Aim

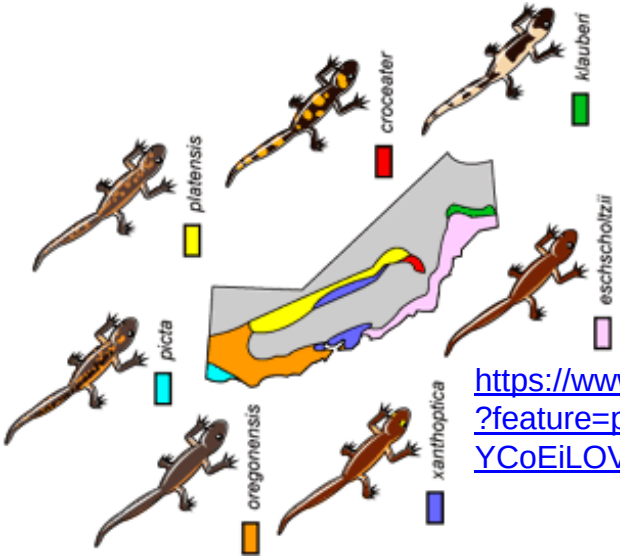
To understand the difficulties inherent in defining a '***species***' and factors contributing to ***speciation***

Topic Summary: https://www.youtube.com/watch?feature=player_embedded&v=2oKlKmrbLoU

D2: Species & Speciation

"Species are as many as were created in the beginning by the Infinite."

(**Linnaeus**, 1758)



https://www.youtube.com/watch?feature=player_embedded&v=YCoEiLOV8jc

Same or different species?

Canis lupus
Canis lupus familiaris (mans best friend)

D.2.1 Define allele frequency and gene pool

al·lele fre·quen·cy
Allele frequency is the proportion of all copies of a gene that is made up of a particular gene variant (allele).

gene pool
Noun: The total collection of different alleles in an interbreeding population.

Example
Say if a recessive allele h made up 2% of the total in a human population...

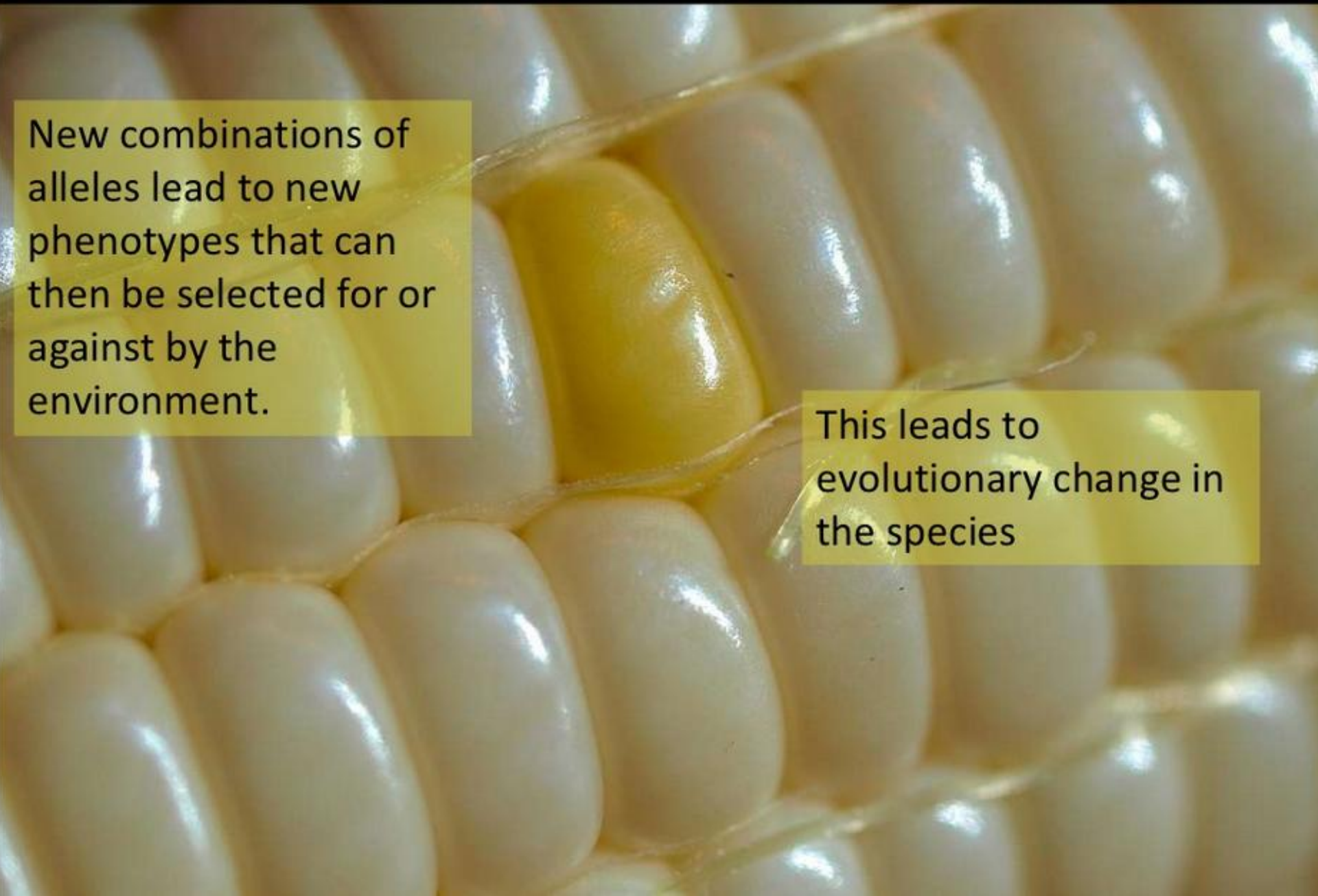
...then the dominant allele H would make up 98%.

The frequency for h would be expressed as 0.02 and for H 0.98
Recessive allele frequency + dominant allele frequency = 1

(for characteristics determined by two alleles)

http://www.flickr.com/photos/limowreck666/171979083/

D.2.2 State that evolution involves a change in allele frequency in a population's gene pool over a number of generations



New combinations of alleles lead to new phenotypes that can then be selected for or against by the environment.

This leads to evolutionary change in the species

What the *heck* is a Species?

In truth – there is no universally agreed upon species concept.

The organisms a scientist studies will often define the concept they ***choose*** to use

For more info on species concepts see:
http://evolution.berkeley.edu/evosite/evo101/VADefiningSpecies.shtml
Click biological species concept & other species concepts

D.2.3 Discuss the definition of the term species

There are many definitions, here are five!

Ecological species
A set of organisms adapted to a particular set of resources, called a niche, in the environment.

Genetic species
Based on similarity of DNA of individuals or populations. Having a common gene pool.

Evolutionary species
A group of organisms that shares an ancestor; a lineage that maintains its integrity with respect to other lineages through both time and space. At some point in the progress of such a group, some members may diverge from the main population and evolve into a subspecies.

Lots to *discuss* if you get a question about this!

Cladistic Species
A group of organisms that shares an ancestor; a lineage that maintains its integrity with respect to other lineages through both time and space. At some point in the progress of such a group, members may diverge from one another: when such a divergence becomes sufficiently clear, the two populations are regarded as separate species. (This differs from the Evolutionary definition in that the parent species goes extinct when two new species are recognised).

Breeding Species
Two organisms that are able to reproduce naturally to produce fertile offspring of both sexes.

More infor on species concepts:
http://en.wikipedia.org/wiki/Species

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The **genetic definition** is the most widely used/accepted and works well for most multi-cellular organisms…..

However there are exceptions!

s to *discuss* if you get a question about this!

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But there are problems with every concept!

Hors d'oeuvre?

It could be (ahem) physically impossible for members of the same species to mate.

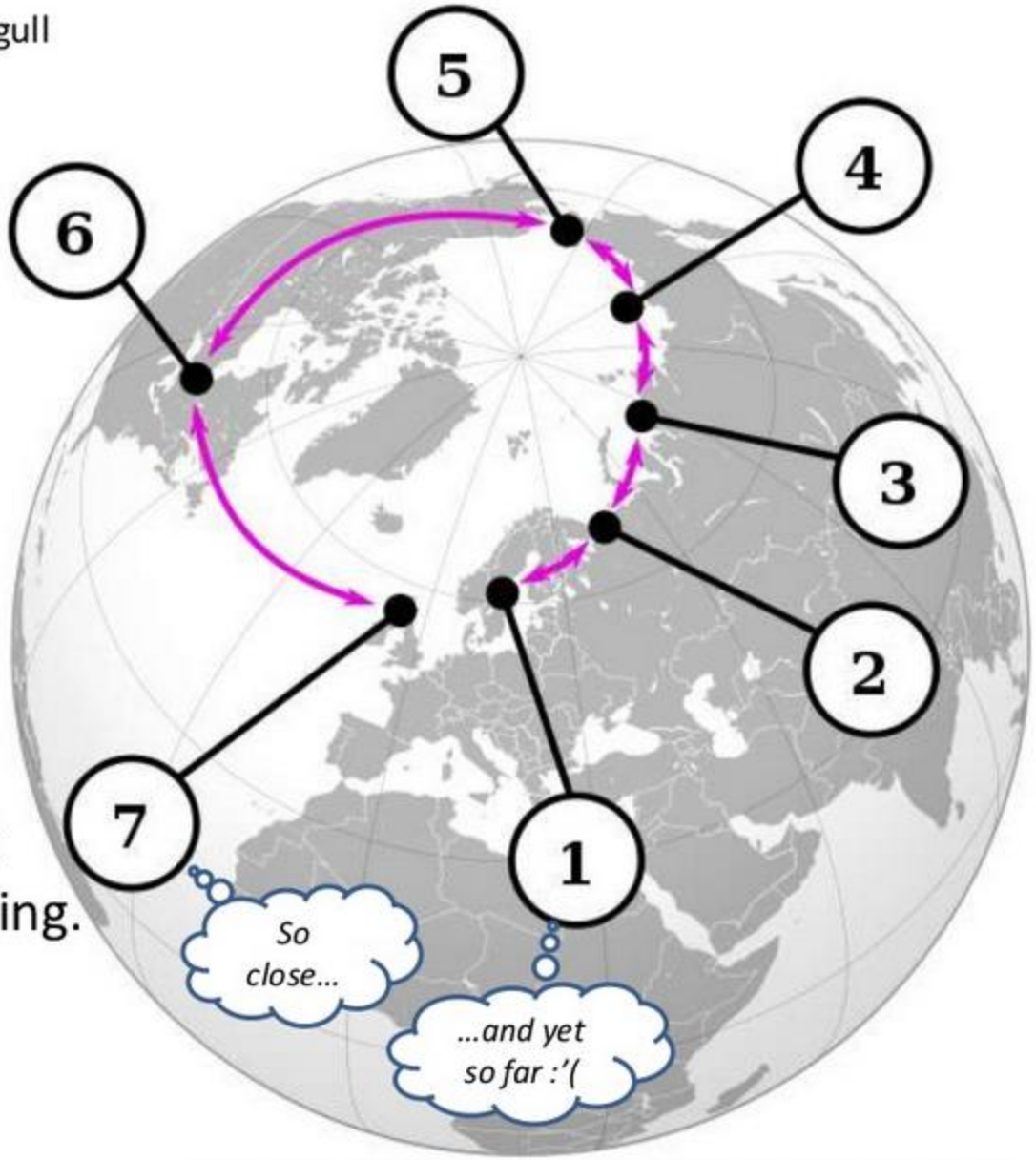
Therefore they are genetically isolated.

https://www.youtube.com/watch?feature=player_embedded&v=YCoEiLOV8jc

1 : Lesser Black-backed Gull
2 : Siberian population Black-backed gull
3 : Heuglin's gull
4 : Birula's Gull
5 : East Siberian Herring Gull
6 : American Herring Gull
7 : Herring Gull

Ring Species:
Adjacent populations can interbreed but the populations at the "end of the line" cannot.

1 and 7 cannot produce offspring.



Hydrid Fertility/Infertility

Hybrids are usually **infertile** and can not produce offspring together, for example the **mule** (63 chromosomes): a cross between a Male horse (64 chromosomes) and a female donkey (62 chromosomes)

Why are 63 chromosomes a problem when reproducing?

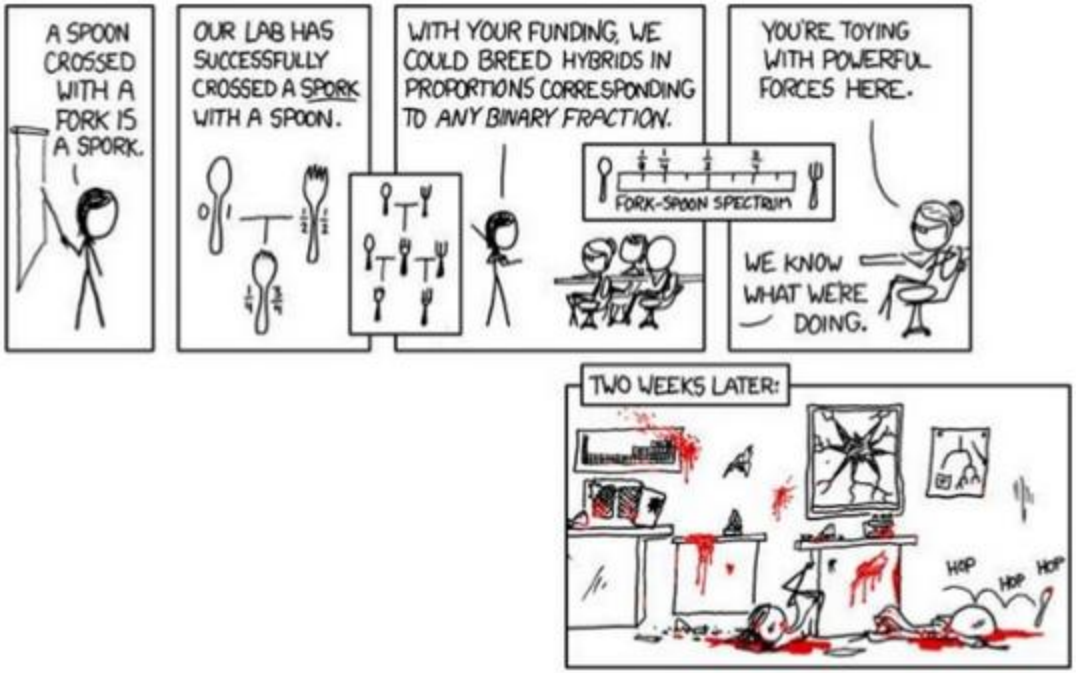
The **liger** is a hybrid cross between a male *Panthera leo* (lion), and a female *Panthera tigris* (tiger) and is denoted scientifically as:
Panthera tigris × Panthera leo.

...conversely...

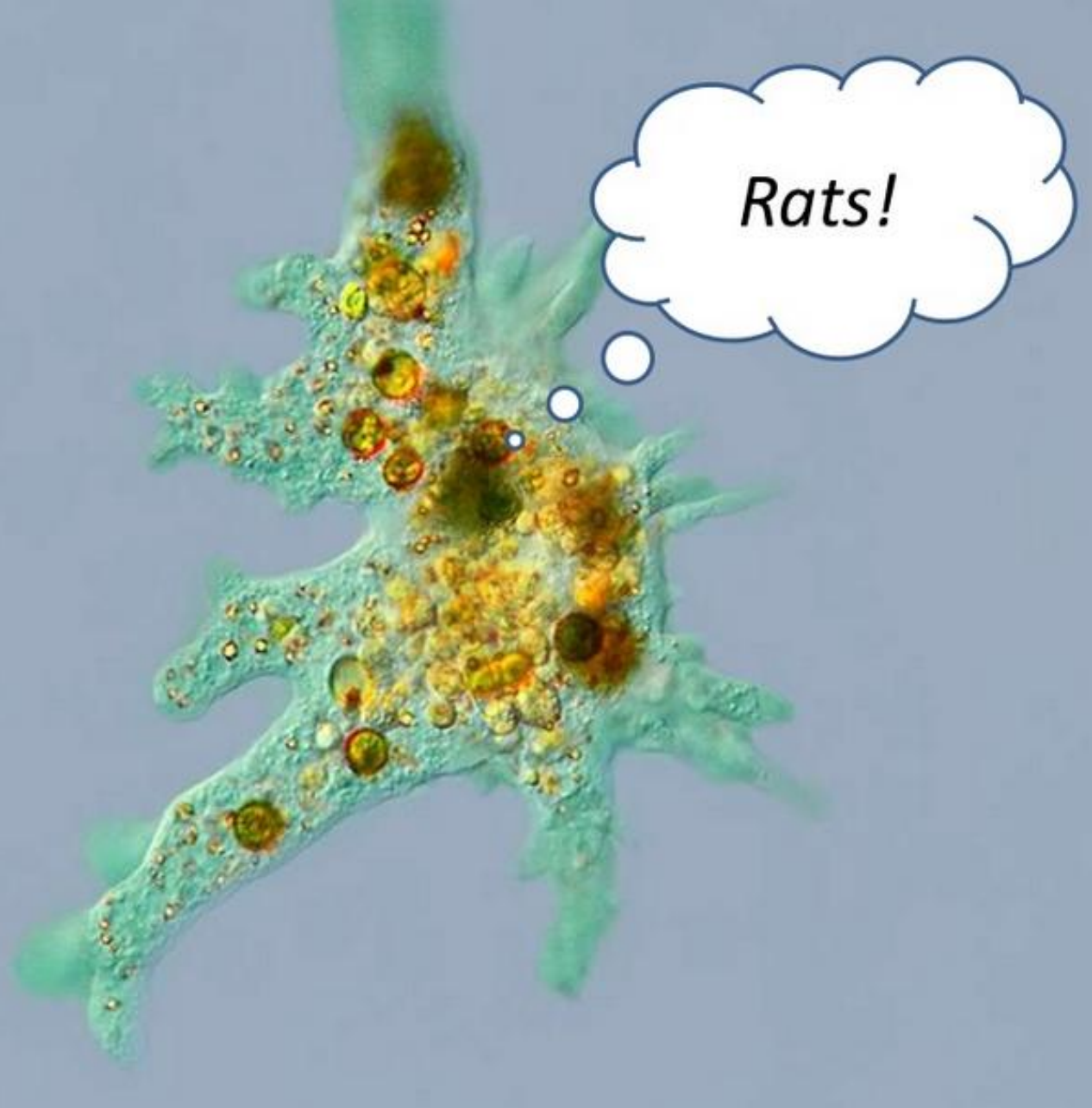
The **tiglon** is a hybrid cross between a female *Panthera leo* (lion), and a male *Panthera tigris* (tiger) and is denoted scientifically as: *Panthera leo × Panthera tigris*.

Ligers and tiglons sometimes produce offspring when mated back with a parent species

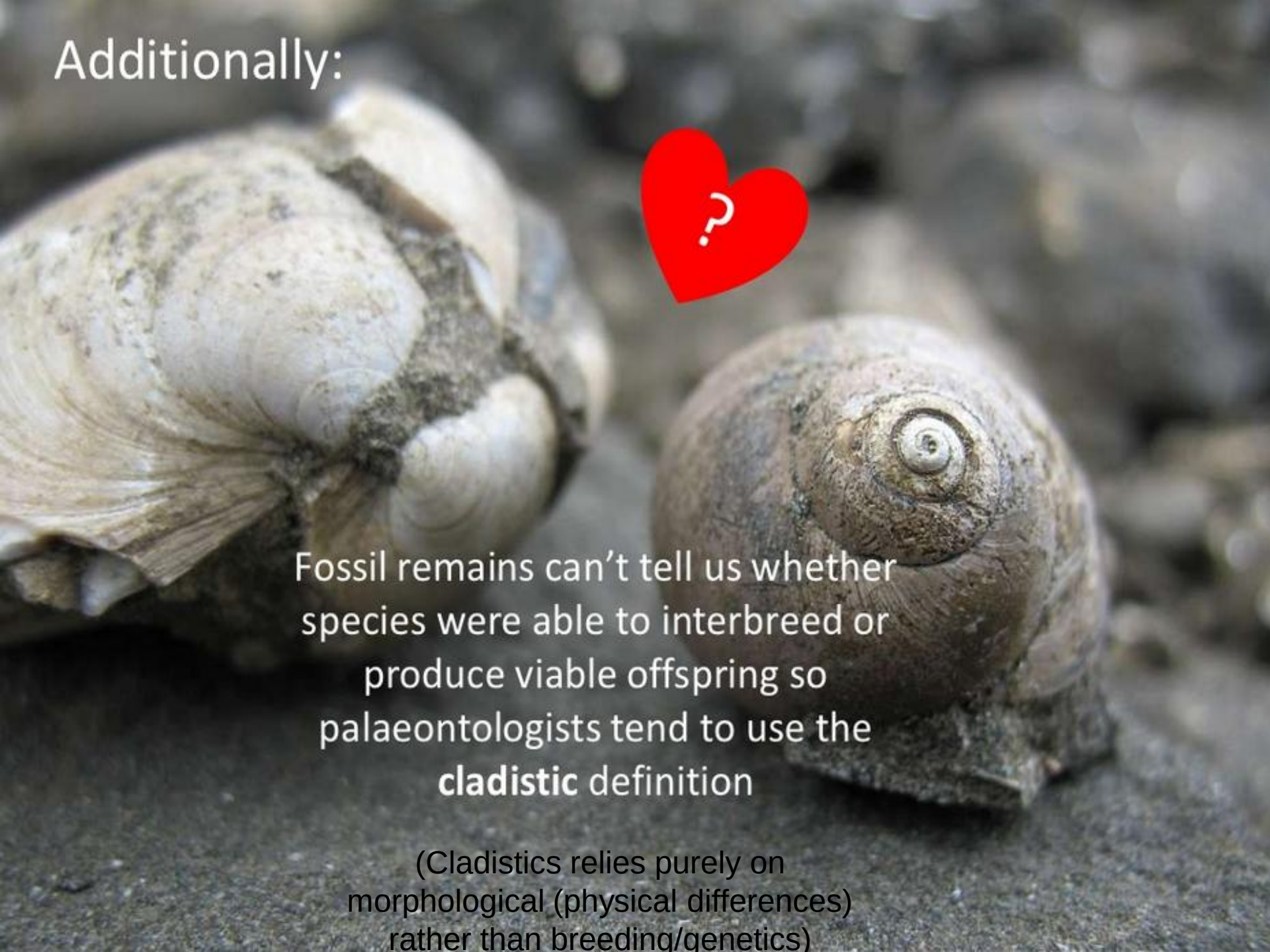
e.g. The hybrid of a male lion and a female tiglon is a li-tiglon! MADNESS!!



The genetic definition only applies to sexually reproducing organisms and doesn't apply to single-celled organisms



Additionally:



Fossil remains can't tell us whether species were able to interbreed or produce viable offspring so palaeontologists tend to use the **cladistic** definition

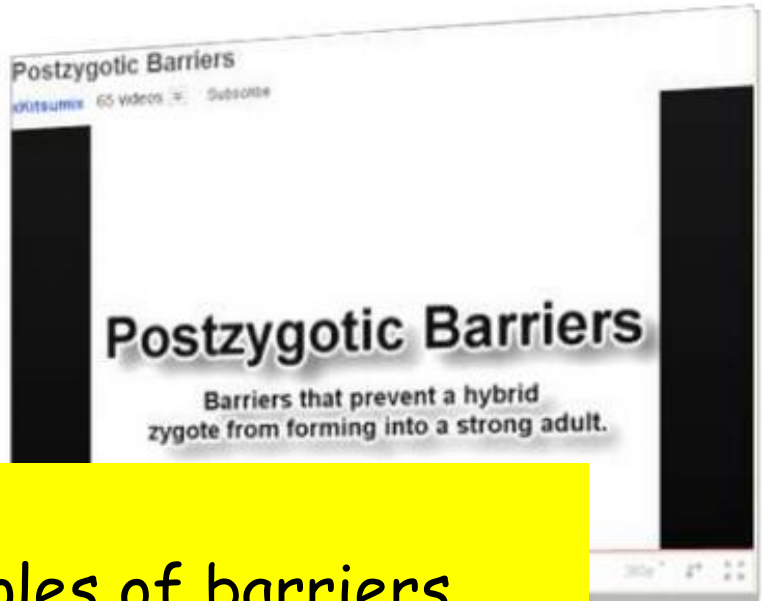
(Cladistics relies purely on morphological (physical differences) rather than breeding/genetics)

Things to keep in mind about species concepts

1. All are trying to objectively identify **evolutionarily independent** lineages
2. All have strengths & weaknesses
3. The species groupings they recognize are often the same
4. Differences occur when you run into messy biological realities/exceptions
5. Due to horizontal gene transfer, almost no concept works for prokaryotes/single celled organisms

D.2.4 Describe three examples of barriers between gene pools

The circumstances preventing different species from interbreeding are known as **reproductive isolating mechanisms**



Task

Research 3 or 4 examples of barriers between populations (gene pools) that may lead to isolation/ a change in allele frequency and ultimately a new species

(see clues in spec)

Pre-zygotic Isolating Mechanisms		Example
Temporal Isolation	Occurs when two species mate or flower at different times of the year	Different frog species live in the same pond but breed at different times
Ecological Isolation	Occurs when two species inhabit similar regions, but occupy different habitats	Lions and tigers occupy different habitats and do not interbreed (usually)
Behavioural Isolation	Occurs when two species respond to different specific courtship patterns	Some crickets are morphologically identical but only respond to species-specific mating songs
Mechanical Isolation	Occurs when genital differences prevent copulation (animals) or when flowers are pollinated by different animals (plants)	Bush babies have distinctly shaped genitalia that will only fit other members from the same species
Post-zygotic Isolating Mechanisms		Example
Hybrid Inviability	Hybrids are produced but fail to develop to reproductive maturity	Frogs of the genus *Rana* can form hybrid tadpoles which die before adulthood
Hybrid Infertility	Hybrids fail to produce functional gametes	Mules are the sterile hybrids of a male donkey and a female horse
Hybrid Breakdown	The F1 hybrids are fertile but the F2 generation fail to develop or are infertile	The offspring of hybrid copepods have a reduced potential for survival or reproduction

Similarities:

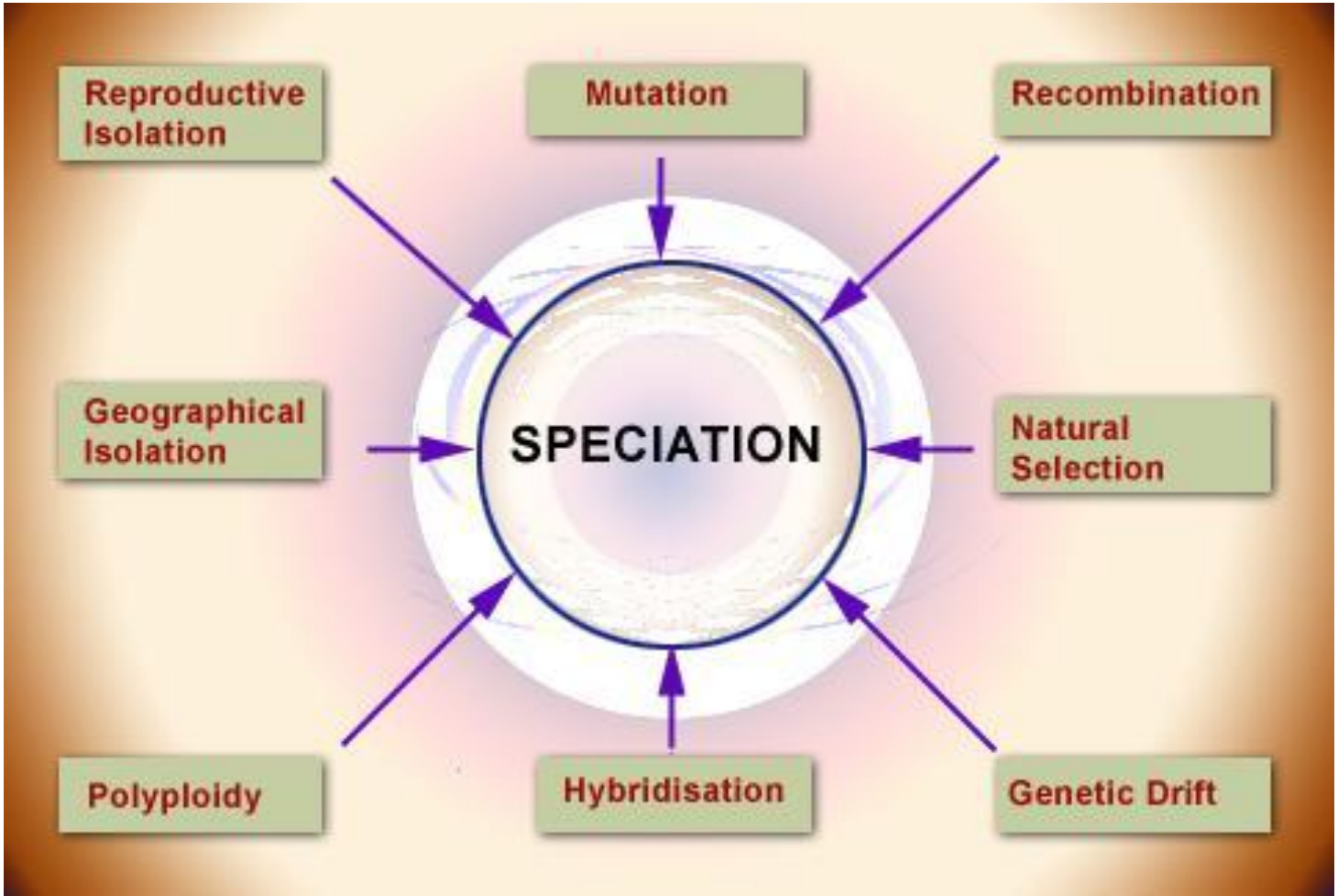
- Both involve the formation of a new species via isolation of the genetic pool from an existing species
- Both occur when natural selection creates genetic divergence between the new and ancestral populations

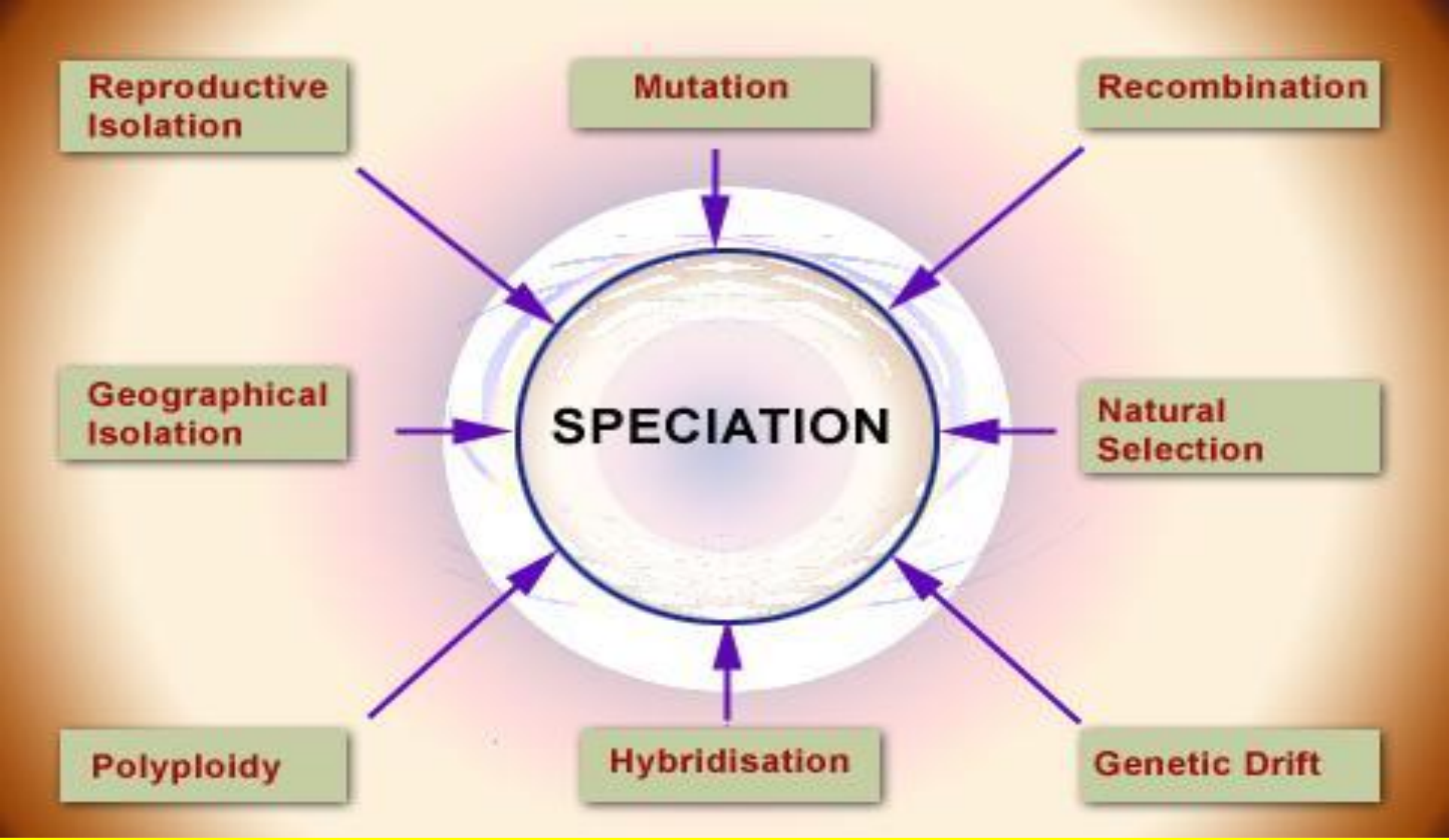
Speciation

The formation of a new species by splitting of an existing species.

Speciation is divided into two types:

Sympatric **Allopatric**



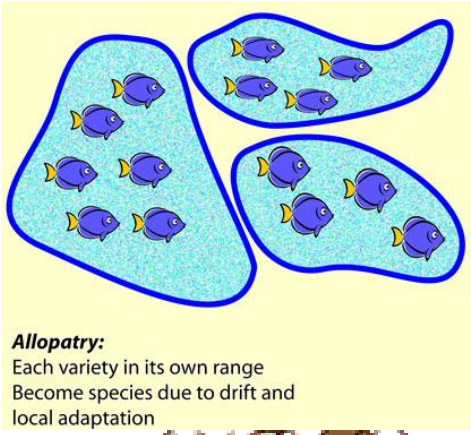


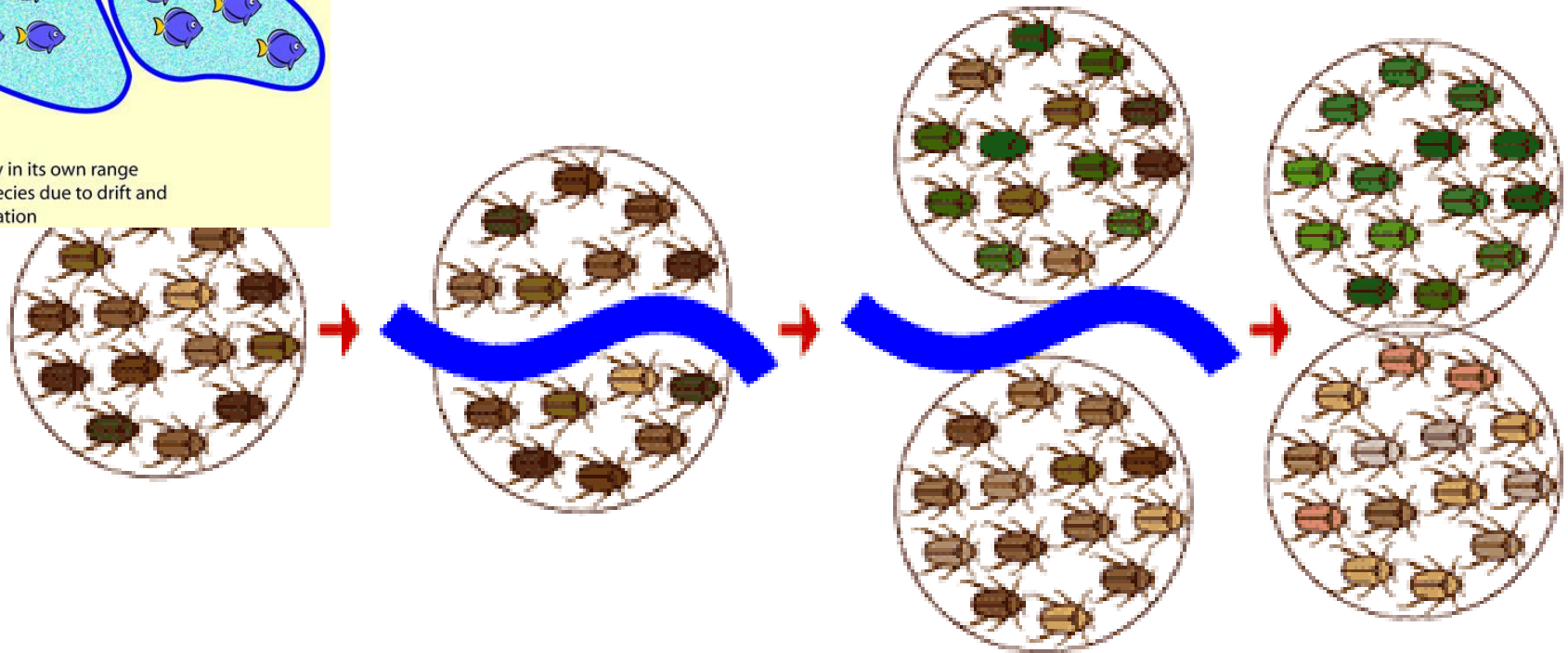
Task

Research what is meant by ***sympatric*** & ***allopatric*** speciation and annotate the diagrams in your notes to explain ways each can happen *(see clues in spec for help)*

Allopatric Speciation

- Relies on physical barriers like mountains or islands to separate populations
- Island species are the best studied examples
- e.g. Galapagos finches, tortoises, iguanas





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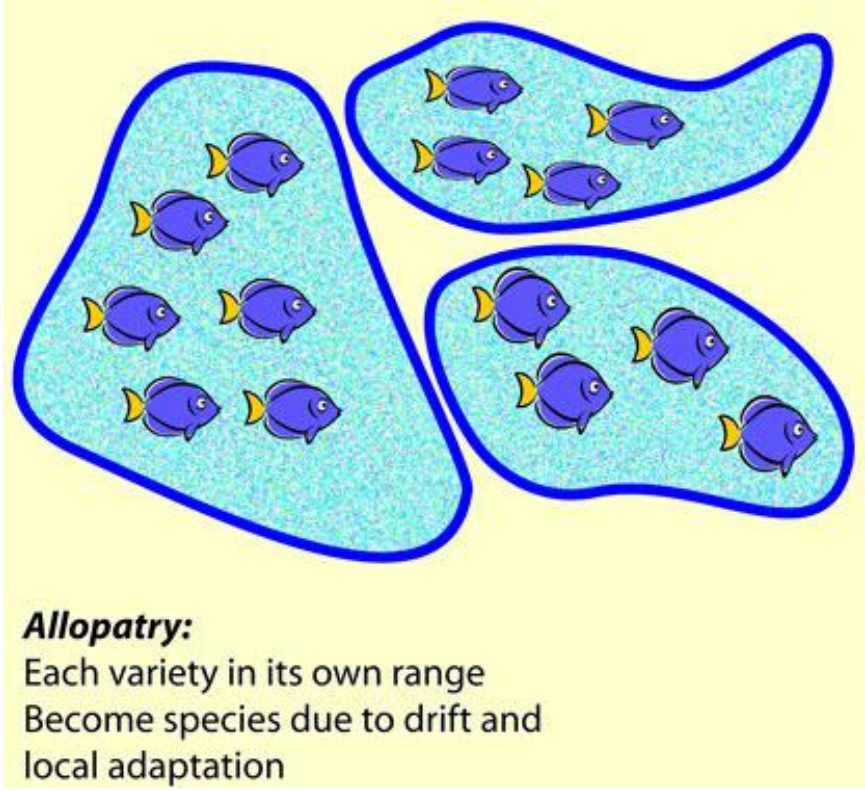
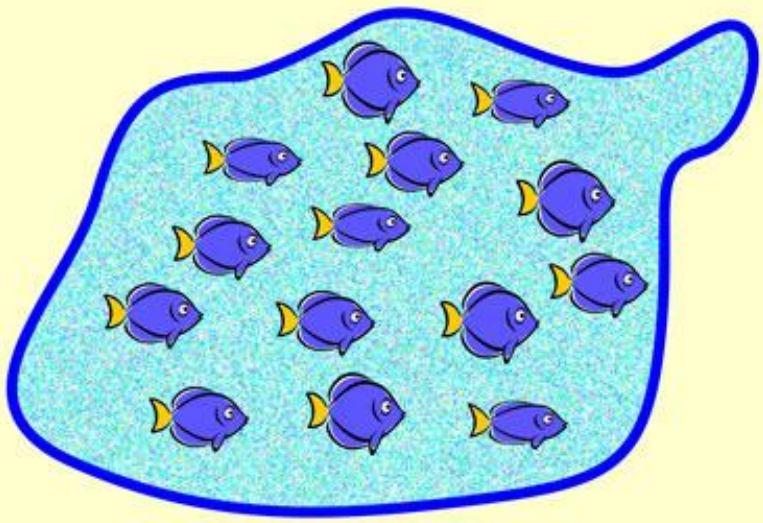


Sympatric Speciation

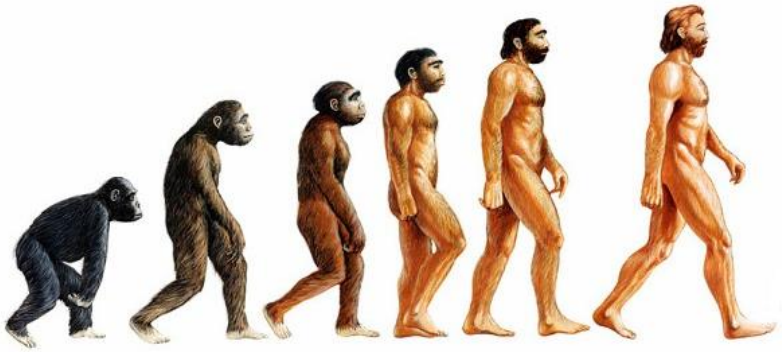
- This is speciation of organisms within the same habitat
- This could be due to e.g. organisms undergoing biochemical changes, preferring different food species or different mates
- Often species that will not mate with each other in the wild will do so under laboratory conditions e.g stickleback & cichlid fish studies



Sympatry:
Many varieties in one range
Become species through adaptation
to different aspects of the range

http://www.youtube.com/watch?v=Q2vsG77PZ80

Definition Match



Match the word to the definition

Species

Evolution

Speciation

The processes leading to the formation of a new species… a population of individuals with a common/shared gene pool

Depends on the definition…A group of organisms with many features in common which can breed successfully together, producing fertile offspring.

The gradual change in allele frequency in a population's gene pool over a number of generations.

D2: Speciation

"***Species are as many as were created in the beginning by the Infinite.***"
(**Linnaeus**, 1758)

Can you define/discuss:

Allele frequency
Gene pool
What is evolutions effect on the above
Strengths and weaknesses of at least 3 species concepts?
Barriers between gene pools?
Allopatric speciation
Sympatric speciation

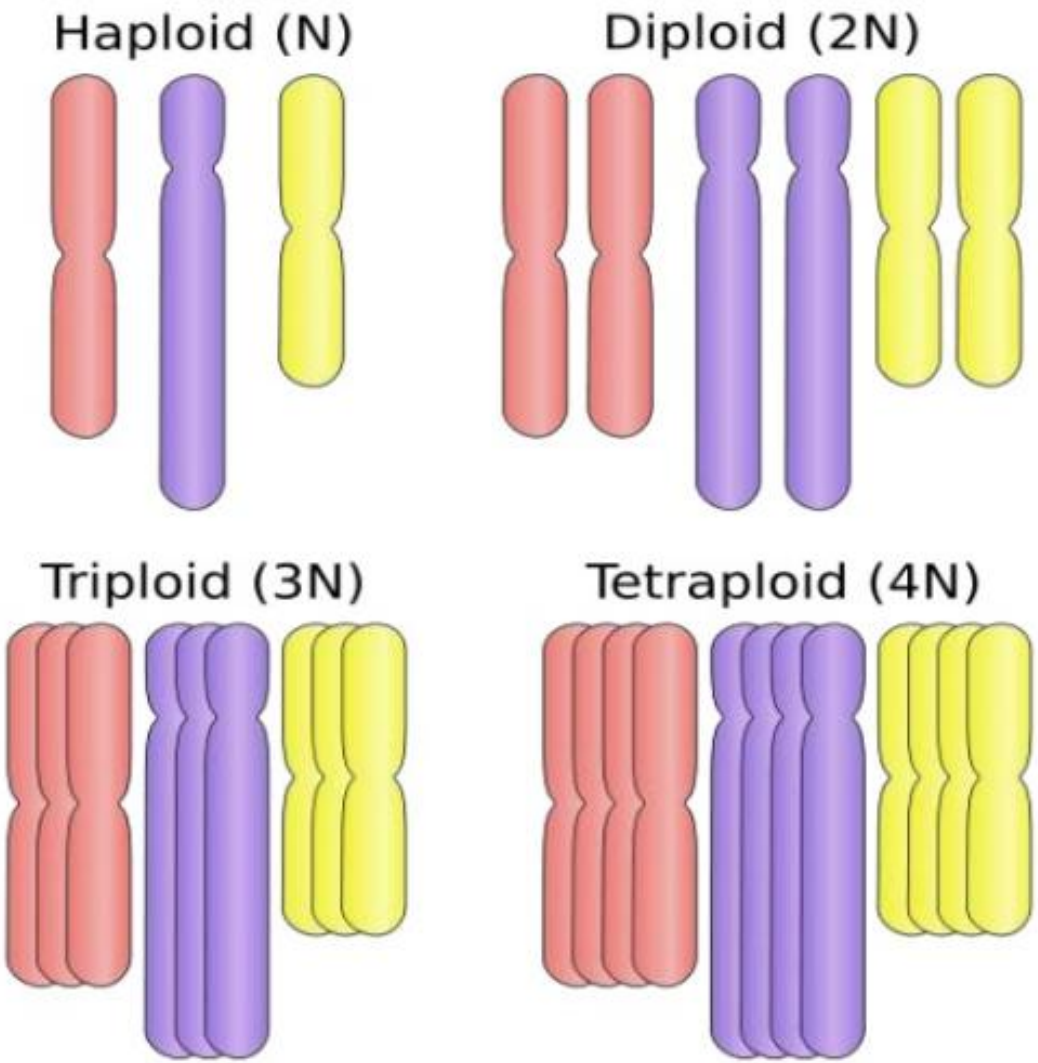
Aim

Discuss the main processes contributing to evolution and ultimately speciation

D.2.5	Explain how polyploidy can contribute to speciation.
D.2.7	Outline the process of adaptive radiation
D.2.8	Compare convergent evolution divergent evolution.
D.2.9	Discuss ideas on the pace of evolution including gradualism and punctuated equilibrium.
D.2.10	Describe one example of transient polymorphism.
D.2.11	Describe sickle-cell anaemia (SCA) as an example of balanced polymorphism.

D.2.5	Explain how polyploidy can contribute to speciation

So far you've learnt that cells contain two homologous sets of chromosomes.
Well..... that isn't always the case.



It goes on:
Pentaploid
Hexaploid
Septaploid
Octaploid
Etc.
up to:

84-ploid and 1260 chromosomes

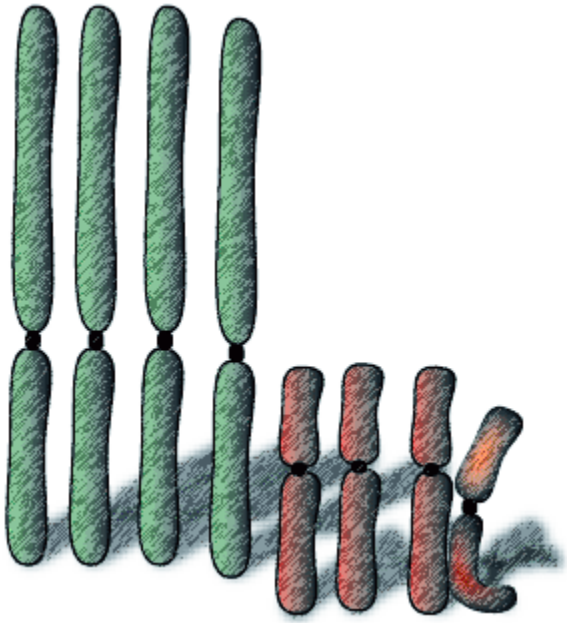
Ophioglossum reticulatum
A small fern.
The incredible thing is that this plant is able to carry out meiosis accurately with 1260 chromosomes to divvy up

http://kisdwebs.katyisd.org/campuses/MRHS/teacherweb/hallk/Teacher%20Documents/AP%20Biology%20Materials/Evolution/Speciation%20by%20Changes%20in%20Ploidy/25_A02s.swf

Polyploidy
(>Diploid!)

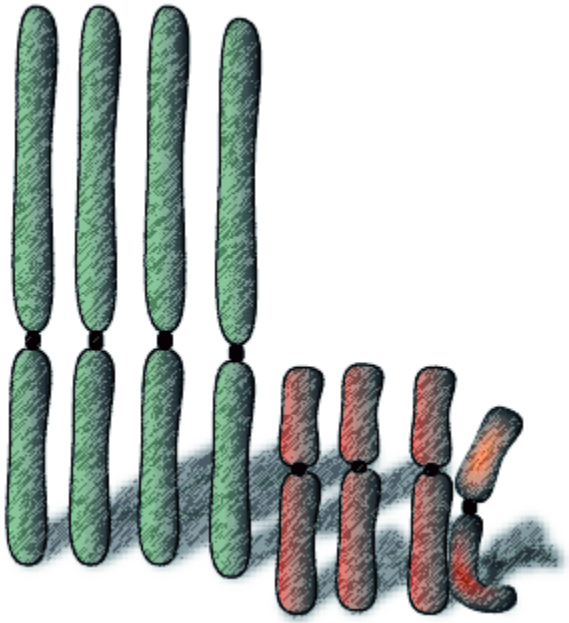
- An organism has more than two complete sets of chromosomes in all somatic cells
- Rare in the animal kingdom… do you know why?

- Common in plants due to lack of separate sexes/self-pollination



Polyploidy
(>Diploid!)

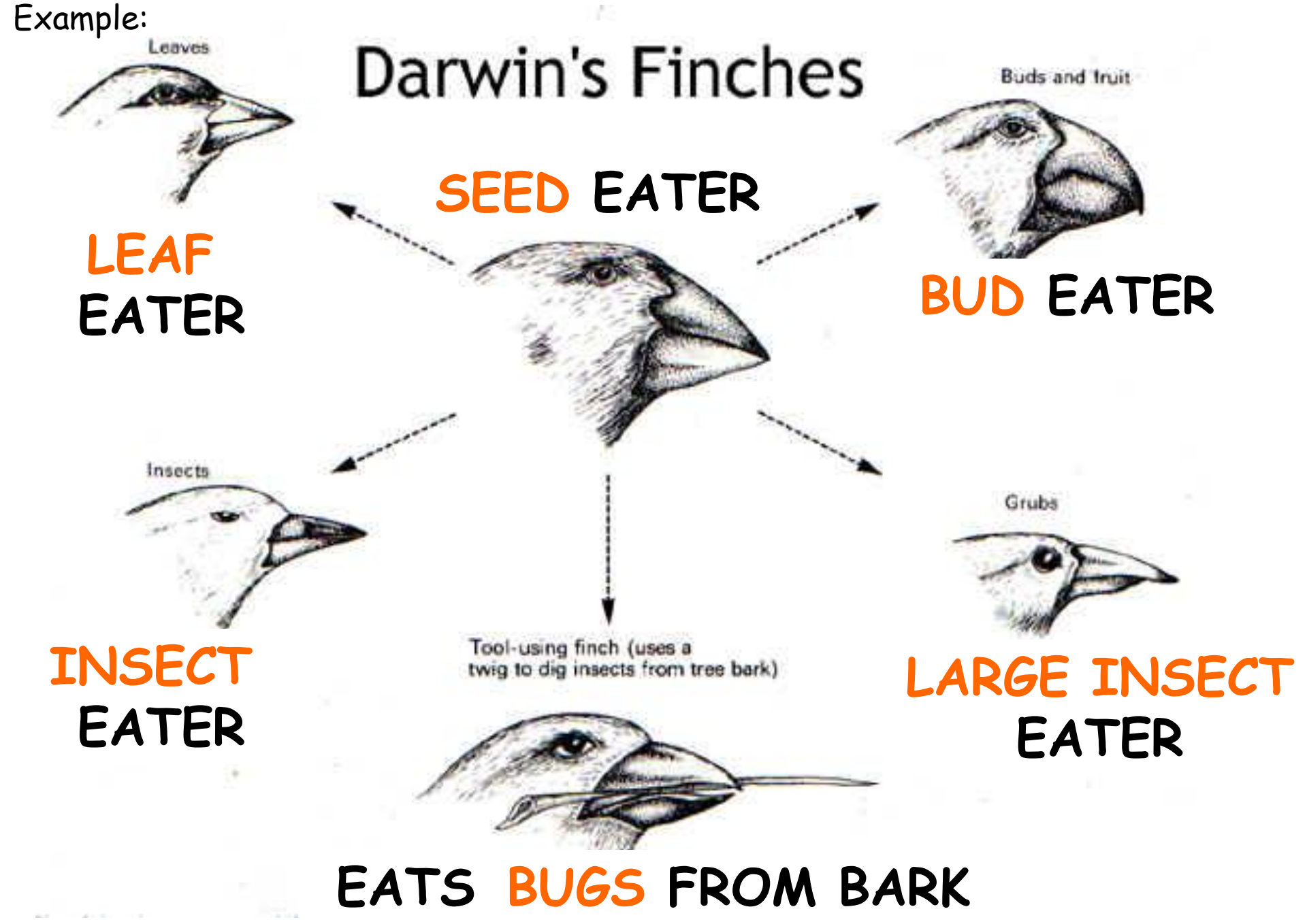
- May be a result of total non-disjunction
- So gametes are diploid (2n) & offspring tetraploid (4n)
- Tetraploid offspring can no longer mate with diploids (triploid offspring tend to be infertile)
- Speciation has occurred!



http://www.youtube.com/watch?v=6Jjilc5eqS0

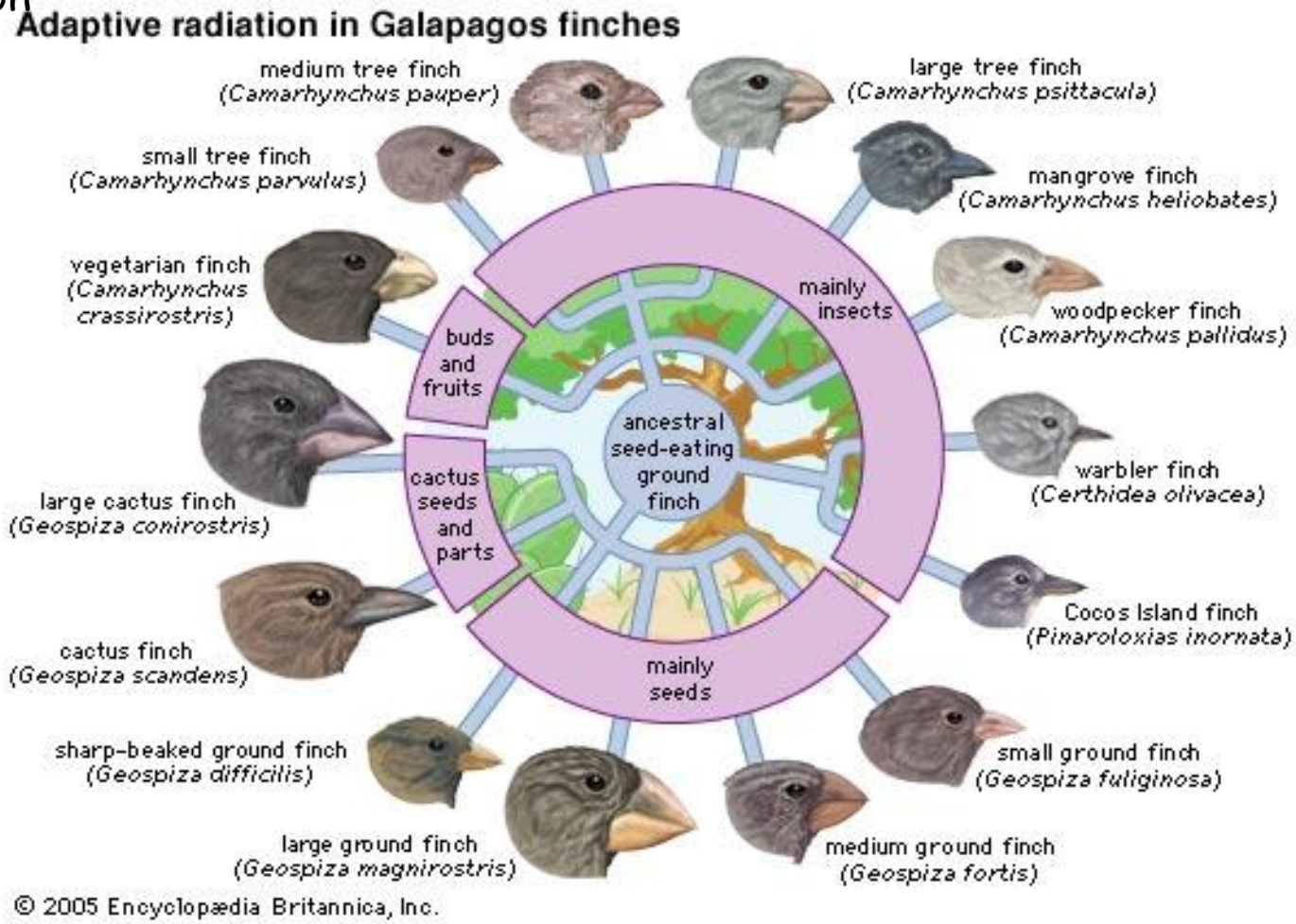
D.2.7	Outline the process of adaptive radiation

Example:



D.2.7	Outline the process of adaptive radiation

1. Rapid evolutionary diversification of a single ancestral lineage
2. When a species occupy a variety of niches with different environmental selection pressures
3. Morphological adaptations due to selection pressure
4. Separation of population/gene pool
5. Reproductive isolation
6. Speciation



D.2.8	Compare: Convergent evolution - Divergent evolution.

What is the difference between two things **converging** and one thing **diverging**?

D.2.8	Compare: Convergent evolution - Divergent evolution.

What do humans, octopi and box jellyfish have in common?

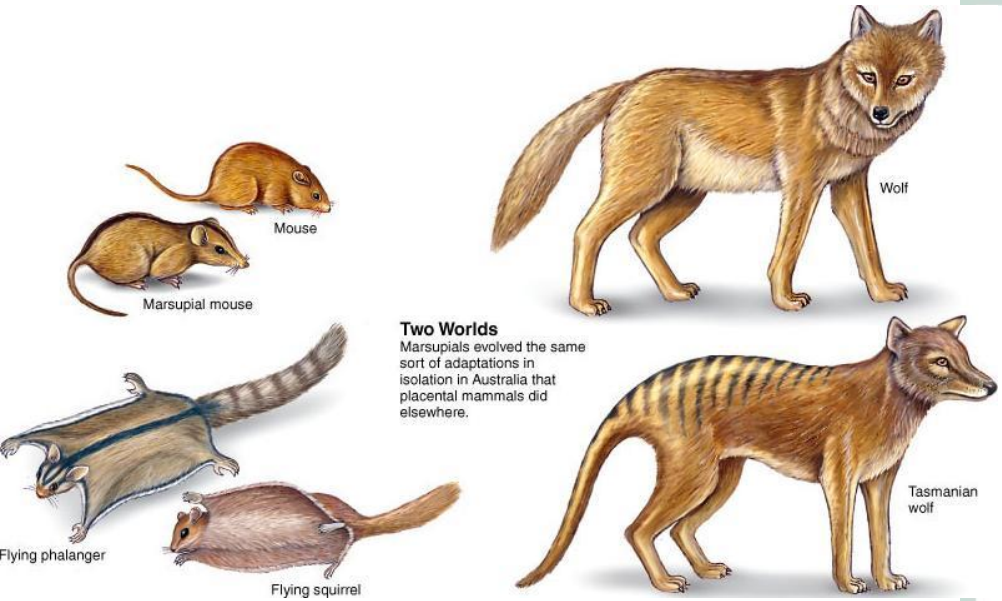
D.2.8	Compare: Convergent evolution - Divergent evolution.

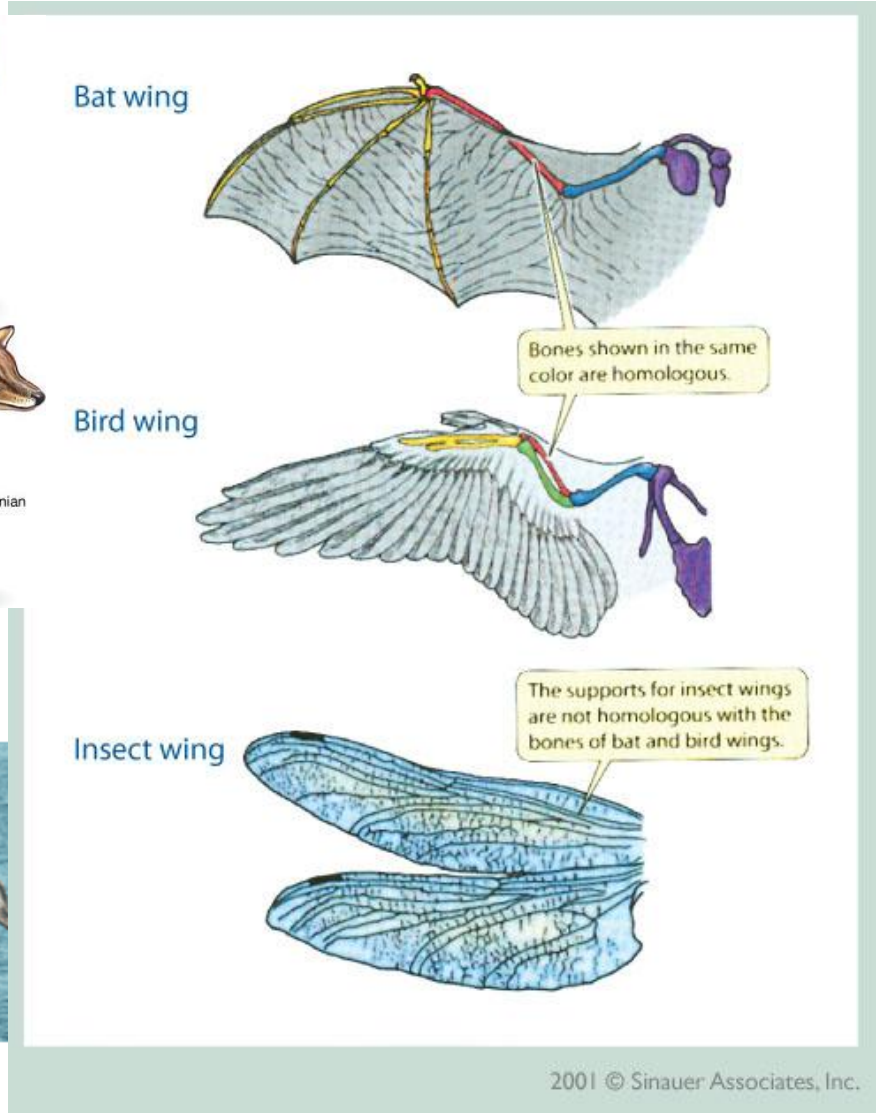
We all have complex camera* eyes. They evolved independently in organisms only very distantly related. They are an example of convergent evolution

Complex eyes have evolved 50 to 100 times!

D.2.8	Compare: Convergent evolution - Divergent evolution.

- Convergent evolution describes the acquisition of the same biological trait in unrelated lineages:
- Do you remember what these non-related traits are called?





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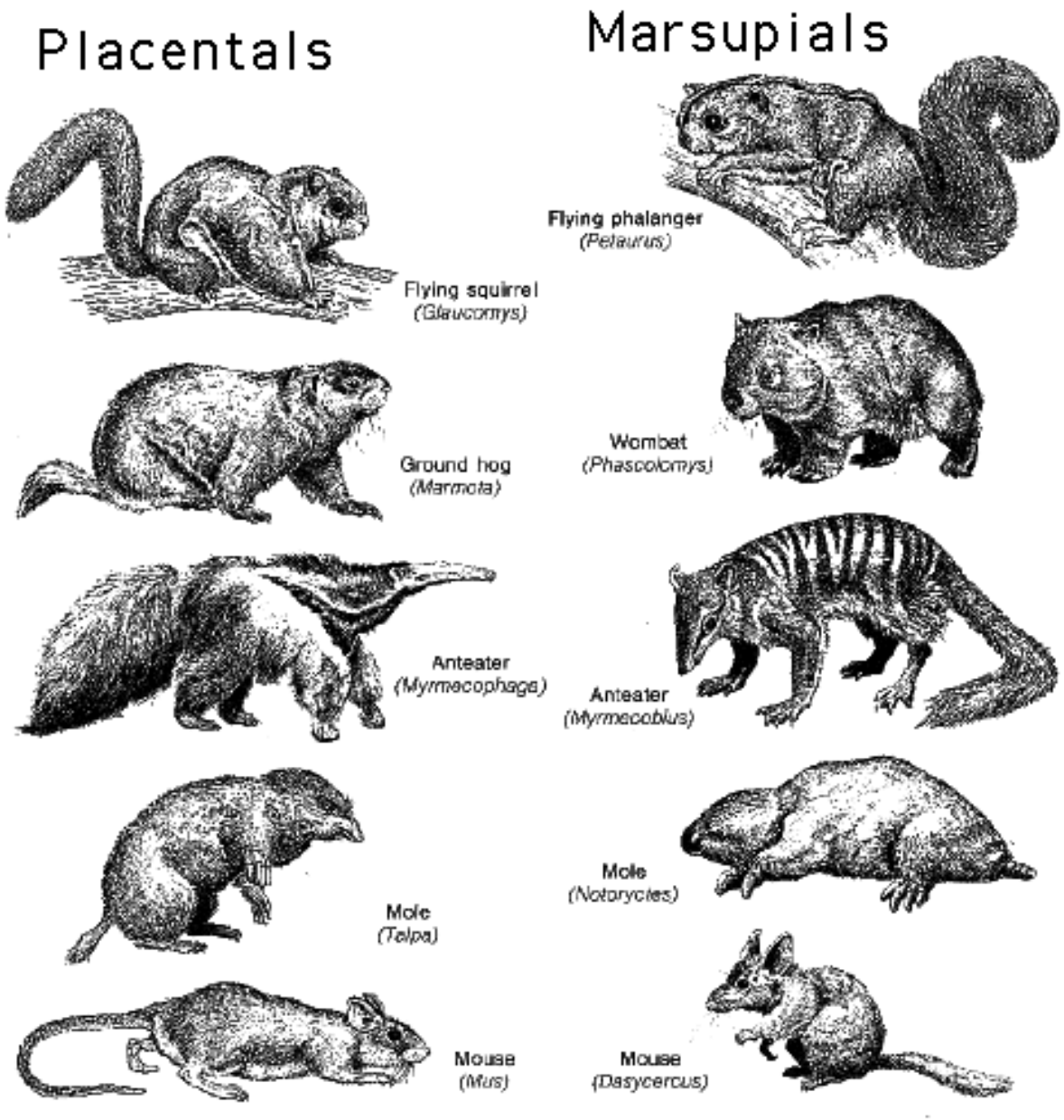

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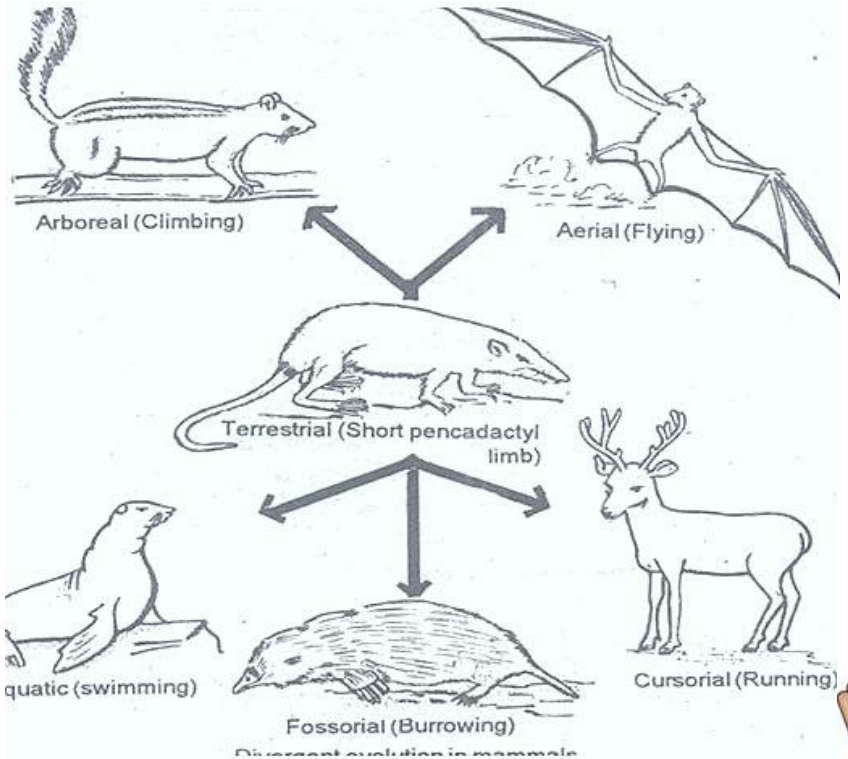
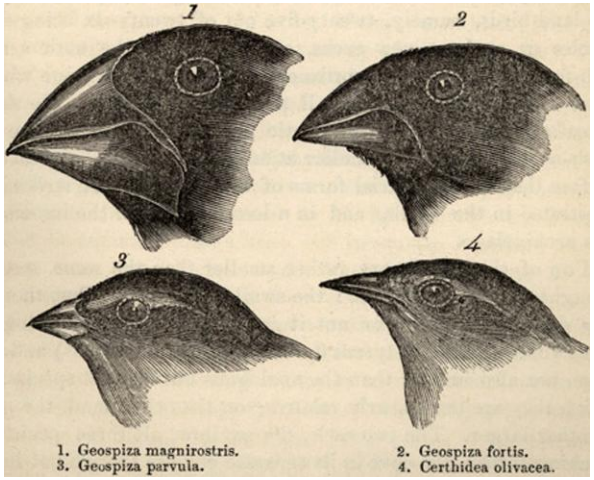
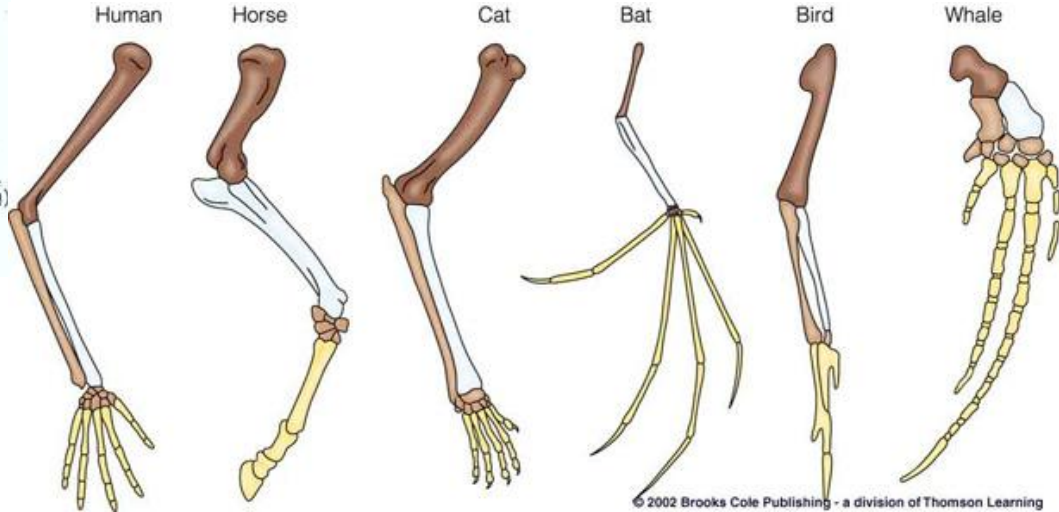
Divergent Evolution

- Same as an adaptive radiation
- Populations of a species adapts to varying selections pressures
- Over time speciation occurs
- Homologous structures become more different







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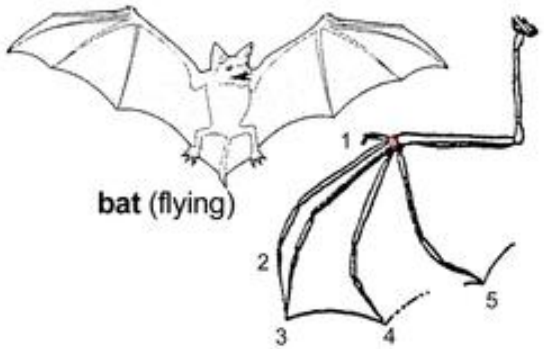
The Pentadactyl Limb

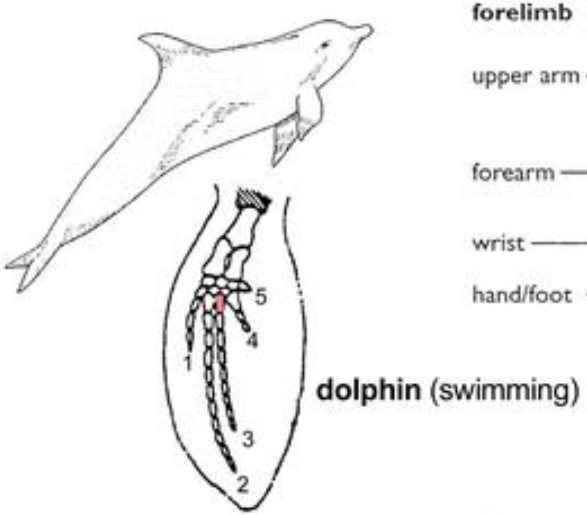


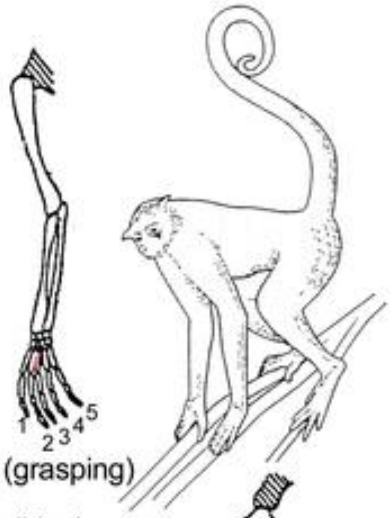
The **pentadactyl limb** as the 'ancestral' terrestrial vertebrates limb plan, subsequently adapted by modification for different uses/habitats.

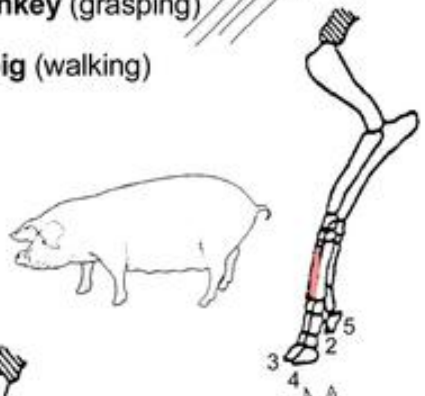
lay-out of a 'five-fingered' (pentadactyl) limb

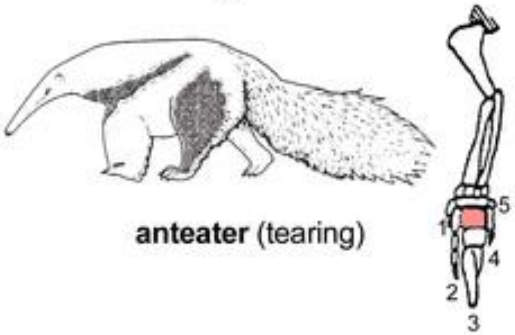
forelimb		hindlimb	
upper arm →	humerus	femur ←	thigh
forearm →	radius + ulna	tibia + fibula ←	lower leg
wrist →	carpals	tarsals ←	ankle
hand/foot →	metacarpals + phalanges	metatarsals + phalanges ←	foot

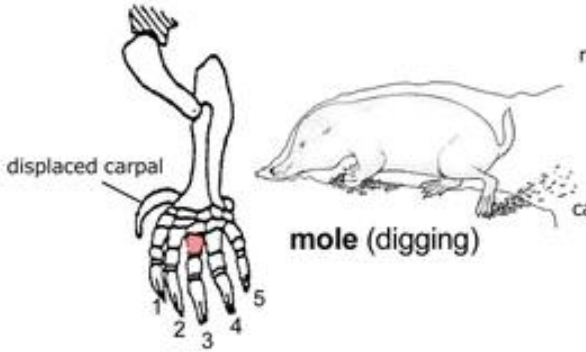
digits

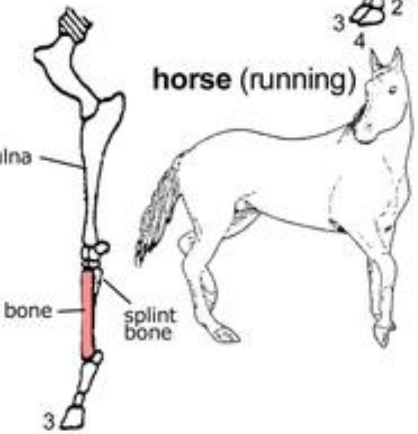












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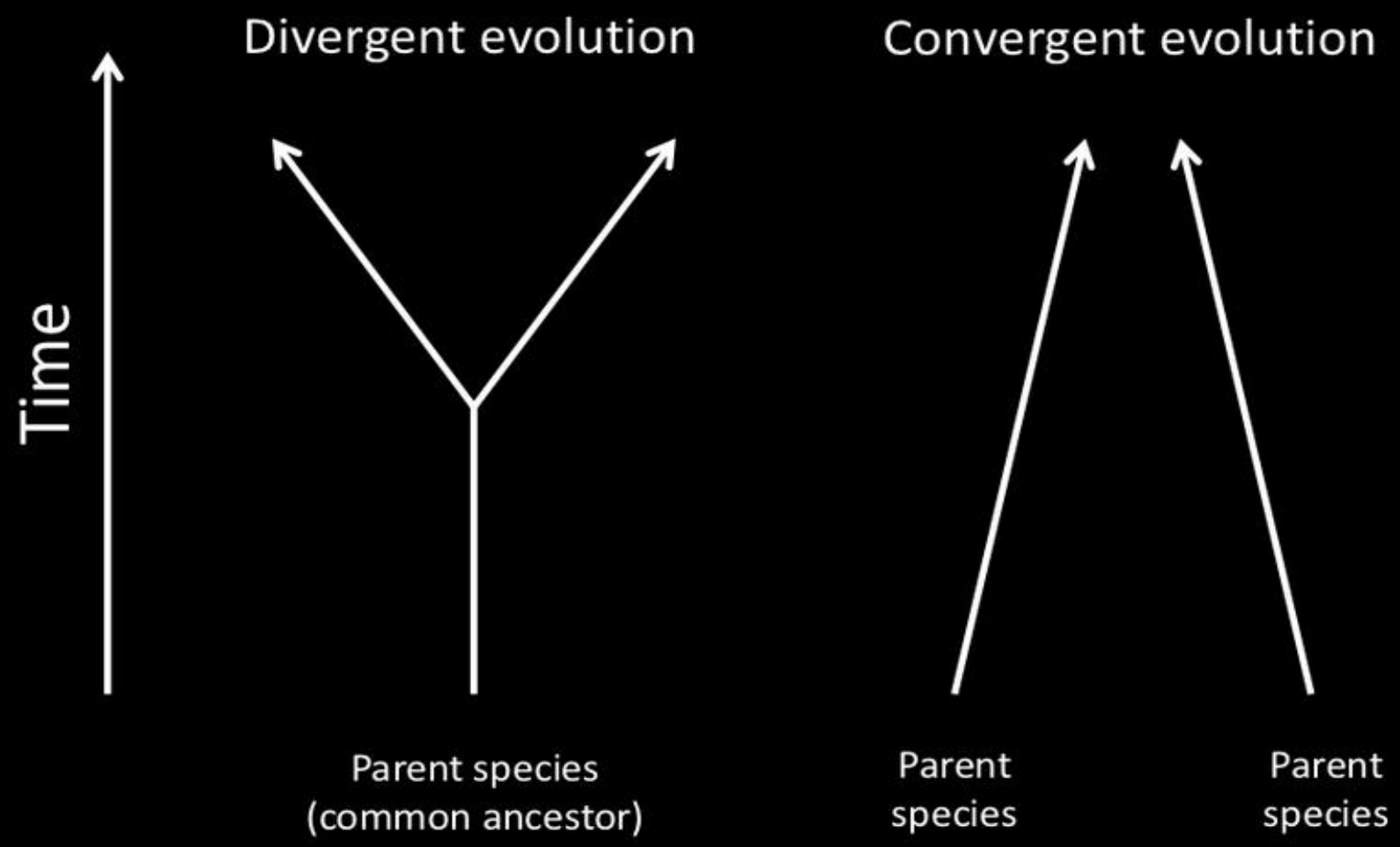


D.2.8	Compare: Convergent evolution - Divergent evolution.

shark

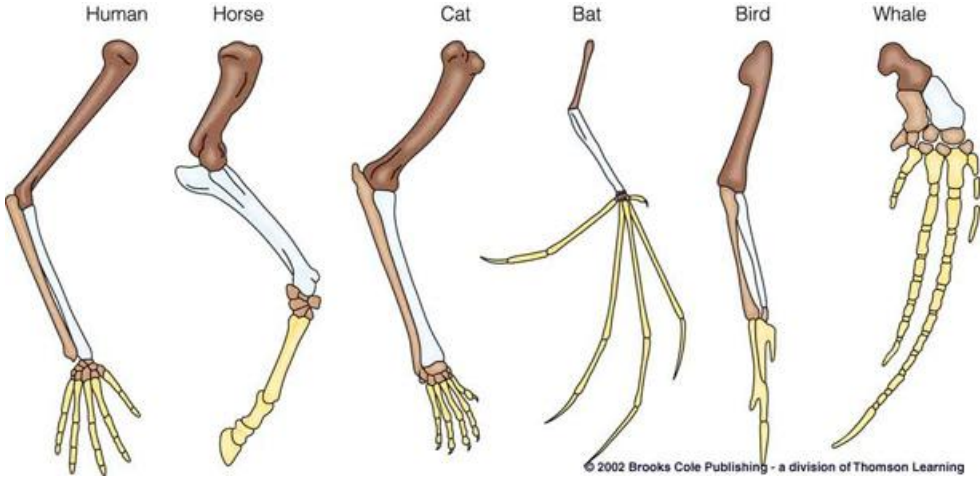
fish

ichthyosaur

reptile

dolphin

mammal

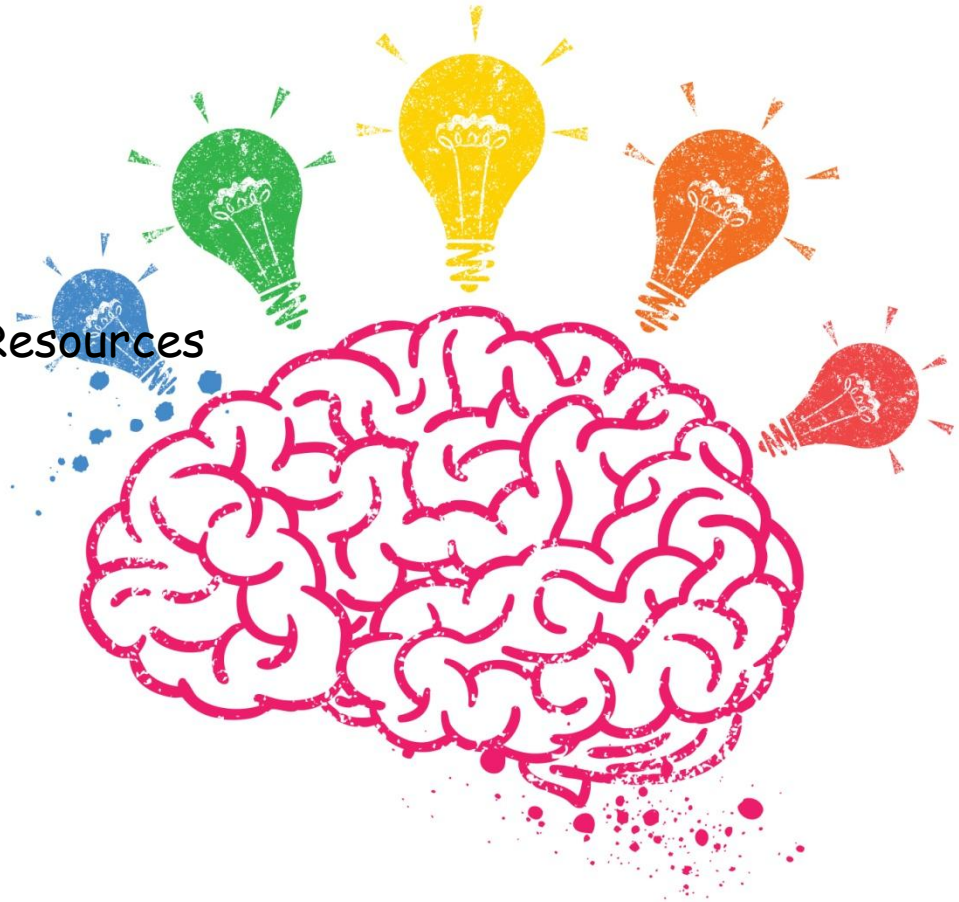


	Convergent Evolution	Divergent Evolution
Ancestor		
Type structure (homo or anal)		
Change in appearance over time		
Relatedness of species		
Examples of traits:		

Convergent Evolution	**Divergent Evolution**
Different ancestor	Common ancestor
Converge to produce analogous structures	Diverge to produce homologous structures
Species appearance becomes more similar over time	Species appearance becomes more different over time
Species are unrelated (genetically different)	Species are closely related (share genetic homology)
Example: Wings in insects, birds and bats	Example: Pentadactyl limb structure (vertebrates)

Brainstorm the keywords your would need to use in an exam question on natural selection

Variation / Heritable trait
More offspring
Competition / Selection pressure / Resources
Survival / Reproduction
Advantage
Gene pool / Allele frequency
Speciation
Evolution

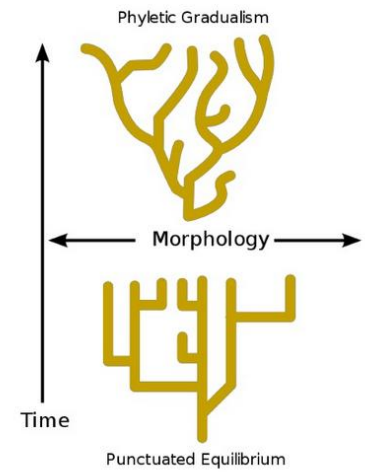


Aim

Discuss the main processes contributing to speciation (evolution)

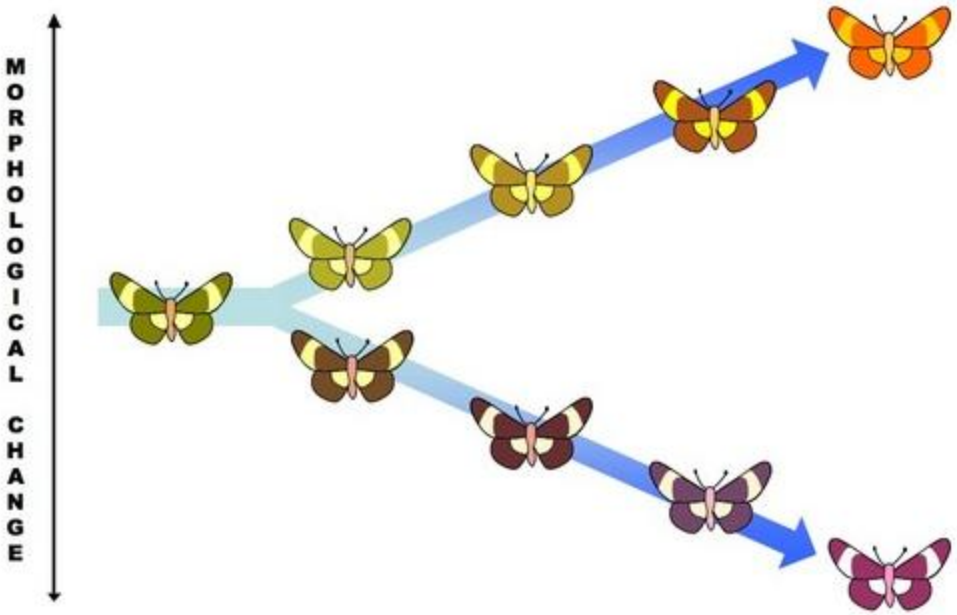
D.2.9	Discuss ideas on the pace of evolution including **gradualism** and **punctuated** equilibrium.

Can you explain what is meant by these two theories using the diagrams?

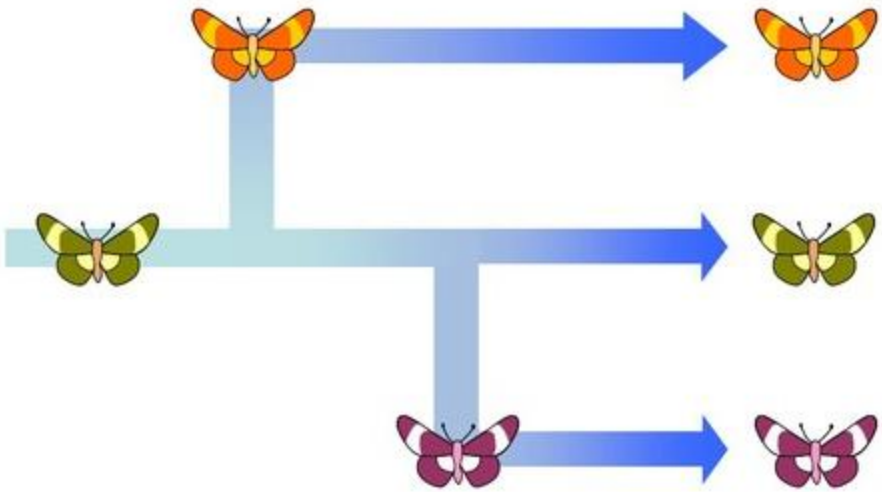


The slope of the line indicates rate of change.

- Vertical lines = little/no change
- Horizontal lines = very rapid change



Phyletic Gradualism



Punctuated Equilibrium

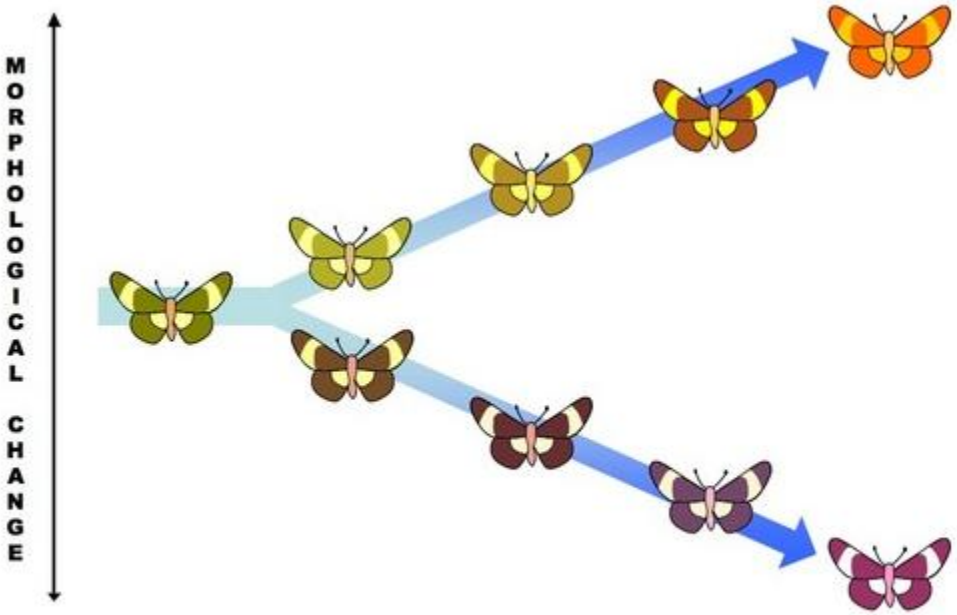
D.2.9	Discuss ideas on the pace of evolution including **gradualism** and **punctuated** equilibrium.

Gradualism

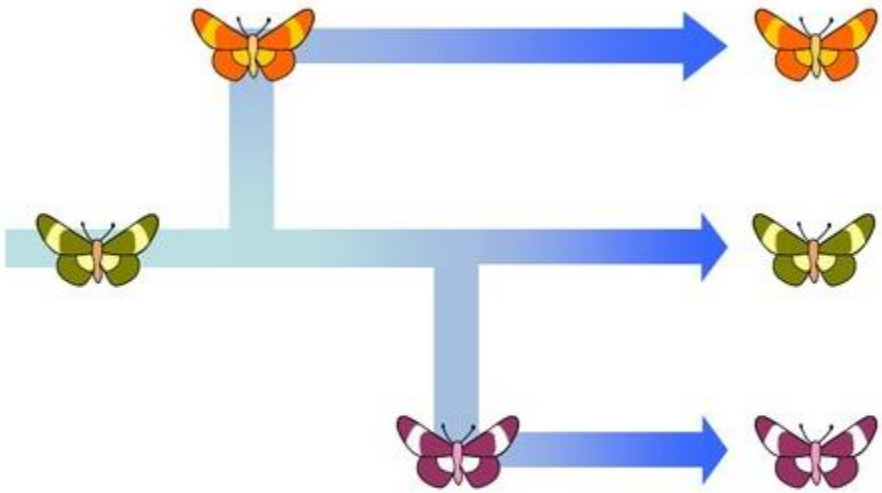
Evolution occurs at a slow pace, gradually and steadily

Punctuated Equilibrium

Species are stable and every now and then a disruptive (punctuated) event prompts rapid change



Phyletic Gradualism



Punctuated Equilibrium

D.2.10	Describe one example of transient polymorphism.

What does it mean: Transient Polymorphism

Transient - Changeable
Polymorphism – Existence of two or more forms of a species
Transient Polymorphism - Two alleles exist in a gene pool (polymorphic) and one is gradually replacing another due to selection pressure.
Do you know one we have already studied as a form of natural selection 'in action'?

D.2.10	Describe one example of transient polymorphism.

Transient polymorphism – Two alleles exist in a gene pool (polymorphic) and one is gradually replacing another due to selection pressure

Strong environmental selective pressure causing directional selection in favour of on allele

Examples: Industrial melanism or antibiotic resistance in bacteria

D.2.11	Describe sickle-cell anaemia (SCA) as an example of balanced polymorphism.

- Two alleles exist in a gene pool and the frequency of the two alleles in not changing
- Occurs when different selective pressures promote the coexistence of the two alleles (i.e. heterozygous advantage) causing a stabilising selection

Can you think of a balanced polymorphism in topic 4 that has both detrimental and positive effects?

Hb^A vs Hb^S