Species richness: The number of species in an area

Evenness: A community’s range of number of individuals per species

Radiometric dating: A method for determining the absolute age of rocks and fossils, based on the half-life of radioactive isotopes; some materials are easier to establish than others; has to decompose slowly, bury fast- fossilization is really rare; absolute does not mean errorless

Molecular clock: A method for estimating the time required for a given amount of evolutionary change, based on the observation that some regions of genomes evolve at constant rates; it may be inaccurate

Continental drift: plates that make up the earth’s crust move along the top of the mantle; they can collide, separate, or slide past one another; have formed a supercontinent 3 times- it affects organisms  
Tectonic Plates: earth’s crust is composed of plates floating on the mantle; each of these plates has a different name

Mass Extinction: The elimination of a large number of species throughout Earth, the result of global environmental changes; most species that have ever lived are extinct; we have had 5; > 50% of marine species go extinct; take 1000’s of years to happen, take 5-100 million years to recover; all lineages with advantageous traits are gone

Adaptive Radiation: Period of evolutionary change in which groups of organisms form many new species whose adaptions allow them to fill different ecological roles in their communities; can come from mass extinctions; rapid evolution of diversely adapted species from a single common ancestor; maximizes opportunity; can also occur when organisms colonize new environments with little competition

Multicellularity: Origin was around 1.5 billion years ago; they remained small until around 565 million years ago during the Cambrian explosion; cells got together because of the evolution of collagen and connective tissues; values of multicellularity: increased size, division of labor, longer lives

Cambrian Explosion: A relatively brief time in geologic history when many present-day phyla of animals first appeared in the fossil record; this burst of evolutionary change occurred about 535 -525 million years ago and saw the emergence of the first large, hard-bodied animals

Pangaea: The supercontinent that formed near the end of the Paleozoic era, when plate movements brought all the land masses of Earth together

Endosymbiosis: A relationship between two species in which one organism lives inside the cell or cells of another organism; useful for an anaerobe during the oxygen revolution to live inside another cell

Evolution: Descent with modification; the idea that living species are descendants of ancestral species that were different from the present-day ones; also defined more narrowly as the change in the genetic composition of a population from generation to generation

Maximum Parsimony: The explanation that makes the most sense because of its simplicity; one should first investigate the simplest explanation that is consistent with the facts

Maximum Likelihood: As applied to DENA sequence data, a principle that states that when considering multiple phylogenetic hypotheses, one should take into account the hypothesis that reflects the most likely sequence of evolutionary events, given certain rules about how DNA changes over time

Extant vs. Extinct: Extant means the species is still living, extinct means the species is not living anymore but at one time was

Character/Trait: An observable, heritable trait that may vary among individuals; one of two or more detectable variants in a genetic character

Dichotomy vs. Polytomy:

Dichotomy: In a phylogenetic tree, a branch point from where two descendant taxa emerge

Polytomy: In a phylogenetic tree, a branch point from which more than two descendant taxa emerge; indicates that the evolutionary relationships between the descendant taxa are not yet clear

Dichotomous key: Used by biologists to identify unknown organisms to some taxonomic level; consists of a sequence of couplets, which represent a choice between two statements that the biologist must make while inspecting the organism; a biologist should be able to identify an organism to the lowest taxonomic level possible on the key

Extremophile: An organism that lives in environmental conditions so extreme that few other species can survive there

Halophile: An organism that lives in a highly saline environment, such as the Great Salt Lake or the Dead Sea

Methanogen: An organism that produces methane as a waste product of the way it obtains energy; all are in domain Archaea

Extreme Thermophile: an organism that thrives in hot environments (60-80 degrees Celsius or hotter

Peptidoglycan: A type of polymer in bacterial cell walls consisting of modified sugars cross-linked by short polypeptides; anchors other molecules that extend from its surface

Gram Stain: A staining method that distinguishes between two different kinds of bacterial cell walls; may be used to help determine medical response to an infection

Process: Stained with crystal violet dye & iodine; rinsed in alcohol, stained with a red dye; decolorizer (alcohol) dehydrates the peptidoglycan layer; trapping the crystal violet-iodine complex in the cell in gram-positive bacteria

Gram positive: Describing the group of bacteria that have a cell wall that is structurally less complex and contains more peptidoglycan than the cell wall of gram-negative bacteria; usually less toxic

Gram negative: Describing the group of bacteria that have a cell wall that is structurally more complex and contains less peptidoglycan than the cell wall of gram-positive bacteria; often more toxic

Geologic Record: A standard time scale dividing Earth’s history into time periods grouped into four eons- Hadean, Archaean, Proterozoic, and Phanerozoic- and further subdivides into eras, periods, and epochs

Resistance: The overuse of antibiotics leads to bacteria not being affected by them; it is a heritable trait that varies among individuals in a population; if bacteria have a resistant strain, they can give it to other bacteria

Virulence: The ability to cause disease; also heritable

Pathogen: bacteria that causes disease; only a small amount of bacteria are pathogenic; cause about ½ of human disease

Antibiotic: Molecule that kills bacteria- soil grown

Cyanobacteria: photoautotrophs that generate O2; chloroplasts likely came from cyanobacteria, fix nitrogen for themselves (heterocysts)

Flagella: A long cellular appendage specialized for locomotion; eukaryotic flagella have a core with nine outer double microtubules and two inner single microtubules ensheathed in an extension of the plasma membrane; prokaryotic flagella have a different structure; most common structure for movement; prokaryotic is 1/10 the width and not covered my membrane; arose separately in archaea, bacteria, and eukaryotes

Chemotroph vs. Phototroph:

Chemotroph: an organism that obtains energy from chemicals

Phototroph: an organism that obtains energy from the sun

Autotroph vs. Heterotroph:

Autotroph: An organism that obtains organic food molecules with out eating other organisms for substances derives from other organisms; use energy from the sun or from oxidation of inorganic substances to make organic molecules from inorganic ones

Heterotroph: Those that need at least 1 organic nutrient in order to produce energy

Nitrogen Fixation: The conversion of atmospheric nitrogen (N2) to ammonia; carried out by certain prokaryotes which may have mutualistic relationships with plants

Plasmid: A small, circular, double-stranded DNA molecule that carries accessory genes separate from those of a bacterial chromosome; in DNA cloning, plasmids are used as vectors carrying up to about 10,000 base pairs of DNA; also found in some eukaryotes such as yeast

Germ Theory: Made by Robert Koch; infectious diseases are caused by bacteria and viruses

Homeotic Genes/Hox Gene: Any of the regulatory genes that control placement and spatial organization of body parts in organisms by controlling the developmental fate of groups of cells

Hox Gene: contains the positional info in animal embryos

Regulatory/Developmental Gene: A gene that codes for a protein that controls the transcription of another gene or group of genes; control the rate and timing of development of an organism

Paedomorphosis: Rate of reproductive development accelerates compared to somatic development; the retention in an adult organism of the juvenile features of its evolutionary ancestors

Phylogenetic Tree: The diagram of evolutionary history; represent a hypothesis about evolutionary relatedness- use the simplest explanation

Archaea: One of two prokaryotic domains; don’t have a nuclear envelope or membrane enclosed organelles; do not have peptidoglycan in their cell walls; have histones associated with their DNA, have a circular chromosome; can perform nitrogen fixation, and grow at extreme temperatures: Crenarcheotes: extremophiles that can perform nitrification and dominate the oceans; believed to be an intermediate group between the bacteria and eukaryotes

Bacteria: One of two prokaryotic domains; do not have a nuclear envelope or membrane enclosed organelles, have peptidoglycan in their cell walls, do not have histones associated with their DNA, have a circular chromosome, and can grow at extreme temperatures; Spirochetes: gram negative heterotroph, spiral through their environment; some are free-living others are pathogenic; some bacteria can cause disease

Shannon-Wiener Diversity Index (H’): One of the most common measures biologists use to quantify biodiversity; takes into account both the number of species and evenness;

Biodiversity: Diversity among living things from all sources: within species; among species; and of ecosystems; with out all the living things and their interactions the Earth wouldn’t be habitable

Taxonomy: How organisms are named; the science of identifying, naming, and classifying organisms

The Linnaean Hierarchy: made my Carolus Linnaeus; transformed how we name things

Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species

Phylogeny: The evolutionary history of a species or group of species

Systematics: the science of inferring evolutionary relationships or phylogenies; by examining which morphological traits are shared between which species, we can infer evolutionary relationships; classification can but does not always reflect evolutionary relationships

Taxon: The named taxonomic unit at any level of hierarchy; placement of species does not always reflect evolution

Monophyletic: Consisting of an ancestral species and all of its descendants

Paraphyletic: Consisting of an ancestral species and some of its descendants- most recent is part of the group

Polyphyletic: Consisting of distantly related species but not their most recent common ancestor

Convergent Evolution: The evolution of similar features in independent evolutionary lineages due to similar environments

Clade: A group of species that includes an ancestral species and all of its descendants; a clade is equivalent to a monophyletic group

Common Ancestor: On a phylogenetic tree, the most recent species from which both organisms diverge from

Sister taxa: groups of organisms that share an immediate ancestor

Outgroup: A species or group of species from an evolutionary lineage that is known to have diverged before the lineage that includes the species we are studying

Basal Taxon: a lineage that diverges early in the history of a group and lies near the origin

Node: Where a species splits and becomes two new species; where a mutation or change occurs

Synapomorphy: A shared derived character among species or lineages- sets it apart from other species; ancestor may not have trait because it develops over time; for mammals- mammary glands; includes/describes the species in question, but not others

Sympleisiomorphy: other species can have the trait; species share the trait but doesn’t necessarily set them apart from other species- for mammals- vertebral column because they all share it but other groups have them too.

Homoplasy: Analogous structures that arose independently- molecular; a similar structure or molecular sequence that has evolved independently in two species

Homology: phenotypic and genetic similarities due to shared ancestry

Ancestral: A character that originated in an ancestor of the taxon

Derived: An evolutionary novelty unique to a clade- can determine the clade where it appeared

Prokaryotes: a type of cell lacking a membrane enclosed nucleus and membrane enclosed organelles; include the bacteria and cyanobacteria

Eukaryotes: A type of cell with a membrane enclosed nucleus and membrane enclosed organelles

Vestigial Structure: A feature of an organism that is a historical remnant of a structure that served a function in the organism’s ancestors

Three Domains of Life: Bacteria, Archaea, and Eukarya

Transduction: Phages (virus) carry prokaryotic genes from one host cell to another- usually results from accidents

Transformation: genotype and phenotype are altered by the uptake of foreign DNA (non pathogenic takes up a strain of pathogenic and becomes pathogenic)

Conjugation: Prokaryotic cell shares with another- DNA transfer is only 1 way though

Translation: Prokaryotic cell picks up a piece of DNA

Cocci: spheres, ovals, or elongated shape of bacteria

Bacilli: rod shape of bacteria

Spirilla: spiral shape of bacteria

Aerobic Respiration: A catabolic pathway for organic molecules, using oxygen (O2) as the final electron acceptor in an electron transport chain and ultimately producing ATP. This is the most efficient catabolic pathway and is carried out in most eukaryotic cells and many prokaryotic organisms

Koch’s postulates:

1. Microbe must be present in sick and not in healthy
2. Must be isolated and grown in a pure culture separate from the organism
3. Organisms from the pure culture injected into healthy will get sick
4. Must be re-isolated from the inoculated and identified as identical to the original causative agent

Eons and eras in the current eon, major events: Hadean, Archaean, Proterozoic, Phanerozoic – (Paleozoic, Mesozoic, Cenzoic) – look at major events in slide shows

Permian Extinction: Biggest mass extinction, claimed 96% of species; 251 million years ago, happened in a few thousand years; most extreme episode of volcanism in past 500 million years; triggered a series of catastrophic events

Cretaceous Extinction: 65.5 million years ago; All dinosaurs were killed, more than 50% of marine species, many terrestrial species; an asteroid or large comet collided with the earth- we know because there is a crater and because there is a layer of iridium around the area (not commonly found on Earth)

Typically takes 5-10 million years to recover the diversity that was found on Earth before a mass extinction

Binomial Nomenclature: two part, latinized format for naming a species, consisting of the genus and the specific epithet

Bacteriophage: A virus that infects bacteria

Horizontal gene transfer: When individuals from 2 different species bring together prokaryotic DNA; the transfer of genes from one genome to another through mechanisms such as transposable elements, plasmid exchange, viral activity, and perhaps fusions of different organisms

Orthologous Genes: genes have diverged after a speciation event; tend to have similar functions

Paralogous Genes: Gene can be duplicated; it is redundant and can acquire a new function

Example with humans and mouse- we both have more olfactory genes than our most recent common ancestor because of paralogous genes

Heterochrony: change in rate or time of developmental events- impact body shape; bat example

Allometric Change: an example of heterochrony; faster development like in bat wings that causes them to become larger than the most recent ancestor’s

Heterocyst: A specialized cell that engages in nitrogen fixation in some filamentous cyanobacteria

Dominance: The amount individuals within one species is more than the number of individuals in another species

1. What are the names and dates of all eons? What key events occurred in each eon?

What are the names and dates of the eras in the current eon? What key events occurred in each era?

* 1. Hadean – 4.6 billion years ago

Formation of Earth- 4.6 billion years ago with rest of solar system

Formation of Water- 4 billion years ago

* 1. Archaean – 3.8 billion years ago

First Prokaryotes

Oxygenation of Oceans

Origin of life

Atmospheric Oxygen- 2.7 billion years ago

First evidence of photosynthesis

First single-celled organisms (stromatolites) – 3.5 billion years ago

Oxygen Revolution - 2.7-2.3 billion years ago- caused the extinction of many prokaryotes because they could not live in oxygen

* 1. Proterozoic – 2.5 billion years ago

First Eukaryotes- 2.1 billion years ago

Multicellularity- 1.2 billion years ago

* 1. Phanerozoic – 542 million years ago
     1. Paleozoic – 542 million years ago

Cambrian Explosion- 535-525 million years ago

Fungi, plants, and animals began to colonize land – 500 million years ago

Vascular tissue in plants – 420 million years ago

Tetrapods – 365 million years ago

First Insects - 410 million years ago

* + 1. Mesozoic- 251 million years ago – Permian Extinction

Mammals, birds, flowering plants – 65.5 million years ago

* + 1. Cenozoic – 65.5 million years ago – Cretaceous Extinction

Human lineage of tetrapods – 6-7 million years ago

Modern humans = 195,000 years ago

1. Can you list and explain the four key events scientists hypothesize were necessary for life to evolve on early earth?
   1. Abiotic synthesis of small organic molecules – Early earth had a reducing atmosphere with water vapor and chemicals; could have occurred but there are other possibilities that would have produced organic molecules spontaneously
   2. Joining of these into macromolecules- RNA can be synthesized abiotically; molecules can polymerize spontaneously on hot surfaces
   3. Packaging into probionts- Small, cell-like things that have replication and metabolism; consists of a membrane with molecules inside
   4. Reproduction- RNA is most likely the first because it could self replicate and they are simpler and required for the synthesis of other macromolecules; many cell components have RNA
2. Can you explain how regulatory genes can cause major changes in body form?
   1. Regulatory genes decide which genes are expressed and which are not. By changing the expression of the gene, a morphological trait of an organism can be present or not present. For example, in the fish we learned about in class, there was a spine like thing on the bottom of the fish that was useful in salt water environments but not in freshwater. When investigated, scientists found that both fish had the same genetic code, but one of the codes was restricted by a regulatory gene that told the gene not to be expressed and therefore not have a spine.
3. Can you explain the importance of prokaryotes for the persistence of life on Earth?
   1. With out any species on the planet, the world would be different. But in particular, prokaryotes are one of the central parts for the persistence of life on Earth. Most organisms need nitrogen for their function in making proteins and nucleic acids. However, they cannot produce it themselves, instead prokaryotes play an important role in nitrogen fixation, through which organisms can access a form of nitrogen that they can use.
4. Can you explain the importance of cyanobacteria on early earth?
   1. Cyanobacteria are one of the biggest causes of the accumulation of O2 in Earth’s atmosphere. Without this accumulation where would not be enough O2 on the planet for most of the current aerobic life forms to exist.
5. Can you describe ways in which prokaryotes are diverse?
   1. Prokaryotes are composed of bacteria and archaea. Bacteria are very diverse, ranging in size and shape- cocci, bacilli, and spirilli. They have multiple kinds of cell walls that differ in structure and composition. Some of them are motile and some of them are pathogenic
6. Can you explain why larger taxonomic groups are not comparable across lineages?
   1. When comparing species that are closely related- in the same genus, they share many characteristics because they most likely came from a more recent common ancestor than two species who are part of the same order. It’s like comparing any two mammals- which would have some things in common, but not all, and two trees- which would have a lot more in common.
7. Can you explain why classification can, but does not always reflect evolutionary relationships?
   1. Classification is largely based on the morphological characteristics of species. This means that often, species that appear to be closely related are placed in the same genus, but actually have their most recent common ancestor a very long time ago.
8. Can you explain why we consider phylogenetic trees to be hypotheses?
   1. There is no way we can say for sure which organisms came from which and who they were most closely related to with out having been there and seen them. Because most of history happened before our time, we must make assumptions using maximum parsimony and maximum likelihood to come up with the solution for phylogenetic trees that are most likely to have occurred throughout history.
9. Can you describe the ways in which the fossil record is biased?
   1. The fossil record is biased because certain types of organisms are more likely to be fossilized than others because of the rarity of fossilization. Species with a large number of individuals, those who were around for a long period of time, those with hard parts, and those that lived in particular environments are more likely to have been fossilized and therefore we are more likely to know more about.
10. How does radiometric dating work? What is meant by “absolute” date? Does it mean without error?
    1. Radiometric dating is the technique used to date fossils. It looks at the components of a fossil and dates how old it is using the radioactive isotopes that will slowly decay to become more stable. This happens at a constant rate and scientists are able to measure the amount of decay and use this information to date the fossil. Absolute date means an age is given in years, but is not errorless.
11. Can you explain what the fossil record provides evidence of?
    1. The fossil record provides evidence of the existence of specific organisms at different points during the history of Earth and how they changed. It also gives some indication to the changes these individual species underwent as a result of evolution.
12. Can you explain why biologists care about continental drift? How does knowledge about continental drift inform our thinking about evolution?
    1. Continental drift affect organisms. It causes allopatric separation- when organisms of the same species are separated geographically, they evolve separately and differently.
13. Can you identify the bacterial types you saw in lab? Can you distinguish among them?
    1. Cocci: spherical
    2. Bacillli: Rods
    3. Spirilli: Spirals
    4. Gram positive: purple
    5. Gram negative: pink
14. Can you list and explain Koch’s Posulates?
    1. The bacteria must be present in those who are sick and not in those who are healthy
    2. The bacteria must be able to be isolated and grown in pure culture
    3. When introduced to a healthy patient, the patient must become sick
    4. When removed from the healthy patient, and identified as identical to the original causative agent