichinosis) & hookworms. Pharyngeal slits: One of the four distinguishing features of chordates, located in the pharynx, the region just behind the mouth. In simple chordates like tunicates & lancelets, they are used for suspension feeding. Jaws in vertebrates may have evolved from modifications of the skeletal supports of the anterior pharyngeal slits, with the remaining slits serving as sites of gas exchange. Phloem: A type of vascular tissue in land plants that consists of living cells & conveys sugars throughout the plant. Placenta: A structure formed in mammals where nutrients from the mother's blood diffuse into the embryo's blood, supporting its development. The placentas of eutherians are more complex than those of marsupials. Placental mammals: Mammals that bear fully developed live young. They are commonly called placental mammals because their placentas are more complex than those of marsupials, & the young complete their embryonic development in the mother's uterus attached to the placenta. Examples include elephants, rodents, rabbits, dogs, cows, whales, bats, & humans. Pollen grains: Structures in pines & flowering plants that contain the sperm-producing cells. They are carried by wind or animals, eliminating the need for moisture for fertilization. Pollen grains are male gametophytes enclosed within a tough wall. Pollination: The event that occurs when a pollen grain lands on a compatible female structure. Polyp: A cylindrical, radially symmetrical body form of cnidarians with tentacles projecting from one end, typically more sedentary. Hydras & sea anemones are examples of polyps. Population: A group of individuals of a single species that occupy the same general area. Individuals in a population rely on the same resources, are influenced by the same environmental factors, & are likely to interact & breed with one another. Population ecologists define the boundaries of a population appropriate to the species & research purposes. Population density: The number of individuals of a species per unit area or volume. Examples include the number of oak trees per square kilometer in a forest or earthworms per cubic meter in forest soil. Ecologists use sampling techniques to estimate it. Population ecology: The scientific study of how & why populations change. It is concerned with changes in population size & the factors that regulate populations over time. It also examines population dynamics, which are the interactions between biotic & abiotic factors that cause variation in population sizes. Post-anal tail: One of the four distinguishing features of chordates, a muscular tail located posterior to the anus. Posterior: Refers to the tail end of an animal with bilateral symmetry. In tapeworms, the units at the posterior end are full of ripe eggs. Predation: An interspecific interaction in which one species (the predator) kills & eats another species (the prey). Predation significantly impacts prey reproductive success, leading to the evolution of numerous predator avoidance adaptations. Prevailing winds: Global wind patterns that, along with ocean currents, influence regional climate & the distribution of terrestrial communities. Primary consumers: Herbivores that eat plants, algae, or phytoplankton. Examples include grasshoppers, many insects, snails, grazing mammals, birds that eat seeds & fruits, & zooplankton. Primary production: The conversion of solar energy to chemical energy (as organic compounds) by photosynthesis, carried out by producers. Gross primary production is the total amount, while net primary production is the remainder after producers fuel their own cellular respiration, representing the stored chemical energy available to consumers. Primary succession: Ecological succession that begins in a virtually lifeless area with no soil, such as rubble left by a retreating glacier or fresh volcanic lava flows. Producers: Autotrophs ("self-feeders") that form the trophic level supporting all others. They convert light energy (or in some cases, chemical energy) into organic compounds through photosynthesis or chemosynthesis. Plants are the main terrestrial producers, while photosynthetic protists & cyanobacteria (phytoplankton) are the main aquatic producers. Protostomes: One of two groups into which animals with three embryonic layers can be separated based on embryonic development. In protostomes, the opening formed during gastrulation develops into the mouth. Flatworms, molluscs, annelids, nematodes, & arthropods are examples. Proximate causes: The immediate reason for a behavior, explaining how it is triggered by stimuli, what physiological or anatomical mechanisms play a role, & what underlying genetic factors are at work. Proximate questions: In behavioral ecology, these questions concern the immediate reason for a behavior, such as how it is triggered or what mechanisms are involved. Quaternary consumers: The highest trophic level in some food chains, eating tertiary consumers. Hawks & killer whales are examples. Radial symmetry: A type of body symmetry where body parts radiate from the center like spokes of a wheel. An imaginary slice through the central axis divides the animal into mirror images, meaning it has a top & bottom but no back/front or right/left sides. Cnidarians (hydras, sea anemones, jellies) exhibit radial symmetry. Adult echinoderms also display radial symmetry. Radula: A unique rasping organ found in many molluscs, used to scrape up food. Cephalopods use beak-like jaws & a radula to crush or rip prey apart. Random dispersion pattern: A pattern where individuals in a population are spaced in an unpredictable way, without a pattern. This is rare due to varying habitat conditions & social interactions. Dandelions, whose seeds are windblown, might show this pattern. Ray-finned fishes: A lineage of jawed fishes with gills & paired fins, whose internal skeleton is reinforced with a hard matrix of calcium phosphate. Their fins are supported by thin, flexible skeletal rays. They typically have an operculum covering their gills & a buoyant swim bladder. This group includes familiar species like tuna, trout, & goldfish. Reptiles: A clade of amniotes that includes lizards, snakes, turtles, crocodilians, & birds, as well as extinct dinosaurs. They have a skin covered with scales & waterproofed with keratin, obtain most oxygen using lungs, & are ectothermic. Birds are considered feathered reptiles. Restoration ecology: An expanding field that uses ecological principles to develop methods of returning degraded areas to their natural state. Strategies include bioremediation, replanting native vegetation, & returning waterways to their natural course. Sac fungi: Also known as ascomycetes, named for saclike structures called asci that produce spores in sexual reproduction. They are a diverse group found in various habitats & include elaborate morels & cup fungi, as well as some devastating plant pathogens. Scavengers: Large animals, such as crows & vultures, that feast on carcasses left behind by predators or other means. Secondary consumers: Carnivores that typically eat herbivores (primary consumers). On land, these include small mammals, birds, frogs, spiders, lions, & wolves. In aquatic ecosystems, small fish that eat zooplankton are secondary consumers. Secondary succession: Ecological succession that occurs when a disturbance destroys an existing community but leaves the soil intact. Sedentarians: One of the two major clades of annelids, which tend to be less mobile than errantians. This group includes earthworms, many tube-dwellers, & leeches. Seed: A structure that consists of an embryo packaged with a food supply within a protective covering. Seeds are an elaborate, embryo-containing structure well-protected from the elements & dispersed by wind or animals. Seed coat: A protective covering of a seed, derived from the tissues surrounding the ovule. In some plants, it extends into a wing-like structure for wind dispersal. Seedless vascular plants: A group of plants that evolved vascular tissue but still require moist conditions for fertilization & disperse offspring as spores. This group includes lycophytes (club mosses) & pterophytes (ferns & their relatives). Segmentation: The subdivision of the body along its length into a series of repeated parts (segments). This feature played a central role in the evolution of many complex animals, allowing for greater flexibility & mobility. It is characteristic of annelids & arthropods. Sepals: The outermost layer of a flower, often green & leaf-like, that enclose the flower before it opens. Sessile: Describes adult sponges & some echinoderms (like sea stars & sea urchins) as being anchored in place & unable to escape from predators. Many bivalves & barnacles are also sessile. Species diversity: A characteristic of a community defined by two components: species richness (the number of different species in a community) & relative abundance (the proportional representation of each species). High species diversity often provides a broader range of habitats & food sources, promoting overall diversity & having consequences for pathogen spread. Sponges: Members of the phylum Porifera, they are simple, sedentary animals without true tissues. Their porous body allows water to enter & filter food through flagellated choanocytes. Sporangia: Protective structures within which the diploid generation (sporophyte) produces spores. In gymnosperms, sporangia are found within cones. Spore: A cell that can develop into a new organism without fusing with another cell. The earliest land plants relied on tough-walled spores for dispersal. Fungi typically release vast numbers of haploid spores for reproduction. Sporophyte: The diploid generation in a plant's life cycle that produces haploid spores by meiosis within protective structures called sporangia. In ferns & most plants, including all seed plants, the sporophyte is the dominant stage. In all plants, the fertilized egg (zygote) develops into an embryo while attached to & nourished by the parent plant, becoming the sporophyte. Stamens: The male reproductive structures of a flower, consisting of a filament & an anther; the anther contains male sporangia & releases pollen. Stimuli: Environmental cues that cause a response in an animal. Animals respond to various stimuli, & their behaviors may be innate or learned responses to these stimuli. Suspension feeders: Animals that collect food particles from water passed through some type of food-trapping equipment. Sponges & tunicates are examples. Many bivalves are also sedentary suspension feeders. Sustainability: The goal of developing, managing, & conserving Earth's resources in ways that meet the needs of people today without compromising the ability of future generations to meet theirs. It involves using resources in a way that allows them to regenerate naturally or with technological assistance. Sustainable development: Development that meets the needs of people today without limiting the ability of future generations to meet their needs. It seeks to improve the human condition while conserving biodiversity, depending on increased ecological knowledge & valuing our linkages to the biosphere. Swim bladder: A gas-filled sac in ray-finned fishes that helps them stay buoyant. It evolved from balloon-like lungs used by ancestral fishes in shallow water for gas exchange. Tapeworms: Parasitic flatworms that inhabit the digestive tracts of vertebrates. They consist of a ribbon-like body with repeated units, have an anterior scolex with hooks & suckers to grasp the host, & absorb nutrients directly across their body surface as they lack a mouth & digestive tract. Temperate zones: Refers to mid-latitude regions where temperate broadleaf forests & temperate grasslands are found. These areas typically have distinct seasonal changes in temperature & precipitation. Tertiary consumers: Carnivores that typically eat secondary consumers. Snakes that eat mice are an example. Tetrapods: Jawed vertebrates with limbs & feet that can support weight on land. This lineage of lobe-finned fishes gave rise to all subsequent groups of vertebrates on land (amphibians, mammals, & reptiles, including birds). The evolution of tetrapods involved adaptations for gas exchange, water conservation, structural support, locomotion, & sensory organs in a terrestrial environment. Transpiration: The process by which plants release water vapor from their leaves into the atmosphere. While explicitly labeled in diagrams, the provided text does not offer a detailed definition of transpiration. Trophic structure: A pattern of feeding relationships consisting of several different levels within a community. The sequence of food transfer through these levels is known as a food chain. Tropics: Refers to equatorial areas where tropical forests cluster. These regions are characterized by warm temperatures & consistent day lengths year-round, with rainfall variability determining specific vegetation types. Tunicates: Simple chordates that do not have a backbone. Adult tunicates are stationary & attached, using pharyngeal slits for suspension feeding, while their larvae are tadpole-like & exhibit all four chordate features. They are often called sea squirts because they shoot a jet of water when threatened. Ultimate causes: Evolutionary explanations for a behavior, lying in its adaptive value & how natural selection has shaped it. Ultimate questions: In behavioral ecology, these questions address why a particular behavior occurs, considering its evolutionary history & adaptive value. Uniform dispersion pattern: An even dispersion pattern of individuals within a population. It often results from interactions between individuals, such as plants secreting chemicals to inhibit nearby growth or animals exhibiting territorial behavior. Vascular plants: Plants that evolved with lignin-hardened vascular tissues about 425 million years ago. This allowed them to stand upright & grow tall on land. They include seedless vascular plants (lycophytes & pterophytes) & seed plants (gymnosperms & angiosperms). Vascular tissue: A network of thick-walled cells joined into narrow tubes that extend throughout the plant body, used to conduct water & minerals upward from roots to leaves, & distribute sugars produced in leaves throughout the plant. It includes xylem (conveys water & minerals) & phloem (conveys sugars). Ventral: Refers to the bottom surface of an animal with bilateral symmetry. In a planarian, the mouth is on its midventral surface. Vertebrae: A series of bones that make up the backbone or vertebral column. In most vertebrates, the vertebrae enclose the nerve cord & provide skeletal support. Vertebral column: The backbone, composed of a series of bones called vertebrae, which is a distinguishing feature of vertebrates. Vertebrates: Animals that possess a backbone or vertebral column & a skull. They belong to the phylum Chordata & include hagfishes, lampreys, fishes, amphibians, reptiles (including birds), & mammals. Visceral mass: One of the three main parts of a mollusc's body, containing most of the internal organs. Water vascular system: A network of water-filled canals that branch into extensions called tube feet, unique to echinoderms. Tube feet function in locomotion, feeding, & gas exchange. Xylem: A type of vascular tissue in land plants that consists of dead cells & conveys water & minerals up from the roots. Yeast: Any single-celled fungus. Yeasts reproduce asexually by cell division, often by budding, & inhabit liquid or moist habitats. They are used in producing alcohol & causing bread to rise. Zoned reserve: An approach to conservation consisting of undisturbed wildlands surrounded by buffer zones of compatible economic development. Costa Rica has established many such reserves. Zygomycetes: Also known as zygote fungi, they are characterized by their protective zygosporangium, where zygotes produce haploid spores by meiosis. This diverse group includes fast-growing molds that attack bread & various produce.

--DETAILED INFO ON A FEW TOPICS--

Adaptations for Life on Land - Land plants have evolved several key adaptations to survive in a terrestrial environment. One important adaptation is a waxy cuticle covering the above ground parts, which helps prevent water loss. However, the cuticle also restricts gas exchange, so plants developed stomata, tiny pores on leaf surfaces regulated by surrounding cells, to allow CO_2 & O_2 diffusion. - To obtain resources from both the soil & the air, plants developed distinct organs: roots anchor the plant & absorb water & minerals from the soil, while leaves obtain CO_2 from the air & sunlight for photosynthesis. Apical meristems, growth-producing regions of cell division, are found near the tips of stems & roots, enabling elongation & branching to maximize resource exposure. - Many land plants also possess vascular tissues (xylem & phloem) that efficiently transport water, minerals, & sugars throughout the plant body. Xylem consists of dead cells that convey water & minerals up from the roots, while phloem consists of living cells that distribute sugars produced in the leaves.

Alternation of Generations - Plants exhibit a unique life cycle called alternation of generations, where both haploid (n) & diploid (2n) stages are distinct, multicellular bodies. - The haploid gametophyte stage is responsible for producing gametes (eggs or sperm) through mitosis. - Fertilization of these gametes results in a diploid zygote, which then develops into the diploid sporophyte stage. The sporophyte produces haploid spores through meiosis. These spores, when dispersed, can germinate & develop into new gametophytes, completing the cycle. - The dominance of either the gametophyte or sporophyte generation varies among plant groups; for instance, the moss life cycle is dominated by the gametophyte, while ferns & most other plants have a dominant sporophyte.

Amniotes: Terrestrial Adaptations of Reptiles & Birds - Reptiles (including lizards, snakes, turtles, crocodilians, birds, & extinct dinosaurs) & mammals are amniotes, a clade defined by the presence of an amniotic egg. - The amniotic egg is a terrestrially adapted egg containing specialized extraembryonic membranes: the amnion (fluid-filled sac surrounding the embryo), yolk sac (nutrients), allantois (disposal of metabolic waste, gas exchange), & chorion (gas exchange). This waterproof shell allowed vertebrates to complete their life cycles entirely on land. - Reptiles generally have skin covered with scales waterproofed with keratin & primarily use lungs for oxygen uptake. Most are ectothermic, relying on external heat. - Birds are feathered reptiles with remarkable adaptations for flight, including a high metabolic rate (making them endothermic), reduced weight (lack of teeth, hollow-shafted feathers, honeycombed bones), & acute senses with large brains for complex behaviors.

Angiosperm Reproduction: Flowers & Fruits - The flower is the central reproductive structure in angiosperms, housing separate male & female sporangia & gametophytes. Flowers typically consist of sepals (enclosing the flower before opening), petals (attracting pollinators), stamens (male reproductive parts, with a filament & anther that releases pollen), & carpels (female reproductive structure, producing eggs). - A key angiosperm adaptation is the ovary, which encloses the ovules. After fertilization, ovules develop into seeds, & ovaries mature into fruits. - Fruits are adaptations that aid in seed dispersal, using mechanisms like wind (e.g., dandelion's parachute-like extensions) or hitching rides on animals (e.g., cocklebur's hook-like modifications). This diverse array of flower structures & fruit dispersal methods contributes to the widespread success of angiosperms. - About 90% of angiosperms use animals to transfer their pollen. This has led to coevolution, with flowers evolving features like colorful petals (attracting birds), fruity odors (attracting beetles), or large, highly scented flowers (attracting night-flying bats & moths).

Animal Body Plans: Key Features for Classification - Animals can be characterized by basic features of their "body plan," which are used to infer phylogenetic relationships. - Symmetry is a primary feature: radial symmetry means the animal has a top & bottom but lacks distinct front/back or right/left sides, while bilateral symmetry (characteristic of most animals) involves mirror-image right & left sides, a distinct head (anterior) & tail (posterior) end, & dorsal (back) & ventral (bottom) surfaces. - The presence of true tissues is another distinguishing feature; sponges are the only animals that lack true tissues. Most other animals form specialized tissues from embryonic layers. - The number of embryonic layers (two, ectoderm & endoderm, or three, including mesoderm) further characterizes animals. Animals with three layers may also possess a body cavity or coelom, a fluid-filled space that cushions organs & allows independent movement. A true coelom is fully lined by mesoderm-derived tissues, while a pseudocoelom is not. - Embryonic development details, specifically what the first opening formed during gastrulation becomes, differentiate protostomes (mouth develops first) from deuterostomes (anus develops first).

Arthropods: The Most Successful Animal Phylum - With over a million identified species & potentially up to 30 million, arthropods (phylum Arthropoda) are the most successful animal phylum in terms of species diversity, geographic distribution, & sheer numbers. - Their success is largely attributed to three key features: segmentation (subdivision of the body into repeated parts, allowing flexibility), a hard exoskeleton (an external skeleton made of protein & chitin, providing protection & muscle attachment, but requiring molting for growth), & jointed appendages (for which the phylum is named, adapted for various functions like sensory reception, defense, feeding, walking, & swimming). - The arthropod body typically comprises a head, thorax, & abdomen, though these may be fused into a cephalothorax. They possess an open circulatory system. - Insects, the fourth lineage of arthropods, are the most diverse group within the phylum, making up about 70% of all identified animal species. Their extraordinary success is due to features like flight, a waterproof cuticle, short generation times, & complex life cycles often involving metamorphosis (complete or incomplete), which reduces intergenerational competition for food. Their modular body plan, where embryonic segments can develop independently, allows for significant diversification of specialized appendages like mouthparts & wings through changes in homeotic gene expression.

Biotic & Abiotic Factors - The environment is composed of two major types of factors that influence organisms: - Biotic factors are the living components of the environment, including all the organisms in an area (e.g., animals, plants, fungi, bacteria). These include food sources, predators, competitors, & pathogens. - Abiotic factors are the nonliving physical & chemical components of the environment. Important abiotic factors include: energy source (usually solar energy, or chemical energy for chemosynthetic ecosystems); temperature (influencing metabolism, with adaptations for extremes); water (essential for all life, with concerns for dehydration in terrestrial & solute concentration in aquatic environments); nutrients (inorganic chemicals like nitrogen & phosphorus); & other factors like oxygen availability (in aquatic environments), salinity, current, tides, wind, & fire (on land). - Organisms are adapted by natural selection to the specific biotic & abiotic factors present in their habitat.

Community Structure & Interspecific Interactions - A biological community is an assemblage of all the populations of organisms living close enough together for potential interaction. Its structure is described by species composition, which includes species richness (the number of different species) & relative abundance (the proportional representation of each species). High diversity provides more habitats & food sources, potentially leading to higher animal diversity & reduced pathogen spread. - Interspecific interactions are relationships between individuals of different species within the community, significantly affecting population structure & dynamics. These can be categorized by their effects on each species: - Competition (-/-): Occurs when populations of two different species compete for the same limited resource & their ecological niches overlap. Competition generally lowers the carrying capacity for both competing populations. - Mutualism (+/+): Both interacting populations benefit (e.g., corals & dinoflagellates, where algae provide food to corals). - Predation (+/-): One species (predator) kills & eats another (prey). This leads to diverse protective adaptations in prey, such as camouflage, mechanical defenses (e.g., spines), & chemical defenses (often coupled with warning coloration). - Herbivory (+/-): An animal (herbivore) consumes plant parts or algae. Plants have evolved numerous defenses, including spines, thorns, & chemical toxins, sometimes leading to coevolution (reciprocal evolutionary adaptations) with herbivores. - Parasitism (+/-): A parasite lives on or in a host, obtaining nourishment from it. Pathogens are disease-causing microscopic parasites (bacteria, viruses, fungi, protists) that can have rapid & dramatic impacts on communities, especially non-native ones (e.g., chestnut blight).

Conservation Biology & Protected Areas - Conservation biology is a goal-oriented science focused on understanding & countering the rapid loss of biodiversity. Efforts involve protecting endangered populations, often through captive breeding programs & reintroduction into the wild (e.g., black-footed ferret, silversword plants). - A key strategy is establishing legally protected nature reserves. Locations for protection often target biodiversity hot spots, which are relatively small areas with an exceptional concentration of endemic species (found nowhere else) & a large number of endangered/threatened species (e.g., Madagascar). - Zoned reserves are a conservation approach where undisturbed wildlands are surrounded by buffer zones of compatible economic development, aiming to provide a stable economic base for local people while protecting the core area (e.g., Costa Rica). Ecotourism is an important source of revenue for these efforts. - To counteract habitat fragmentation, movement corridors

(wildlife corridors) are established as narrow strips or clumps of habitat connecting isolated patches, promoting dispersal & reducing inbreeding. Large-scale initiatives like the Yellowstone to Yukon Conservation Initiative (Y2Y) aim to connect vast protected areas with corridors to support wide-ranging species like wolves.

Defining Animal Characteristics - Animals are fundamentally defined as eukaryotic, multicellular heterotrophs. - A unique characteristic of animal cells is the lack of cell walls, a feature that distinguishes them from plants & fungi; instead, animal cells are held together by extracellular structural proteins like collagen & by specialized intercellular junctions. - Most adult animals are diploid & reproduce sexually, with eggs & sperm being the only haploid cells. Sexual reproduction involves the fusion of an egg & sperm to form a zygote. - Animal development includes distinct embryonic stages: the zygote divides by mitosis to form a hollow ball of cells called a blastula, which then folds inward to form a gastrula. The gastrula establishes three embryonic layers: the endoderm (forms the digestive tract lining), ectoderm (forms outer layer, skin, nervous system), & mesoderm (forms middle layer, muscles, most internal organs). - Many animals also undergo larval stages that are distinct from the adult form, followed by a process of metamorphosis to become a reproductively mature adult. The transformation from zygote to adult is controlled by master control homeotic genes.

Defining Chordates & Vertebrates - The phylum Chordata is distinguished by four defining features present in embryos, & often adults: a dorsal, hollow nerve cord; a flexible, supportive notochord (a longitudinal rod between the digestive tract & nerve cord); pharyngeal slits (located behind the mouth); & a muscular post-anal tail. - The simplest chordates are invertebrates like tunicates & lancelets, which possess these features & use their pharyngeal slits for suspension feeding. Vertebrates (our own subphylum) are distinguished by the presence of a backbone or vertebral column, composed of vertebrae, & a skull. In most vertebrates, the vertebrae enclose the nerve cord & provide skeletal support, & the skull encases the brain. The vertebrate skeleton is an endoskeleton.

Ecosystem Energy Flow & Chemical Cycling - An ecosystem encompasses all organisms in a community plus their abiotic environment. Ecosystem ecology emphasizes two fundamental processes: energy flow & chemical cycling. - Energy flows through an ecosystem, generally entering as sunlight, being converted to chemical energy by producers (primary production), transferred through trophic levels, & ultimately lost as heat. Primary production is the rate at which solar energy is converted to chemical energy, forming biomass (living organic material). Only about 1% of available sunlight is converted to primary production. - An energy pyramid illustrates the cumulative loss of energy at each trophic level. Only about 10% of the energy stored at one trophic level is transferred to the next; the rest is lost, primarily as heat from cellular respiration. This explains why food chains are typically limited to three to five levels, as there isn't enough energy to support more. It also explains the high ecological cost of meat, as eating plants (primary consumers) makes ~10 times more energy available to humans than eating herbivores (secondary consumers). - In contrast to energy, chemicals are cycled within ecosystems (biogeochemical cycles), meaning matter is continuously reused. These cycles involve both biotic components (producers, consumers, decomposers) & abiotic reservoirs (where chemicals accumulate outside living organisms, e.g., atmosphere, soil, rocks). Major cycles include: - Carbon cycle: Global, primarily driven by the reciprocal processes of photosynthesis (removes CO_2 from atmosphere) & cellular respiration (returns CO_2). Burning fossil fuels & wood significantly increases atmospheric CO_2. - Phosphorus cycle: Local, primarily depends on the weathering of rock, which releases phosphates into the soil for plants to absorb. - Nitrogen cycle: Global, heavily relies on bacteria to convert atmospheric N_2 into forms usable by plants (nitrogen fixation), & to recycle nitrogen from organic matter.

Evolution of Jaws & Fish Diversity - Jawed vertebrates first appeared about 440 million years ago, a development that likely contributed to their success by enabling them to capture & eat a wider variety of prey. Jaws are hypothesized to have evolved from modifications of skeletal supports of anterior pharyngeal (gill) slits. - Living jawed fishes are commonly grouped into three lineages: - Chondrichthyans (sharks & rays): characterized by a flexible skeleton made primarily of cartilage. Most are adept predators with streamlined bodies & powerful jaws. - Ray-finned fishes (e.g., tuna, trout): possess an internal skeleton reinforced with a hard matrix of calcium phosphate. They have an operculum covering their gills, allowing them to breathe without constant swimming, & a buoyant swim bladder (a lung derivative). This is the largest group of vertebrates. - Lobe-finned fishes (e.g., coelacanths, lungfishes, tetrapods): distinguished by muscular pelvic & pectoral fins supported by rod-shaped bones. A lineage of lobe-finned fishes gave rise to tetrapods, a pivotal event in vertebrate history as they adapted to life on land.

Factors Limiting Population Growth - Population growth is regulated by a mixture of factors, which can be density-dependent or density-independent: Density-dependent factors are those whose intensity is related to population density. As density increases, these factors can decrease birth rates or increase death rates. Examples include: intraspecific competition for limited resources (food, space), increased predation, spread of disease, & physiological factors like stress syndrome at high densities. - Density-independent factors are those that affect a population's size regardless of its density. These are typically abiotic factors such as severe weather events (e.g., hot/dry summers killing aphids, freezing temperatures), natural disasters (fires, floods), or habitat disruption by humans. Some populations exhibit "boom-and-bust" cycles, dramatic fluctuations in density with regular intervals, often influenced by predator-prey dynamics (e.g., snowshoe hare & lynx populations).

Fungi: Diversity, Roles, & Uses - Fungi are heterotrophs that obtain nutrients by absorption, secreting powerful enzymes to digest macromolecules externally before absorbing the smaller nutrient molecules. - They are classified into five main groups: Chytrids (the only fungi with flagellated spores, earliest lineage), Zygomycetes (zygote fungi, characterized by protective zygosporangium, includes fast-growing molds), Glomeromycetes (arbuscular mycorrhizal fungi), Ascomycetes (sac fungi, produce spores in saclike asci, include yeasts, morels, cup fungi, & plant pathogens), & Basidiomycetes (club fungi, include common mushrooms, puffballs, shelf fungi, named for club-shaped basidium, important decomposers, & plant parasites like rusts & smuts). - Fungi play essential ecological roles as decomposers, breaking down dead organic material. Many form symbiotic associations, notably mycorrhizae with plant roots, where fungi supply essential minerals to plants in exchange for sugars. - Humans also derive many practical uses from fungi, including food (mushrooms, cheeses), alcohol production (yeasts), antibiotics (e.g., Penicillium), & their use in molecular biology & biotechnology (e.g., yeasts in genetic studies, potential for biofuel production).

Global Climate Patterns & Biomes - The Earth's global climate patterns are primarily determined by the uneven heating of Earth's surface by the sun as it orbits. This uneven heating, combined with Earth's tilt & rotation, sets up patterns of precipitation & prevailing winds. - Prevailing winds (e.g., trade winds, westerlies) result from vertically circulating air being deflected by Earth's rotation. Ocean currents also significantly influence coastal climates by warming or cooling the air over land. Landforms like mountains affect local climate, creating rain shadows on their leeward sides where descending dry air absorbs moisture. - The influence of these abiotic factors (especially temperature & precipitation) results in biomes, which are major types of ecological associations occupying broad geographic regions of land or water. Terrestrial biomes are distinguished by their predominant vegetation, while aquatic biomes are defined by factors like salinity, light, & nutrients. Similar biomes can occur in geographically distant places if their climates are similar, demonstrating convergent evolution.

Innate Behaviors & Learning - Innate behaviors are those that do not have to be learned; they are under strong genetic control & are performed similarly by all members of a species. An example is a fixed action pattern (FAP), a series of actions triggered by a specific stimulus & performed in its entirety once initiated (e.g., a goose retrieving an egg). - Learning is the modification of behavior as a result of specific experiences, allowing animals to adapt to changing environmental conditions. Various forms of learning exist: - Habituation is a simple type of learning where an animal learns to ignore a repeated, irrelevant stimulus (e.g., no longer noticing a humming roommate). - Imprinting is irreversible learning limited to a specific sensitive period in an animal's life (e.g., ducklings imprinting on the first moving object they see). This is crucial for conservation programs to ensure proper social & survival behaviors. - Associative learning involves animals associating a stimulus or their own behavior with a positive or negative effect (e.g., a dog learning to associate a clicker with a treat). - Social learning is learning by observing & imitating the behavior of others (e.g., vervet monkeys learning to fine-tune alarm calls by observing adults). - Problem-solving behavior relies on cognition, the process by which an animal's nervous system perceives, stores, integrates, & uses sensory information (e.g., ravens solving puzzles).

Levels of Ecological Study - Ecology is the scientific study of the interactions between organisms & their environment. Ecologists investigate these interactions at several hierarchical levels: - Organismal Ecology: Focuses on how an individual organism (e.g., a Himalayan blue poppy) meets the challenges & opportunities of its environment through physiological or behavioral adaptations. - Population Ecology: Studies a group of individuals of the same species living in a particular geographic area (e.g., a population of blue poppies). It examines factors affecting population size, distribution, & dynamics - Community Ecology: Involves an assemblage of all the populations of organisms living close enough for potential interaction (e.g., all organisms in an alpine meadow). It focuses on interspecies interactions & community dynamics. - Ecosystem Ecology: Includes both the biotic & abiotic components of the environment (e.g., an alpine meadow with its plants, animals, soil, temperature, & precipitation). Key questions at this level concern how chemicals cycle & energy flows. - Landscape Ecology: Studies arrays of ecosystems visible as distinctive patches from the air, emphasizing the exchange of energy, matter, & organisms across ecosystem boundaries. - Biosphere: The broadest level, encompassing all of Earth inhabited by life, from the atmosphere several kilometers up to the ocean depths.

Life Histories & Selection (rand K-selection) - An organism's life history refers to the traits that affect its schedule of reproduction & death, including age of first reproduction, frequency of reproduction, number of offspring, & amount of parental care. Natural selection shapes these traits, often involving trade-offs (e.g., many offspring means less parental care). - Ecologists describe two general life history patterns: - r-selection: Favored in unpredictable environments with abundant resources, allowing for exponential growth. Organisms with r-selected traits are typically small-bodied, short-lived, develop rapidly, reach sexual maturity quickly, produce a large number of offspring, & provide little to no parental care (e.g., insects, dandelions). These species are good colonizers of disturbed habitats. K-selection: Favored in stable environments where population size is near carrying capacity (K) & competition for resources is keen. Organisms with K-selected traits are typically large-bodied, long-lived, develop slowly, produce few but well-cared-for offspring (e.g., bears, elephants, coconut palms). They allocate more energy to their own survival & their descendants' survival.

Population Ecology & Variables - Population ecology is the study of how & why populations change over time. A population is defined as a group of individuals of a single species occupying the same general area, relying on the same resources, influenced by similar environmental factors, & likely to interact & breed. - Key variables used to describe a population include its number & distribution of individuals. - Population density refers to the number of individuals of a species per unit area or volume (e.g., oak trees per km² or earthworms per m³). Ecologists use sampling techniques to estimate these densities. - The dispersion pattern describes how individuals are spaced within their area. - Clumped dispersion is the most common pattern, where individuals are grouped in patches, often due to unequal resource distribution, reduced predation risk, or social behavior (e.g., sea stars grouping where food is abundant). - Uniform dispersion (even spacing) usually results from interactions between individuals, such as plants secreting chemicals to inhibit competitors or animals exhibiting territorial behavior (e.g., sunbathers on a beach). - Random dispersion is less common & suggests unpredictable or varying spacing without strong attractions or repulsions between individuals.

Population Growth Models: Exponential & Logistic - Population ecologists use idealized models to predict how population size changes over time: Exponential growth is a model of unlimited population growth, resulting in a J-shaped curve. In this model, the per capita rate of increase (r) remains constant, & the growth rate (G) depends solely on the population size (N), described by the formula G = rN. This pattern occurs when resources are abundant & there are no restrictions on growth. - Logistic growth is a more realistic model that incorporates limiting factors. It predicts that population growth will slow & eventually stop as the population reaches its carrying capacity (K), the maximum number of individuals the environment can sustainably support. This model produces an S-shaped curve. The formula for logistic growth is G = rN(K - N)/K. The population grows fastest when its size is at approximately half the carrying capacity (K/2), as at this point there are ample resources for growth, & the population size is large enough to contribute significantly to the increase.

Primate & Hominin Evolution - The mammalian order Primates (lemurs, tarsiers, monkeys, apes, humans) likely arose as small arboreal mammals. Many primate characteristics are adaptations to life in trees, such as limber shoulder/hip joints for climbing, grasping hands/feet with mobile/flexible digits, sensitive hands/feet, a short snout, & forward-pointing eyes that enhance depth perception. - Primates are divided into three groups: lemurs/lorises/pottos, tarsiers, & anthropoids (monkeys & apes, including humans). Apes are distinguished from monkeys by lacking a tail, having relatively longer arms & shorter legs, larger brains, & more flexible behavior. - The hominin branch of the primate tree includes species more closely related to humans than to chimpanzees. The oldest hominin, Sahelanthropus tchadensis, lived 7-6 million years ago. The fossil record indicates that hominins did not evolve in a straight line; multiple species often coexisted. - Evidence suggests that bipedalism (upright posture) evolved before significantly larger brains in hominins, a reversal of earlier hypotheses. The genus Homo (including H. habilis, H. ergaster, H. erectus, & H. sapiens) shows a trend of increasing brain size. Homo sapiens originated in Africa & spread globally. The relationship between Neanderthals & modern humans suggests they were distinct species with a common ancestor around 500,000 years ago.

Proximate & Ultimate Causes of Behavior - Behavioral ecology studies behavior in an evolutionary context, addressing two main types of questions: - Proximate questions concern the immediate reasons for a behavior. These questions explore "how" a behavior occurs, focusing on the stimuli that trigger it, the physiological or anatomical mechanisms involved (e.g., muscle & nerve control), & underlying genetic factors. For example, how do voles choose mates, or how does mating cause lifelong bonds?. - Ultimate questions address the evolutionary reasons or "why" a particular behavior occurs. They consider how behavior, as a component of an animal's phenotype, has been shaped by natural selection due to its adaptive value. For instance, why would natural selection favor monogamous bonding in prairie voles, perhaps because it increases reproductive success by preventing other males from getting close to mates. Understanding both proximate & ultimate causes provides a comprehensive view of behavior.

Restoration Ecology - Restoration ecology is a developing field that applies ecological principles to return degraded areas to their natural state. - Key methods include: - Bioremediation: Te use of living organisms (e.g., bacteria, plants) to detoxify polluted ecosystems by metabolizing or absorbing toxins from soil or water (e.g., cleaning up oil spills or contaminated soil in New Orleans). - Replanting native vegetation: Reintroducing plant species native to the area. - Returning waterways to their natural course: Restoring altered rivers (like the Kissimmee River project) to their original meandering paths & floodplains to re-establish wetlands & improve water quality & habitat.

Social Behavior & Altruism - Social behavior encompasses any interaction between two or more animals, usually of the same species. These interactions can include aggression, cooperation, & communication. - Territorial behavior involves individuals defending a fixed area (territory) from others of the same species, often proclaimed by calls or scent markers. Territories provide exclusive access to resources like food, breeding areas, & shelter, increasing fitness. - Agonistic behavior refers to conflicts over limited resources, involving threats, rituals, & sometimes combat, which determine who gains access to the resource. This can lead to dominance hierarchies, a ranking of individuals within a group that can remain fixed for extended periods. - Altruism is defined as behavior that reduces an individual's own fitness while increasing the fitness of others in the population (e.g., worker bees sacrificing themselves for the hive, ground squirrels giving alarm calls). - Altruistic acts are often explained by the concept of inclusive fitness, which describes an individual's success at perpetuating its genes not only through its own offspring but also by helping close relatives (who share many of those genes) to reproduce. This form of natural selection favoring altruistic behavior towards relatives is called kin selection.

Sustainable Development - Sustainable development is the ultimate goal, aiming to meet the needs of people today without compromising the ability of future generations to meet their needs. - It requires both increasing & applying ecological knowledge & valuing the interconnectedness of humans with the biosphere. This approach integrates life sciences with social sciences, economics, & humanities, recognizing that improving the human condition & conserving biodiversity are interdependent. - The current overconsumption of resources, especially in affluent nations, & rapid population growth in some developing countries, pose significant challenges to achieving sustainability. Overcoming these challenges requires global cooperation & changes in human activities to reduce our ecological footprint.

Threats to Biodiversity - Biodiversity encompasses three main levels: ecosystem diversity (variety of ecosystems), species diversity (number & relative abundance of species, including extirpation as local loss & extinction as irreversible global loss), & genetic diversity (variation within & between populations, crucial for adaptation). - Human activities are the primary cause of biodiversity decline, with major threats including: - Habitat loss & fragmentation: The single greatest threat, caused by agriculture, urban development, forestry, mining, & pollution, leading to massive destruction & isolation of habitats (e.g., deforestation). - Invasive species: Non-native organisms introduced by human actions that establish themselves & outcompete or prey on native communities due to a lack of natural enemies (e.g., Burmese pythons in the Everglades, zebra mussels). - Overharvesting: Exploitation of wildlife at rates exceeding populations' ability to rebound (e.g., rare trees, game fish, tigers, bushmeat trade). - Pollution: Diverse pollutants from human activities can have local, regional, & global effects, transported by water & air (e.g., oil spills, acid precipitation, pesticides). Biological magnification concentrates synthetic toxins (like PCBs, DDT, mercury) at higher trophic levels, severely affecting top-level consumers. - Climate change: Rapid warming due to rising greenhouse gas concentrations (CO_2, CH_4, N_2O) from human activities (especially burning fossil fuels) is changing global climate patterns, affecting biomes, ecosystems, & species distributions, & is becoming a leading cause of biodiversity loss.

Trophic Structure & Food Webs - A community's trophic structure describes its feeding relationships, arranged in several trophic levels. The flow of food, chemical nutrients, & energy through these levels is called a food chain. - The base of the food chain consists of producers (autotrophs), primarily photosynthetic organisms like plants on land or phytoplankton in water, which convert light energy into chemical energy. - All organisms at higher levels are consumers (heterotrophs). Primary consumers are herbivores that eat producers. Secondary consumers typically eat primary consumers, tertiary consumers eat secondary consumers, & so on up to quaternary consumers. - Detritivores obtain energy from detritus (dead organic material). Decomposers (mainly prokaryotes & fungi) break down organic materials into inorganic forms, recycling nutrients back into the ecosystem through decomposition. - A food web is a more realistic representation of feeding relationships, showing a network of interconnecting food chains, as consumers often eat multiple types of prey & can operate at multiple trophic levels.

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Abiotic Factors These are the nonliving components of an environment, such as physical & chemical factors They significantly influence life in the biosphere Key abiotic factors include the energy source (usually solar energy), temperature, the abundance & type of water, nutrients, oxygen availability (for aquatic environments), & terrestrial factors like wind & fire Alternation of Generations This is a plant life cycle where haploid & diploid stages are distinct, multicellular bodies The haploid gametophyte produces gametes (eggs or sperm) by mitosis Fertilization of gametes results in a diploid zygote, which then develops into the diploid sporophyte The sporophyte produces haploid spores by meiosis, & these spores grow into gametophytes, completing the cycle This life cycle ensures that gametes & embryos are kept moist, & the fertilized egg (zygote) develops into an embryo attached to & nourished by the parent plant Amnion A fluid-filled sac that surrounds the embryo within an amniotic egg This is one of four internal membranes that characterize the amniotic egg, a major derived character of reptiles (including birds) & mammals, which are known as amniotes Yolk Sac: Contains a rich store of nutrients for the embryo Allantois: Helps dispose of metabolic waste and, along with the chorion, enables gas exchange Chorion: Facilitates oxygen uptake from the air & carbon dioxide disposal Amphibians A group of tetrapods that includes salamanders, frogs, & caecilians They were the first tetrapods to move onto land Amphibians use their moist skins to supplement lungs for gas exchange & often have poison glands in their skin They typically return to standing water to reproduce & undergo metamorphosis from a larval stage to their adult form Amoebocytes (in Sponges) Cells that wander through the middle body region of a sponge They produce skeletal fibers composed of flexible protein & mineralized particles called spicules Amoebocytes are also involved in engulfing food filtered by choanocytes Angiosperms These are flowering plants that represent a lineage marked by the presence of flowers They include flowering trees & grasses Their ovules develop into seeds, & their ovaries mature into fruit Most human food comes from the fruits & seeds of angiosperms, such as grains (corn, rice, wheat) & fleshy fruits (apples, cherries, tomatoes, squash) About 90% of angiosperms rely on animals for pollen transfer, leading to coevolutionary adaptations like colorful flowers for birds or fruity odors for beetles Animals Animals are eukaryotic, multicellular heterotrophs that ingest their food Their cells lack cell walls Most adult animals are diploid & reproduce sexually Eggs & sperm, the only haploid cells, are produced by meiosis & fuse during fertilization to form a zygote The zygote then undergoes mitosis to form a hollow ball of cells called a blastula, which folds inward to form a gastrula, establishing three embryonic layers: Endoderm: Forms the lining of the future digestive tract Ectoderm: Forms the outer layer, giving rise to skin & the nervous system Mesoderm: Forms the middle layer, which develops into muscles & most internal organs Some animals develop directly into adults, while others have one or more larval stages that undergo metamorphosis to become reproductively mature adults Animal diversification accelerated rapidly during the Cambrian period (535 to 525 million years ago), an event known as the Cambrian explosion Annelids Known as segmented worms (eg, earthworms, polychaetes, leeches), annelids exhibit segmentation, which is the subdivision of the body into repeated parts along its length They have a true coelom that functions as a hydrostatic skeleton, a nervous system with a simple brain & ventral nerve cord, & a closed circulatory system where blood remains enclosed in vessels Anthropoids A group of primates that includes monkeys & apes (gibbons, orangutans, gorillas, chimpanzees, & humans) Asexual Reproduction (Fungi) Fungi can produce huge numbers of asexual spores, each capable of germinating into a new fungus Spore-producing structures arise from haploid mycelia without a heterokaryotic stage or meiosis Molds are rapidly growing fungi that reproduce asexually by producing spores Yeasts are single-celled fungi that reproduce asexually by cell division or budding Biological Community An assemblage of all the populations of organisms living close enough together for potential interaction It is described by its species composition, & its boundaries can vary depending on the research question Biological Magnification A process where synthetic toxins that cannot be degraded by microorganisms become concentrated as they move up the food chain, leading to higher concentrations in top predators Biomass The amount of living organic material in an ecosystem, produced by primary production (conversion of solar energy to chemical energy by producers) Biomes Major types of ecological associations that occupy broad geographic regions of land or water Their global distribution is controlled by climate & other abiotic factors Terrestrial biomes are primarily distinguished by their predominant vegetation, which depends on temperature & precipitation Biosphere The entire part of Earth inhabited by life, extending from several kilometers above the atmosphere to the depths of the oceans Human activities significantly affect all parts of the biosphere Biotic Factors All the organisms in an area, representing the living component of the environment Bipedalism The ability to walk upright on two legs This adaptation in hominins arose millions of years before the evolution of larger brain size Evidence includes 36-million-year-old footprints & fossil skeletons Blastula A hollow ball of cells formed when a zygote (fertilized egg) divides by mitosis One side of the blastula folds inward to form a gastrula Bryophytes Early plants that are seedless & nonvascular, including mosses, liverworts, & hornworts They have apical meristems & embryos retained on the parent plant, but they lack true roots, leaves, & lignified cell walls, which limits their height Cambrian Explosion A period of rapid animal diversification that occurred approximately 535 to 525 million years ago This event, rich in perfectly preserved animal fossils (eg, Burgess Shale), may have been caused by increasingly complex predator-prey relationships or an increase in atmospheric oxygen Carbon Cycle The biogeochemical cycle of carbon, a major ingredient of all organic molecules Carbon is found in the atmosphere (as CO_2), fossil fuels, & dissolved in ocean compounds The return of CO_2 to the atmosphere by respiration is balanced by its removal through photosynthesis Human activities like burning wood & fossil fuels significantly impact this balance Carpels The female reproductive structures in flowers that produce eggs A flower typically consists of sepals, petals, stamens, & carpels The carpel includes the stigma (receives pollen), style (stalk), & ovary (contains ovules) Cephalopods A group of molluscs that are fast, agile predators with large brains & sophisticated sense organs, including complex image-focusing eyes Examples include squids (with a small, internal shell) & octopuses (missing a shell) Charophytes Green algae thought to have evolved from a common ancestor with plants Both charophytes & plants have complex multicellular bodies & are photosynthetic eukaryotes Chemical Cycling The transfer of materials within an ecosystem Unlike energy, which flows through an ecosystem, chemical elements are recycled, as Earth has no extraterrestrial sources of these elements (except meteorites) Chitin A structural polysaccharide that makes up the cell walls of fungal hyphae, distinguishing them from plant cell walls which are made of cellulose Choanocytes Flagellated cells in sponges that form the inner layer of the body They filter food particles from water by trapping them in mucus on membranous collars surrounding their flagella & then engulfing them by phagocytosis Chondrichthyans A lineage of jawed fishes, including sharks & rays, characterized by a flexible skeleton made of cartilage Chordates A phylum defined by four key features present at some point in their life cycle: 1 Dorsal, hollow nerve cord 2 Flexible, supportive notochord 3 Pharyngeal slits 4 Muscular post-anal tail The simplest chordates are tunicates & lancelets, which lack a backbone Climate Often determines the distribution of communities Global climate patterns are primarily determined by the input of solar energy & the Earth's movement in space Regional climates are influenced by ocean currents, landforms (like mountains creating rain shadows), & prevailing winds Cnidarians Radially symmetrical animals (eg, hydras, sea anemones, marine jellies) characterized by two tissue layers: an outer epidermis & an inner cell layer lining the digestive cavity They exhibit two body forms: the sedentary polyp (cylindrical with tentacles) & the more mobile medusa Cnidarians are carnivores that use cnidocytes (unique stinging cells) to capture prey & for defense Coelom A fluid-filled space within an animal's body plan, located between the digestive tract & the outer body wall A true coelom is completely lined by tissues derived from the mesoderm It cushions internal organs, allows them to grow & move independently, & forms a hydrostatic skeleton in soft-bodied animals A pseudocoelom is a body cavity not completely lined by mesoderm-derived tissues Community Ecology The study of factors that influence species composition & the distribution & stability of biological communities Competition (Interspecific) Occurs when populations of two different species compete for the same limited resource This lowers the carrying capacity of the competing populations Coniferous Forest A terrestrial biome primarily characterized by coniferous trees Its distribution is influenced by temperature & precipitation Conservation Biology A goal-driven scientific discipline that aims to understand & counteract the rapid loss of biodiversity It focuses on protecting & increasing endangered populations, assessing threats from human activities, & establishing protected areas like biodiversity hotspots & zoned reserves Consumers Heterotrophic organisms in a food chain that obtain energy by eating other organisms They are classified based on their diet: Primary consumers (Herbivores): Eat producers (plants/algae) Secondary consumers: Eat primary consumers Tertiary consumers: Eat secondary consumers Quaternary consumers: Eat tertiary consumers Cuticle (Waxy) A waxy covering on the leaves & stems of land plants that helps them maintain moisture inside their cells & reduces water loss Decomposers Mainly prokaryotes & fungi that derive energy from detritus (dead organic material) They secrete enzymes to digest organic molecules externally & convert them into inorganic forms through a process called decomposition, playing a crucial role in chemical cycling Dependent Embryos A key adaptation for life on land present in all plants, where the fertilized egg (zygote) develops into an embryo while attached to & nourished by the parent plant Detritivores Organisms that obtain their energy from detritus, which is the dead material produced at all trophic levels Deuterostomes One of two main groups of animals with three embryonic layers In deuterostomes, the opening formed during gastrulation develops into the anus Echinoderms & chordates are deuterostomes Diploid Having two sets of chromosomes (2n) In animals, most adult animals are diploid In plants, the sporophyte generation is diploid & produces haploid spores by meiosis Energy Flow (Ecosystems) The movement of energy through the components of an ecosystem Energy, typically from the sun, flows from producers to consumers & decomposers, & eventually is lost as heat, rather than being recycled Only about 10% of the energy stored at one trophic level is available to the next Eutherians (Placental Mammals) Mammals that bear fully developed live young, nurtured by a complex placenta This group includes most living mammals They diverged from marsupials about 180 million years ago & underwent adaptive radiation after the extinction of dinosaurs

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A **community** includes all the organisms inhabiting a particular area. Community ecology is concerned with factors that influence the species composition of communities & with factors that affect community dynamics. -|- An **ecological** footprint is a measure of resource consumption. An ecological footprint estimates the amount of land required by each person or country to produce all the resources it consumes & to absorb all its wastes. The global ecological footprint already exceeds a sustainable level. There is disparity between resource consumption in more developed & less developed nations. -|- **Animal** diversification began more than half a billion years ago. The oldest animal fossils are from the late Ediacaran period & are about 560 million years old. Animal diversification accelerated rapidly during the Cambrian explosion from 535 to 525 million years ago. -|- **Animals** can be characterized by basic features of their "body plan." Body plans may vary in number of tissue layers (two or three), symmetry (radial or bilateral), presence of a body cavity, & embryonic development (protostome or deuterostome). -|- The **angiosperm** plant is a sporophyte with gametophytes in its flowers. The sporophyte is independent, with tiny, dependent gametophytes protected in flowers. Ovules become seeds, & ovaries become fruits. -|- Angiosperms sustain us—and add spice to our diets. -|- **Annelids** are segmented worms. The lineages of the phylum Annelida are Errantia (mostly mobile marine worms) & Sedentaria (less mobile worms, including earthworms, leeches, & many tube-dwellers). -|- **Arthropods** are segmented animals with jointed appendages & an exoskeleton. The lineages of the phylum Arthropoda are chelicerates (arachnids such as spiders), myriapods (millipedes & centipedes), & pancrustaceans (the mostly aquatic crustaceans & the terrestrial insects). -|- **Australopiths** were bipedal & had small brains. -|- **Body** plans & molecular comparisons of animals can be used to build phylogenetic trees. -|- **Climate** change affects biomes, ecosystems, communities, & populations. Organisms that live at high latitudes & high elevations are experiencing the greatest impact. -|- **Cnidarians** are radial animals with tentacles & stinging cells. Members of the phylum Cnidaria have tissues & a gastrovascular cavity. Their two body forms are polyps (such as hydras) & medusae (jellies). -|- **Competition** may occur when a shared resource is limited. -|- **Coniferous** forests are often dominated by a few species of trees. -|- **Current**, sunlight, & nutrients are important abiotic factors in freshwater biomes. Standing water biomes (lakes & ponds) differ in structure from flowing water biomes (rivers & streams), & communities vary accordingly. Wetlands include marshes, swamps, & bogs. -|- **Density** & dispersion patterns are important population variables. Population density is the number of individuals in a given area or volume. Environmental & social factors influence the spacing of individuals in various dispersion patterns: clumped (most common), uniform, or random. -|- **Deserts** are defined by their dryness. -|- **Diverse** molluscs are variations on a common body plan. Members of the phylum Mollusca include gastropods (such as snails & slugs), bivalves (such as clams & mussels), & cephalopods (such as octopuses & squids). All have a muscular foot & a mantle, which encloses the visceral mass & may secrete a shell. Many molluscs feed with a rasping radula. -|- **Echinoderms** have spiny skin, an endoskeleton, & a water vascular system for movement. Members of the phylum Echinodermata, such as sea stars, are radially symmetric as adults. -|- **Ecologists** study how organisms interact with their environment at several levels. This includes organismal ecology (individual), population ecology (group of individuals of a species), community ecology (all organisms in a particular area), & ecosystem ecology (all organisms & abiotic factors). -|- **Establishing** protected areas slows the loss of biodiversity. Biodiversity hot spots have high concentrations of endemic species. -|- **Flatworms** are the simplest bilateral animals. Members of the phylum Platyhelminthes are bilateral animals with no body cavity between the digestive tract & outer body wall. A planarian has a gastrovascular cavity & a simple nervous system. Flukes & tapeworms are parasitic flatworms with complex life cycles. -|- **The flower** is the centerpiece of angiosperm reproduction. A flower usually consists of sepals, petals, stamens (produce pollen), & carpels (produce ovules). -|- **From** origins in Africa, Homo sapiens spread around the world. Evidence from fossils & DNA studies has enabled scientists to trace early human history. -|- **Fungi** absorb food after digesting it outside their bodies. Fungi are heterotrophic eukaryotes that digest their food externally & absorb the resulting nutrients. A fungus usually consists of a mass of threadlike hyphae, called a mycelium. -|- **Fungi** are classified into five groups. Fungi evolved from a protist ancestor. Fungal groups include chytrids, zygomycetes, glomeromycetes, ascomycetes, & basidiomycetes. -|- **Fungi have** enormous ecological benefits. Fungi are essential decomposers & also participate in mycorrhizae. -|- **Fungi have** many practical uses. Some fungi provide food or antibiotics. -|- **Fungi produce** spores in both asexual & sexual life cycles. In some fungi, fusion of haploid hyphae produces a heterokaryotic stage containing nuclei from two parents. After the nuclei fuse, meiosis produces haploid spores. -|- **The genes** that build animal bodies are ancient. Changes in the regulation of homeotic gene expression have been significant factors in the evolution of animal diversity. -|- **The global** water cycle connects aquatic & terrestrial biomes. -|- Habitat loss, invasive species, overharvesting, pollution, & climate change are major threats to biodiversity. Human alteration of habitats is the single greatest threat to biodiversity. Invasive species disrupt communities by competing with, preying on, or parasitizing native species. Harvesting at rates that exceed a population's ability to rebound is a threat to many species. Human activities produce diverse pollutants that may affect ecosystems far from their source. Biomagnification concentrates synthetic toxins that cannot be degraded by organisms. -|- Haploid & diploid generations alternate in plant life cycles. The haploid gametophyte produces eggs & sperm by mitosis. The zygote develops into the diploid sporophyte, in which meiosis produces haploid spores. Spores grow into gametophytes. The life cycle of a moss is dominated by the gametophyte. Ferns, like most plants, have a life cycle dominated by the sporophyte. In both mosses & ferns, sperm swim to the egg. -|- **Herbivory** leads to diverse adaptations in plants. Some herbivore-plant interactions illustrate coevolution or reciprocal evolutionary adaptations. -|- **The hominin** branch of the primate tree includes species that coexisted. Paleoanthropologists have found about 20 species of extinct hominins, species more closely related to humans than to chimpanzees. Some of these species lived at the same time. -|- **Human** activities are responsible for rising concentrations of greenhouse gases. Much of the increase is the result of burning fossil fuels. -|- **Human** skin color reflects adaptations to varying amounts of sunlight. Human skin color variations probably resulted from natural selection balancing the body's need for folate with the need to synthesize vitamin D. -|- **The human** story begins with our primate heritage. The three groups of living primates are the lorises, bush babies, & lemurs; the tarsiers; & the anthropoids (monkeys & apes). Apes, which have larger brains than other primates, include gibbons, orangutans, gorillas, chimpanzees, & humans. -|- **Insects** are the most successful group of animals. Their development often includes metamorphosis. Insects have a three-part body (head, thorax, & abdomen) & three pairs of legs; most have wings. Specialized appendages & protective color patterns, which frequently result from evolutionary changes in the timing & location of homeotic gene expression, have played a major role in this group's success. -|- **Interspecific** interactions are fundamental to community structure. Interspecific interactions can be categorized according to their effect on the interacting populations. -|- **Invertebrate** diversity is a valuable but threatened resource. -|- Invasive species can devastate communities. Organisms that have been introduced to non-native habitats by human actions & have established themselves at the expense of native communities are considered invasive. -|- **Larger brains** mark the evolution of Homo. The genus Homo includes hominins with larger brains & evidence of tool use. Homo ergaster had a larger brain than H. habilis. H. erectus, with a larger brain than H. ergaster, was the first hominin to spread out of Africa. -|- Lichens are symbiotic associations of fungi & photosynthetic organisms. The photosynthesizers are algae or cyanobacteria. -|- **Loss** of biodiversity includes the loss of ecosystems, species, & genes. Although valuable for its own sake, biodiversity also provides food, fibers, medicines, & ecosystem services. -|- Many primate characters are adaptations to life in the trees. Primates had evolved as small arboreal mammals by 65 million years ago. Primate characters include limber joints, grasping hands & feet with flexible digits, a short snout, & forward-pointing eyes that enhance depth perception. -|- **Multiple factors** may limit population growth. As a population's density increases, factors such as limited food supply & increased disease or predation may increase the death rate, decrease the birth rate, or both. Abiotic, density-independent factors such as severe weather may limit many natural populations. Most populations are probably regulated by a mixture of factors, & fluctuations in numbers are common. -|- Mycorrhizae may have helped plants colonize land. The hypothesis that plant-fungus symbioses facilitated the evolution of land plants is tested by investigating three lines of evidence: present-day mycorrhizal relationships, fossils of early land plants, & molecular homologies. -|- **Nematodes** have a body cavity & a complete digestive tract. Members of the phylum Nematoda are covered by a protective cuticle that is shed periodically. Many nematodes (roundworms) are free-living decomposers; others are plant or animal parasites. -|- New discoveries raise new questions about the history of hominins. The interpretation of fossils of small hominins named Homo floresiensis that were found in Indonesia is controversial. -|- The nitrogen cycle depends on bacteria. Various bacteria in soil (and root nodules of some plants) convert gaseous N_2 to compounds that plants can use, such as ammonium (NH_4^+) & nitrate (NO_3^-). -|- **Our knowledge** of animal diversity is far from complete. -|- **Our** own phylum, Chordata, is distinguished by four features. Chordates have a dorsal, hollow nerve cord, a stiff notochord, pharyngeal slits, & a muscular post-anal tail. The simplest chordates are lancelets & tunicates, marine invertebrates that use their pharyngeal slits for suspension feeding. -|- **Parasitic** fungi harm plants & animals. -|- **Physical** & chemical factors influence life in the biosphere. Major factors include energy sources, temperature, the presence of water, & inorganic nutrients. -|- **Plant** diversity is vital to the future of the world's food supply. As plant biodiversity is lost through extinction & habitat destruction, potential crop species & valuable genes are lost. -|- **Plant diversity** reflects the evolutionary history of the plant kingdom. Nonvascular plants (bryophytes) include the mosses, hornworts, & liverworts. Vascular plants have supportive conducting tissues. Ferns are seedless vascular plants with flagellated sperm. Seed plants have sperm-transporting pollen grains & protect embryos in seeds. Gymnosperms, such as pines, produce seeds in cones. The seeds of angiosperms develop within protective ovaries. -|- Plants have adaptations for life on land. Leaves carry out photosynthesis. Reproductive structures, as in flowers, contain spores & gametes. A cuticle covering leaves & stems reduces water loss. Stomata in leaves allow gas exchange between plant & atmosphere. Lignin hardens cell walls of some plant tissues. The stem supports the plant & may perform photosynthesis. Vascular tissues in shoots & roots transport water, minerals, & sugars, & provide support. Roots anchor the plant; mycorrhizae (root-fungus associations) help absorb water & minerals from the soil. -|- **Pollen** & seeds are key adaptations for life on land. In seed plants, reproduction does not require moisture. Pollen grains carry the male gametophyte to the female gametophyte. The zygote develops into a sporophyte embryo, & the ovule becomes a seed, with stored food & a protective coat. -|- Pollination by animals has influenced angiosperm evolution. Flowers attract pollinators by color & scent. Visiting pollinators are rewarded with nectar & pollen. -|- Polar ice covers the land at high latitudes. -|- **Population** ecology is the study of how & why populations change. -|- **Predation** leads to diverse adaptations in prey species. -|- Protecting endangered populations is one goal of conservation biology. Conservation biology is a goal-driven science that seeks to understand & counter the rapid loss of biodiversity. Some conservation biologists direct their efforts at increasing populations that are endangered. -|- **Proximate** & ultimate factors cause behavior. Behavioral ecology is the study of behavior in an evolutionary context, considering both proximate (immediate) & ultimate (evolutionary) causes of an animal's actions. Natural selection preserves behaviors that enhance fitness. -|- **Rapid warming** is changing the global climate. Increased global temperature caused by rising concentrations of greenhouse gases is changing climate patterns, with grave consequences. -|- **Regional climate** influences the distribution of terrestrial communities. Most climatic variations are due to the uneven heating of Earth's surface as it orbits the sun, setting up patterns of precipitation & prevailing winds. Ocean currents influence coastal climate. Landforms such as mountains affect rainfall. -|- **Savannas** are grasslands with scattered trees. -|- **The science** of ecology provides insight into environmental problems. -|- **Seedless** vascular plants dominated vast "coal forests." -|- **Shared** derived characters define the major clades of chordates. These include the presence of a vertebral column, jaws, lungs or lung derivatives, & lobed fins. Hagfishes & lampreys lack hinged jaws. Jawed vertebrates with gills & paired fins include sharks, ray-finned fishes, & lobe-finned fishes. New fossil discoveries are filling in the gaps of tetrapod evolution. Amphibians are tetrapods—vertebrates with two pairs of limbs. Reptiles are amniotes—tetrapods with a terrestrially adapted egg. Birds are feathered reptiles with adaptations for flight. Mammals are amniotes that have hair & produce milk. -|- **Spiny** shrubs dominate the chaparral. -|- **Sponges** have a relatively simple, porous body. Members of the phylum Porifera have no true tissues. Their flagellated choanocytes filter food from water passing through pores in the body. -|- **The structure** of a fruit reflects its function in seed dispersal. -|- **The study** of how to restore degraded habitats is a developing science. Restoration ecology uses ecological principles to return degraded areas to their natural state, a process that may include detoxifying polluted ecosystems, replanting native vegetation, & returning waterways to their natural course. Large-scale restoration projects attempt to restore damaged landscapes. -|- **Sustainable** development is an ultimate goal. Sustainable development depends on increasing & applying ecological knowledge as well as valuing our linkages to the biosphere. -|- **Temperate grasslands** include the North American prairie. -|- **Terrestrial** biomes reflect regional variations in climate. -|- **Tropical forests** cluster near the equator. -|- **What** is an animal? Animals are multicellular eukaryotes that have distinctive cell structures & specializations & obtain their nutrients by ingestion. Animal life cycles & embryonic development also distinguish animals from other groups of organisms. -|- **Zoned reserves** are an attempt to reverse ecosystem disruption. Zoned reserves are undisturbed wildlands surrounded by buffer zones of compatible economic development. Ecotourism has become an important source of revenue for conservation efforts.