Organismal Biology Final Exam Review

Speciation

Species Concepts:

Biological species

- a group of organisms that can successfully interbreed and produce fertile offspring

*Problems: - interbreeding only applies to eukaryotes and not prokaryotes

- we can't apply this to fossils (the fossil record)

Ecological species

- a group of organisms that share a distinct ecological niche (habitat)

Phylogenetic species

- a group of organisms bound by a unique ancestry (evolutionary trees)
- at the tips of the tree where no further branching occurs, we have a phylogenetic species
- EXTREMELY PROBLEMATIC

Morphospecies

- the idea that all individuals of a species share measurable traits that distinguish them from individuals of other species
- in other words, an organism that is so different that its morphologically different and therefore it is its own species
- the names of species is subjective in morphospecies

ALL 4 concepts fail to solve problem with prokaryotes

Biologists cannot decide exactly what a species is and therefore they tend to use all the concepts to isolate a species

* NO UNIVERSAL WAY TO DEFINE A SPECIES

Elaphe oboleta (rat snake)

- ecologically isolated
- they can however interbreed
- in the zone of mixing we get SUBSPECIES (in the process of becoming a new species)

Salamander

- the coastal one adapted to appear similar to the toxic nute (bright red) *Advantageous
- the valley one was forced to camouflage (black with yellow spots) to avoid predators (they would hide in leaf litter)
- the salamander can interbreed and therefore we must call these subspecies
- the hybrids are LEAST likely to survive (neither red nor splotchy) and they are not viable

* DOGS ARE SUBSPECIES OF WOLVES (THEY CAN INTERBREED)

Reproductive isolation (bio species concept):

- this mechanism is a characteristic that prevents the gene pools of two species from mixing even when they are sympatric (occupying the same spaces at the same time)

Prezygotic isolation

Ecological

- species living in the same geographic region but in <u>different habitats</u>
- therefore they are unlikely to go out of their environment
- ex- lion-tiger hybrids are ulikely

Temporal

- species that live in the same habitat but with mating events that occur at different times (different seasons, or even different times of the day) may experience temporal isolation
- ex: fruit flies- one species mates in morning, another in the afternoon

Behavioural

- behavioural isolation results when the signals used by one species are not recognized by another
- two species do not mate because of differences in behaviour
- ex: fireflies flash each other with signals of different pulses

Mechanical

- occurs when differences in the structure of reproductive organs or other body parts prevent interbreeding of species
- ex: plants usually only allow certain pollinators (certain insects)

Gametic

- incompatibility between the sperm of one species and the eggs of another may prevent fertilization

Postzygotic isolation

Hybrid inviability

- results when developmental programs of the two parent species are incompatible
- these resulting organisms frequently die as embryos or at an early age

Hybrid sterility

- hybrids that can develop into healthy adults but are unable to produce functional gametes
- ex: mule

Hybrid breakdown

- happens when hybrids are fully fertile and healthy, but their offspring exhibit reduced fitness

Allopatric speciation (2 types)

1. Vicariance

- occurs when a physical barrier subdivides a large population into two or more units
- this barrier can be caused by hurricanes, uplifting mountains or land masses

2. Dispersal

- occurs when a small population becomes separated from the species' main geographic distribution
- This separated population will often differ genetically from the central population because they are adapted to somewhat different environments
- the accumulated genetic differences can lead to reproductive isolation
- ex: populations on oceanic islands (individuals from one island may colonize another and they may differentiate into distinct species) – evolution of species cluster

* Second contact

- allopatric speciation may re-establish contact when a geographic barrier is eliminated
- provides a test of whether or not the populations have diverged into separate species

- hybridization outcomes: fusion (if they didn't differentiate much during separation they will interbreed and merge), creation of new species (if they have differentiated enough to become reproductively isolated), hybrid zones (some members of each population mate, producing viable and fertile offspring)

Parapatric speciation

- occurs when a species is distributed across a discontinuity in environmental conditions so that natural selection favours different alleles and phenotypes on either side of the discontinuity

Sympatric speciation

- occurs among subgroups of a population
- neither geographic nor reproductive isolation is necessary for sympatric speciation to occur
- changes in diet, behaviour, or chromosomes can cause it
- ex: insects feeding on different sized seeds, one feeds on small and one feeds on big

Polyploidy and speciation:

Autopolyploid

- diploid (2n) individual may produce tetraploid (4n) offspring, each with four complete chromosome sets
- this occurs through an error in mitosis or meiosis
- these unreduced gametes do not have reduced chromosome numbers
- tetraploids can also arise from the fertilization of a diploid pollen with diploid ovules of self-fertilizing plant or with the diploid eggs of another plant with unreduced gametes
- these tetraploid offspring can reproduce by self-pollination or by breeding with other tetraploid individuals but cannot produce fertile offspring by hybridizing with its diploid parents

Allopolyploid

- two closely related species hybridize and subsequently form polyploidy offspring
- a hybrid mating between two species followed by a doubling of chromosomes during mitosis in gametes of the hybrid can instantly create sets of homologous chromosomes
- self-fertilization can then generate polyploid individuals that are reproductively isolated from both parent species
- ex: wheat (hybrid of 3 plants)

Organizing the Living World

Classification

- an arrangement of organisms into hierarchial groups that reflect their relatedness
- ex: postcards, arrange by country

Taxonomy

- the identification and naming of species and their placement in a classification
- set of rules for organizing things you collect

Systematics

- the rule that you use to organize
- if the rule is evolutionary descent, then systematics shows the common ancestors and evolutionary relationships between the different groups.

Hierarchial

- arranging organisms into more inclusive categories (family, classes, phyla....)

Types of taxonomies:

Folk taxonomy

- when the spoken word was the only way that the classification and its rules were passed between generations
- no matter when and where they live, people around the world have used folk taxonomies to organize a variety of different things including the natural world that surrounds them

Artificial (ancient) taxonomy

- Plato and his students Aristotle and Theophrastus
- wrote down information contained in the folk taxonomies compiling lists of living things (Aristotle-the animals, and Theophrastus-the plants)
- these ancient greek texts were passed between generations and translated (to latin and Arabic)

Mechanical taxonomy

- Linnaeus took the long descriptive lists and reduced every unique organism in the list to a name with two parts (binomen). Latin noun with adjective.

- he also organized the plants and animals in his SYSTEMA NATURAE into categories contained within larger groups- a hierarchial system.
- this was the end of ancient taxonomies and the beginning of mechanical taxonomies based on the physical characteristics of the organisms being classified
- Linnaeus used similarities in appearance when grouping his organism's characteristics

Natural taxonomy

- traditional/classical taxonomy
- begins when Darwin published his works that outline evolution and his idea that different organisms descend from common ancestors. Organisms in a taxon should all have the same common ancestor and the ordering of the taxa should reflect the evolutionary relationships between the different groups
- Anatomical characters were used and organisms that had similar functional structures were assumed to have the same ancestor in the distant past
- Often two animals function, or look the same but don't have a common ancestor
- Traditional taxonomists often argued over which types of characters were better than others for unwinding evolutionary sequences and depending on what was used the results changed. There was a bias in the system and for a brief period of time it was hoped that taking hundreds of physical measurements from different organisms representing different species and plugging then into a computer would solve the problem
- Computers weren't finding the inherent patterns of descent and phonetic(numeric) taxonomy lived a short life

Phylogenetic (cladistic) taxonomy

- Henning
- the problem of bias remained
- What are valid homologies, what are the homoplasies from convergent evolution, and are some of these more important than others in determining the evolution of organisms. The solution came with cladistics (phylogenetic systematics).
- In this technique biologists try and find characters that have ancestral and derived conditions.

Representing groups of animals:

Dendrograms

- look like trees
- like the scala naturae
- has biases in terms of placement of organisms

- doesn’t show evolutionary relatedness
- separates terrestrial from aquatic

Cladograms (Phylogenetic trees)

Cladistics

- produces phylogenetic hypotheses and classifications that reflect only the branching pattern of evolution
- ignores morphological divergence

Clade

- a subset of organisms within a group that all have the same shared characters

ancestral character: old forms of trait (plesiomorphic)

derived character: new form of trait (apomorphic)

Anatomy of a cladogram:

Outgroup comparison

- can be used to identify ancestral and derived traits because it compares the group under study with more distantly related species not otherwise included in the analysis
- ideally the outgroup should be a monophyletic group sharing a direct common ancestor with the ingroup
- outgroup=sister group

Monophyletic

- a group of species derived from a single ancestral species

Polyphyletic

- species from separate evolutionary lineages
- put organisms together that are thought to be related, however further investigation shows this not to be true

Paraphyletic

- a group of species including a common ancestor plus only some of its descendants
- we don’t want this! these groups are not informative in terms of cladistics and characters that lead to the formation of these groups are not homologous

Useful characteristics:

Apomorphies

- derived characters within a group

Plesiomorphies

- primitive characters within a group

Synapomorphies

- derived characters shared between groups

Symplesiomorphies

- primitive characters shared between groups

Parsimony (KISS principle)

- KISS (Keep It Simple Stupid)
- the fewest possible evolutionary changes should be used to account for within-lineage diversity
- the minimum number of character states or transformations, must be selected when different hypotheses are in conflict

The camera eye

- evolved twice
- difference: in vertebrates, the nerves come out in front of retina to form optic nerve while in molluscs the nerves come out behind the retina to form the optic nerve
- HOMOPLASY

Silurian and Devonian

Arthropoda: Crustacea

- primary herbivores
- become food source for larger organisms
- ex: lobsters, crab, shrimp

Armoured fishes

- fish make their appearance
- they don't look like anything we see today
- instead of having scales they had bony plates (armour) for protection
- ex: ostracoderm, placoderm

Ostracoderm

- jawless fish
- pharynx used to draw water with food particles into their mouths and gills used to filter the food from the water
- lacked a true vertebral column
- vertebrate characteristic- 3 regions in brain (fore, mid, hind)

Placoderm

- appeared in Silurian, diversified in Devonian and Carboniferous
- bodies covered with large, heavy plates of bone anteriorly and smaller scales posteriorly
- jaws had sharp cutting edges but no separate teeth

Jawless fishes

- feed on sides of large fish (lamprey did this)
- fed by ramming food in their mouth
- hagfish, lamprey,ostracoderm

Evolution of the jaw

- jaws evolved from paired gill arches in the pharynx of a jawless ancestor
- one pair of ancestral gill arches formed bones in the upper and lower jaws, whereas a second pair was transformed into the hyomandibular bones that braced the jaws against the cranium

Chondrichthyes (Cartilaginous fish)

- the absence of bone is a derived trait
- Elasmobranchii (sharks, rays and skates)
- Holocephali (chimeras)- the only cartilaginous fishes with an operculum (gill cover)
- fins work like airplane since it moves in 3D space
- to stop they must do a turn using their fins, therefore aren't very mobile
- no mechanism for agility

placoid scales

- we now see scales instead of armour
- provide turbulence to decrease resistance with water (laminar flow)

feeding

- teeth are giant version of scales that line its body
- formidable ability to feed
- teeth cannot break prey/food down into smaller pieces

Bony fish skeleton

- like fish we would see today
- bony endoskeleton (cranium, vertebral column with ribs, and bones supporting their movable fins)
- endoskeleton provides lightweight support compared with the bony armour of ostra/olacoderms, enhancing their locomotor efficiency
- pectoral and pelvic fins articulate and allow for agile motion (stopping, sharp turns, floating/hovering)

opercular gill

- a flap of the body wall that serves as cover for the gills

swim bladder

- a gas-filled air bladder in the body controlled by the circulatory system
- increases buoyancy
- derived from an ancestral air-breathing lung

Evolution of the tetrapod stance

- fins formed limbs that allowed organisms to go up on land

Transition to land (plants)

- not an easy step for multicellular organisms

Water conservation

- across exchange surfaces
- across boy wall in general
- need a way to protect against water loss in the terrestrial environment

Protect the gametes

- a way to transfer sperm to egg (since they don't have water)

Support system (gravity)

- supporting mechanism for organism on land due to gravity

Phylogeny of plants

- 1^{st} plants had waxy surfaces and pores opening to minimize water loss and allow for gas exchange (* adaptation for gas exchange)
- However it was not efficient (later we will see pores that open and close when needed)
- stomata regulates gas exchange
- vascular tissues support organism
- seeds solve issue of reproduction

Green algal life cycle

- alternation of generations
- vegetative growth in haploid form
- plant gametes (2 flagella)
- gametes fuse = diploid will grow
- the gametes are entities (part of the life cycle)

Alternation of generations in land plants

*see notes

- zygote undergoes mitosis –> multicellular organism (sporophyte)
- * zygote will never make gametes, it makes cells that into a new growth phase (spores)
- sporophyte makes spores after undergoing meiosis
- spores undergo morphogenic change (via mitosis) forming haploid gametophyte
- gametophytes make the gametes

Sorting out plant parts

Sporophyte (spore plant) 2n

- have sporangia producing spores
- from a zygote (fusion of sperm and egg)

Gametophyte (gamete plant) n

have gametangia producing gametes

- antheridia- makes sperm
- archegonia- makes egg

Evolutionary trend in plant life cycles

- sporophyte stage becomes dominant and protects gametophyte stage
- it wraps around gametophyte
- takes care of gametophyte inside its life cycle

Liverwort (life cycle)

- rain splashes off antheridia and is shot up into “umbrella” which is the archegonial head
- this is how sperm is transferred to egg

Transition to land- water conservation

- waxy surface (cuticle) gives some water-proofing
- pores allow gas exchange
- stomata have guard cells that swell to close opening and shrink to leave it open
- * they are starting to leave behind total dependence on moist environment

Mosses

- will not have vascular tissue
- can absorb water- trap it with leaf like structures of the moss
- mosses can dry out and shut down metabolism (become dormant) and will wait for moist conditions to return (water)
- still see both reproductive life cycles
- the 2 stages are coming together and we start to see strengthening however no vascular tissue

Moss life cycle

- sporangium releases spores formed by meiosis
- each germinating spore becomes a budlike mass
- each bud develops into a male gametophyte with antheridia or a female gametophyte with archegonia
- flagellated sperm develop in antheridia, egg develops in archegonia
- antheridia release sperm that swim in film of water to egg in the neck of the archegonium
- zygote remains in archegonium and develops into small, mature sporophyte
- * can also reproduce asexually via gemmae

Evolution of plant vascular tissues

- plant cells connected to each other (rigid cell walls)
- water diffuses from one cell to the next
- not efficient, but this is the first way it starts out
- Plants create lignin (a tough complex polymer that strengthens the cell wall and allows for upright growth) which makes sure they don't collapse
- * lignin tough to degrade
- plants also used nitrogenous waste to make structure that held them up

Early Devonian

- land plants started to take off in huge numbers
- continents going together
- we start to see soil

Devonian aquatic environments

- we start to see jawless fish disappear as well as some invertebrates

* we are now heading to first vascular plants

Evolution of plants vascular tissue

- refinement of vascular tissue
- tracheids- fluids can move up and down
- water supplied from roots at the bottom, making its way to the top

Ferns

- have tracheids

- use of dead plant cell tubes

Fern life cycle

- alternating generations
- spore develops in sporangia and are released
- a spore germinates and grows into a gametophyte
- in the presence of water, the antheridium bursts, releasing sperm that swim toward a mature archegonium
- fertilization produces a zygote
- the sporophyte (still attached to the gametophyte) grows, develops

Carboniferous and Permian

- plants will expand on land
- animals will start coming up on land as soon as there are enough primary producers (plants)
- ISSUES: water loss, protection of gametes, support system (need some sort of skeletal system)

Early Carboniferous

- Gondwana moves away from poles

Late Carboniferous

- massive supercontinent from pole to pole

Phylogeny of plants

- we are going to see the final stages of the gametophyte stage internally

Carboniferous forests (coal forests)

- made with huge trees and structures (mostly ferns and horsetails, and some mosses)
- fixed huge amount of primary productivity
- carbon scrubbed out of the air into coal beds
- * as soon as the seed becomes perfected, they will be the dominant plant form while the ferns, mosses etc will be the minor plants

Evolution of plant vascular tissues

- the addition of vessel elements (pits and a perforated end wall) allowed for there to be no restrictions on the movement of water from roots to leaves

Spores vs. seeds

Homosporous

- spores look the same (found in seedless vascular plants and non-vasc plants)

Heterosporous

- spores look different
- sperm are smaller spores (microsporangia)
- eggs are larger spores (megasporangia)

- the megasporangia are non motile and await the arrival of the microsporangia
- when they fuse we get a sporophyte

Seeds

- put sporophyte in a case (seed)
- embryo will be protected
- aids in dispersion

Gymnosperm life cycle (conifers)

- 2 year process
- female and male cones each produce spores
- in sporangia of males cones, meiosis gives rise to microspores that develop into pollen and in sporangia of female cones, meiosis yields megaspores
- each microspore will divide into 4 cells (2 inside pollen, 2 for male gametes)
- megaspore undergoes meiosis, results in 4 megaspores, only one survives. This surviving megaspore will undergo mitotic divisions and will put aside 2 archegonia which contain egg cells
- pollination occurs when wind deposits a pollen grain near an ovule on female cone scale
- the pollen grain (male gametophyte) germinates. Sperm form in the pollen tube as it grows toward the egg
- fertilization forms a zygote that develops into a seed
- eventually, the seed gives rise to a seedling that grows into a sporophyte

Lignin

- major innovation by plants
- hydrophobic (vessels lined with lignin and therefore no polar interactions between water and tubes)
- very few organism can digest it (some fungi can, they have digestive enzymes)
- very toxic

Fungi

- major decomposer of lignified plant tissue
- most of life in haploid condition
- resistant to dehydration and cold (will shut down)

Typical fungal life cycle

- hyphae of one mating type fuse to hyphae of the opposite type
- the fungal cells fuse but the nuclei don’t (plasmogamy)

- dikaryotic structures develop
- in the ascus, the two nuclei fuse, producing a diploid zygote (karyogamy)
- meiosis in the diploid nucleus produces four haploid nuclei
- spores released, cycle starts over

Ascomycota (same as above plus these steps)

- the four nuclei now divide by mitosis; then cell walls form around each of the resulting 8 nuclei. These cells are ascopores. Asci develop inside an ascocarp, which began to form soon after sexual reproduction began.
- asci release their ascopores through an opening in the ascocarp
- when an ascopore germinates it gives rise to new mycelium
- asexual reproduction: spores may germinate and give rise to a new mycelium of the same mating type

Basidiomycota (same as typical fungal life cycle)

- after the dikaryotic structure develops, the hyphae form a basidocarp. Spore-producing cells are under the cap, on flap-like gills
- then we get karyogamy
- meiosis produces 4 haploid nuclei
- 4 spores formed and released
- mushrooms
- known for solving lignin issue (can break it down)

Fungal mutualism

- plants can extend their absorptive surface via their relationship with fungi
- fungi locate themselves on outside of cells
- fungi can produce chemicals that will dissolve minerals from rocks etc
- plants provide sugar to fungi
- fungi then transports minerals to plants from extending hypha

Lichens (fungi)

- show relationship of fungi with plants
- association: fungi and algae
- algal cells wrapped around by web of mycelia that protect algal cells
- the algal cells will carry out photosynthesis and provide fungi with nutrients
- the fungi in return will provide minerals to the algae
- lichen are dormant when dry
- * this is probably the first relationship between fungi and plants on land

Annelids, arthropods, chordates move up on land

Lophotrochozoa

- either feed with lophophore or have a trochophore larva

Annelida (earthworm)

Body wall

- shows the secret of burrowing
- hydrostatic skeleton (coelom water part)
- contraction of longitudinal and circular muscles for movement
- segmentally arranged body (success for burrowing)
- this allows for only certain parts of the organism to move/change shapes, INDEPENDENTLY of one another
- has not perfected issue of water loss across body wall
- they breath across skin and therefore must remain moist
- in spring they get out of their burrows because it becomes water logged with deoxygenated water

Locomotion

- hairs (setae) that stick out into ground to anchor worm
- longitudinal contraction (setae out)
- circular contraction (setae in)
- accordion like movement
- push head (anterior end) into substrate (burrowing)
- open mouth- consume soil as pushing through it
- extract nutrients from soil
- burrow in substrate

Reproductive system

- clitellum- secretes mucous that surrounds worm
- hermaphrodites
- worms transfer sperm on soil surfaces
- seminal vesicle releases sperm through duct, it is received by seminal receptacle of another worm
- DIRECT sperm transfer (protective casing- mucous)

Cocoon formation

- "sock" slides down and dumps eggs into it, dumps sperm into it, zygote (cocoon) forms (once sock goes off end)
- worm emerges from cocoon

Insect external anatomy

- insects were feeding on spores produced by plants or leafy tissues
- head- vision, sense, eating
- abdomen- housekeeping (digestion and reproduction)

Insect movement (Flight and wing folding mechanism)

- major innovation- FLIGHT
- ability to escape predators, find mates, leave during unfavourable climate conditions
- folding mechanism to protect wings (ex: beetles)
- *dragonfly- hasn't changed in 200 Ma

Cuticle-Exoskeleton

- procuticle gives strength (made with chitin)
- *suit of armour
- however the procuticle is not waterproof but there is an epicuticle on top of the procuticle
- the epicuticle is waterproof (consists of waxes and oils)
- ecdysis-> molting -> escape from cuticle

Insect tracheal system

- air in insects transferred directly to tissue from (trachea to tracheoles)
- works because gases diffuse through air quicker than in water
- insect will then close spiracles, O_2 concentration will decrease
- BUT diffusion allows for the suppliance of O_2 to the rest of the tissues
- once levels of O_2 are low, the spiracles open again and the process retarts

Insect reproduction

- lock and key mechanism
- sperm package (spermatophore) is resistant to drying and breakdown
- female stores the package in the seminal receptacle
- egg moves down tract and receives sperm from seminal receptacle
- this forms chorion with opening (micropyle)

Insect metamorphosis

- incomplete metamorphosis: juvenile very similar to adult form (ex: grasshopper)
- complete metamorphosis: juvenile and adults different and therefore will not be in competition for food. They tap into different food sources. (ex: caterpillar-butterfly)

Deuterostome phylogeny

- cranium
- vertebrae
- bones
- jawless and jaw fish
- hinged jaws and movable fins
- tetrapod stance (the first are amphibians)
- amniote egg

Amphibians

- nothing like we see today
- 1^{st} ones were lizard like in appearance

Food

- start to feed on insects
- their tongue is designed for capturing insects

Locomotion

- limbs attached to backbone (allows for jumping)
- ability to lift self off ground
- adapting to terrestrial environment
- skeletal issues starting to be solved

Skin

- must keep skin moist (breath through skin)
- skin is smooth (glands produce water or liquid over skin surface to keep it moist)
- *absence of scales
- poison gland acts as protection mechanism

Amniote phylogeny

- place embryo up on land in protective case (amnion)

Amniote egg

- water casing for embryo
- all of the wastes of the embryo are kept in the allantois
- albumen- egg white
- yolk sac- food
- reptiles do this egg thing (solution has finally come at end of Permian)

Types of extinctions

Background extinction

- the continuous background rate of extinction that occurs on the planet
- *more species have been lost in earth's history to background extinctions than to mass extinctions

Mass extinction

- when 50% of the genera (Genus level) are lost and most often the marine environment is where measurement are made
- 5 major mass extinctions (end of Ordovician, Devonian, Permian, Triassic, and Cretaceous periods)

Causes of mass extinction

Meteorite impacts

- causes major damage
- end of the dinosaurs

Flood basalts

- unlike volcanoes that spew out dust particles, toxic gases such as sulfur dioxide and the greenhouse gas carbon dioxide Flood basalts do this on a huge scale
- instead of producing a volcano the lava flows out of the rip in the mantle and floods across the ocean floor or on land

- these can cover large areas
- The only recorded flood basalt eruption occurred in Iceland in 1783-84 and produced three cubic miles of lava
- There are major flood basalt fields on the planet that correspond to each of the major mass extinction events, including the end-Cretaceous and they are increasingly become the main suspect for triggering mass extinctions

Gas hydrates

- Methane gas is solidified in combination with water due to the pressure of the water column above and temperature. If the pressure were to decrease, as the ocean levels fell, or the water was to warm up these gas hydrates would release the methane into the atmosphere and methane is a much more potent green house gas than carbon dioxide

Marine anoxia

- a decrease in the dissolved oxygen in the ocean water
- no oxygen = no life, other than single celled plants and bacteria

Conclusion

- still don't have all the answers to why mass extinctions occur but increasingly they suspect greenhouse gases and global warming that creates an anoxic marine environment
- PERMIAN was probably a deadly combinationof all 3 made possible by the release of gas hydrates

Surviving mass extinctions

Plants

- they are often resistant to physical damage and many can grow from broken and damaged pieces
- seeds and spores are also resistant to adverse environmental conditions that may be associated with a mass extinction
- by their very nature plants are survivors because they are sessile and survive under adverse conditions for prolonged periods – an example the plants that grow in the arctic or lay dormant in the hottest desserts waiting for a brief rainfall
- Finally plants are autotrophic, and make their own food from carbon dioxide and light. They are completely self sufficient and don't have the complicated trophic interactions that animals have. Not only that the green houses gases are used by the plants!

Insects

- are also survivors and their small size, early generalist feeding patterns and wide distribution no doubt helped them to survive. The only evidence for any extinction event affecting insects is the massive end Permian extinction when six insect orders disappeared from the plant.

* small generalist organisms seem to survive better than large specialists (ex: if dependent on other animals = harder to survive)

Single celled organisms

- cyanobacteria are referred to as fossil species and the reason for their success is their simple asexual reproduction, global distributions and they haven't changed that much