

BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS

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TOPIC 2 : SPECIES CONCEPTS & SPECIATION



BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS



OBJECTIVES



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- What is a species
 - Species concepts
 - What is speciation?
- How does speciation occur?

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WHAT IS A SPECIES?



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What is a Species?



<https://learngendev.azurewebsites.net/content/evolution/species>

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SPECIES?

- Species are groups
 - of **actually or potentially interbreeding** populations
 - which are **reproductively isolated** from other such groups
 - that can create **fertile offspring**
- However, the classification of a species can be difficult—even riddled with controversy.

CLASS ACTIVITY 1: Same or Different Species

Instructions

- Get a set of Organism cards.
- Read the information on each card, and decide whether you think the organisms described are
- The same or different species, or somewhere in between. Look for key information, such as:
 - Do they interbreed?
 - Do they live in the same habitat?
 - Do they have different heritable traits?
 - Are there differences in their DNA?
- Arrange all of the cards in a line along a continuum:

- Models of the patterns brought about by the way the evolutionary process works under various conditions.
- Attempts to explain how phenetic variations are compartmentalised.
 - **Phenetic, biological, phylogenetic, ecological, cohesive**

• Phenetic Species Concept

- Species are the smallest groups that are consistently and persistently distinct and distinguishable by ordinary means.
 - Strictly operational and non-explanatory concept based on observable facts of similarity and discontinuity.

• Biological or Reproductive Species Concept

- Species are groups of interbreeding natural populations that are reproductively isolated from other groups.
 - Popular with those who study solitary sexually reproducing organism such as vertebrates

• Phylogenetic Species Concept

- Species are a single lineage of an ancestor-descendant population that maintains its identity from other such lineages and has its own evolutionary tendencies and historical fate
 - Favored by biologist, but has the disadvantage that lineage affiliation cannot be unequivocally proven without time travel

• Ecological Species Concept

- Species are lineages (or sets of closely related lineages) occupying minimally different adaptive zones.
 - Species can be explained but not defined by the zones they inhabit

• Cohesion Species Concept

- Species are the most inclusive population of individuals having the potential for phenotypic cohesion mechanism
 - Favoured by scientist working on asexual organisms.

FURTHER READING ON SPECIES CONCEPTS



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Biological species concept

The biological species concept defines a species as members of populations that actually or potentially interbreed in nature, not according to similarity of appearance. Although appearance is helpful in identifying species, it does not define species.

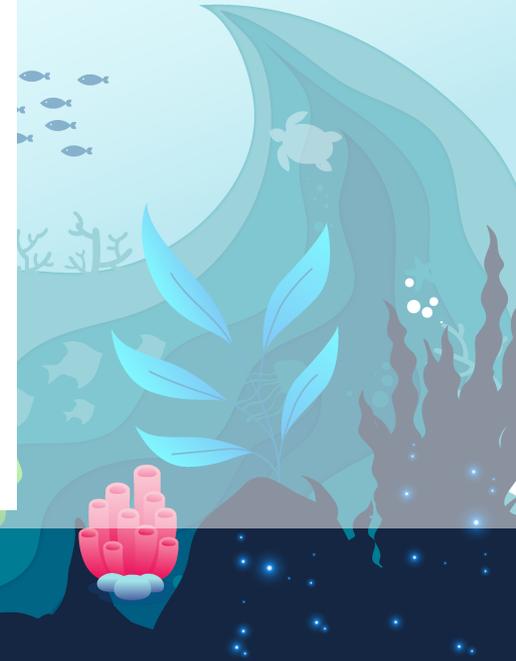
Appearance isn't everything

Organisms may appear to be alike and be different species. For example, Western meadowlarks (*Sturnella neglecta*) and Eastern meadowlarks (*Sturnella magna*) look almost identical to one another, yet do not interbreed with each other — thus, they are separate species according to this definition.



https://evolution.berkeley.edu/evolibrary/article/side_0_0/biospecies_01

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UNDERSTANDING SPECIATION



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<https://www.youtube.com/watch?v=8yvEDqrc3XE>

BIOLOGICAL CLASSIFICATION OF MARINE ORGANISMS



- Speciation is how a new kind of plant or animal species is created.
- Speciation occurs when a **group within a species separates from other members of its species** and **develops its own unique characteristics.**
- Mechanism of Reproductive Isolation:
 - **Prezygotic mechanism**
 - Prevents interspecies mating and fertilization
 - **Postzygotic mechanism**
 - Prevents maturation and reproduction in offspring from interspecies reproduction



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In order for speciation to happen, there must be something that prevents populations from interbreeding—known as a reproductive barrier.

If two groups are reproductively isolated from one another, they can accumulate more differences in their alleles and genes through repeated cycles of mutation and natural selection.

Populations tend to become more different over time, especially as they specialize to their particular habitats.

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Prezygotic Mechanism

- Ecological Isolation
- Behavioural Isolation
- Temporal Isolation
- Mechanical Isolation
- Gametic Isolation

Postzygotic Mechanism

- Zygotic Mortality
- Hybrid Inviability
- Hybrid Infertility

GEOGRAPHY

Geography can be a literal barrier to reproduction.

Other synonyms: Geographical isolation, Prezygotic mechanism

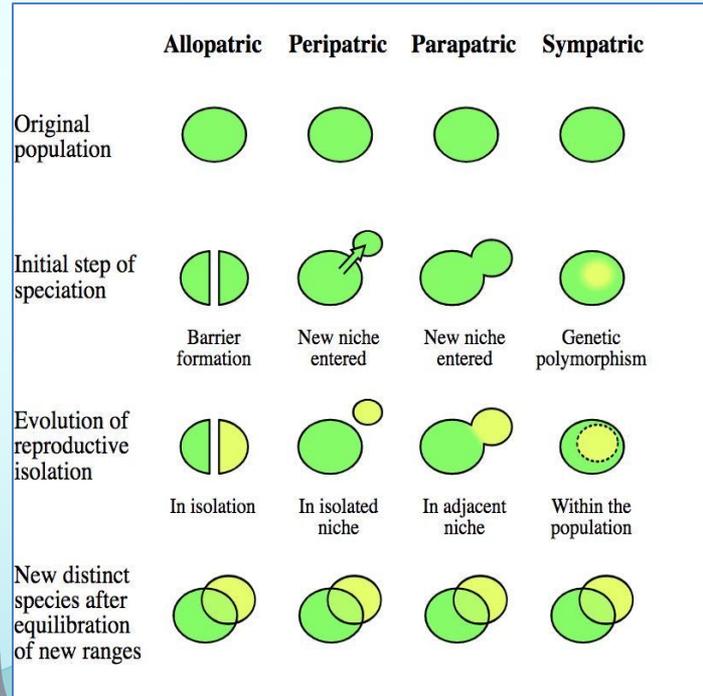
TYPES OF GEOGRAPHICAL ISOLATION



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There are four major variants of geographical speciation: **allopatric**, **peripatric**, **parapatric**, and **sympatric**.



ALLOPATRIC SPECIATION

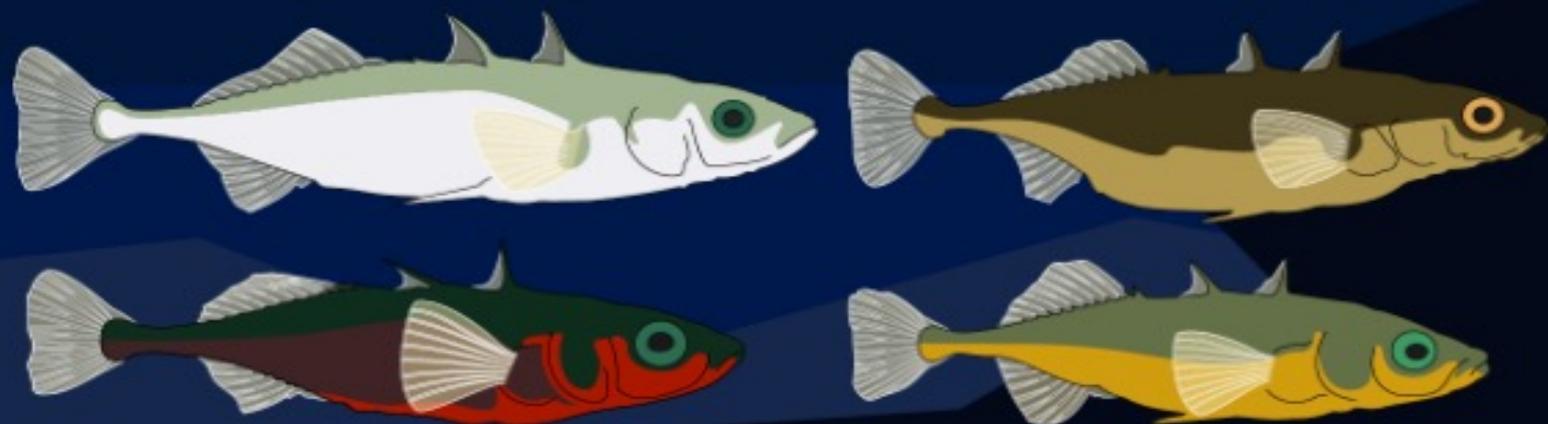


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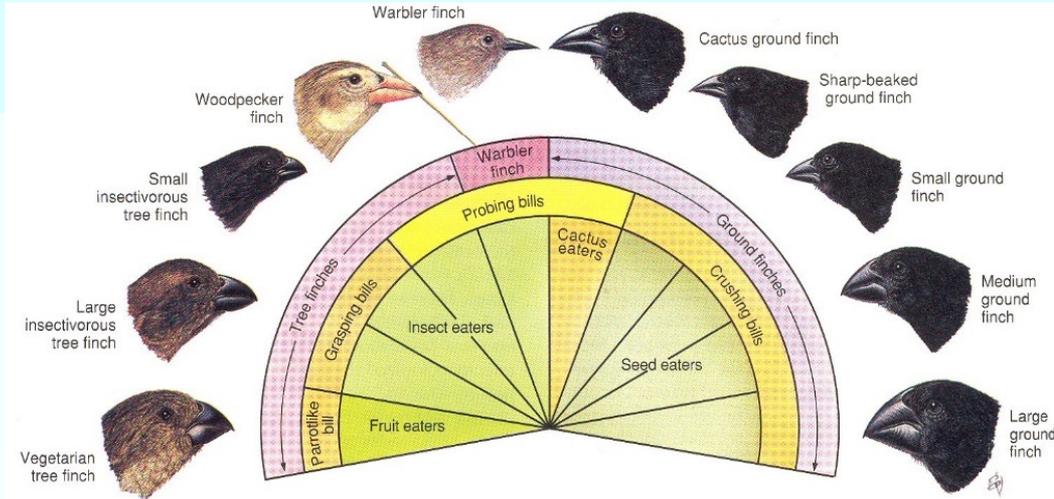
- Occurs when a species separates into two separate groups which are isolated from one another.
- **A physical barrier**, such as a mountain range or a waterway, makes it impossible for them to breed with one another.
- Each species **develops differently based on the demands of their unique habitat** or the **genetic characteristics of the group that are passed on to offspring**.
- The isolated populations then undergo genotypic or phenotypic divergence as:
 - (a) they become subjected to dissimilar **selective** pressures;
 - (b) they independently **undergo genetic drift**;
 - (c) different **mutations** arise in the two populations.

In several freshwater lakes, groups of sticklebacks were physically cut-off from the ocean population. This prevented the groups from interbreeding, and the freshwater populations gradually changed over time.



In the Hawaiian islands, DNA analysis shows that the branching pattern of speciation in flightless crickets matches the order in which the islands formed.





Different species of these birds live on different islands in the Galápagos archipelago, located in the Pacific Ocean off South America. The finches are isolated from one another by the ocean.

Over millions of years, each species of finch developed a unique beak that is especially adapted to the kinds of food it eats. Some finches have large, blunt beaks that can crack the hard shells of nuts and seeds. Other finches have long, thin beaks that can probe into cactus flowers without the bird being poked by the cactus spines. Still other finches have medium-size beaks that can catch and grasp insects. Because they are isolated, the birds don't breed with one another and have therefore developed into unique species with unique characteristics.



PERIPATRIC SPECIATION



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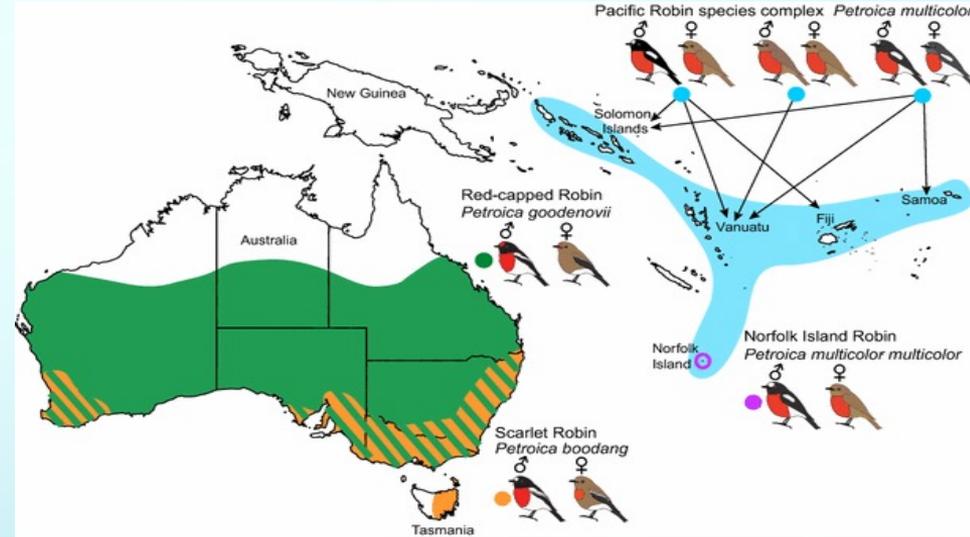
- A subform of allopatric speciation, new species are formed in isolated, smaller peripheral populations that are prevented from exchanging genes with the main population.
- It is related to the concept of a **founder effect**, since small populations often undergo bottlenecks.
 - the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population
- **Genetic drift** is often proposed to play a significant role in peripatric speciation
 - variation in the relative frequency of different genotypes in a small population, owing to the chance disappearance of particular genes as individuals die or do not reproduce



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The robin was considered conspecific with the scarlet robin (*Petroica boodang*) of Australia, but it was separated in 1999, with the Norfolk Island form as part of the Pacific robin assemblage. It was determined to be a distinct species in 2015.



PARAPATRIC SPECIATION



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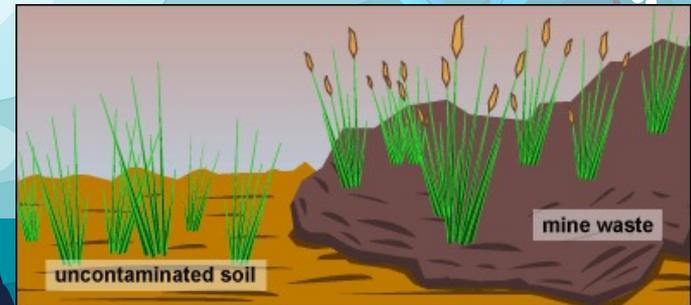
- In parapatric speciation there is no specific extrinsic barrier to gene flow.
 - **The movement of genes between populations. This may happen through the migration of organisms or the movement of gametes (such as pollen blown to a new location).**
- The population is continuous, but nonetheless, the population does not mate randomly.
- Individuals are more likely to mate with their geographic neighbors than with individuals in a different part of the population's range. In this mode, divergence may happen because of reduced gene flow within the population and varying selection pressures across the population's range.



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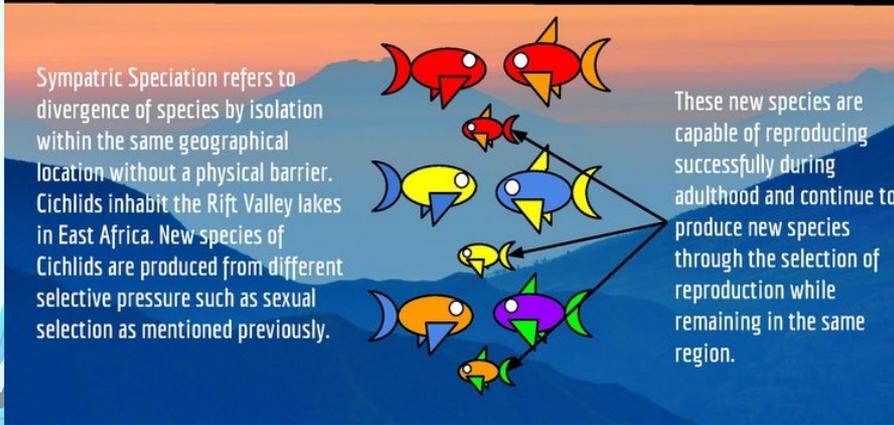
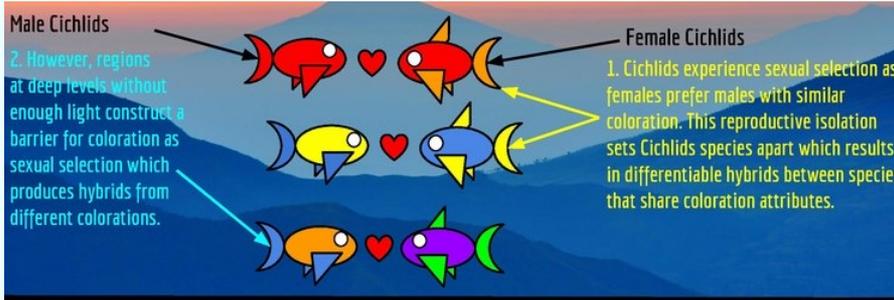


- Some of these **grass species *Anthoxanthum odoratum*** live near mines where the soil has become contaminated with heavy metals.
- The plants around the mines have experienced **natural selection for genotypes that are tolerant of heavy metals**.
- Meanwhile, neighboring plants that don't live in polluted soil have not undergone selection for this trait. The two types of plants are close enough that tolerant and non-tolerant individuals could potentially fertilize each other — so they seem to meet the first requirement of parapatric speciation, that of a continuous population. However, the two types of plants have evolved different flowering times. This change could be the first step in cutting off gene flow entirely between the two groups.



SYMPATRIC SPECIATION

- Formation of **two or more descendant species from a single ancestral species** all occupying the **same geographic location**.
- Examples
 - [Cichlids](#) of [East Africa](#) inhabiting the [Rift Valley lakes](#), particularly [Lake Victoria](#), [Lake Malawi](#) and [Lake Tanganyika](#). There are over 800 described species, and according to estimates, there could be well over 1,600 species in the region. Their evolution is cited as an example of both [natural](#) and [sexual selection](#).
 - A 2008 study suggests that sympatric speciation has occurred in [Tennessee cave salamanders](#).
 - Sympatric speciation driven by ecological factors may also account for the extraordinary diversity of crustaceans living in the depths of Siberia's [Lake Baikal](#).



Cichlids such as *Haplochromis nyererei* diversified by sympatric speciation in the Rift Valley lakes.

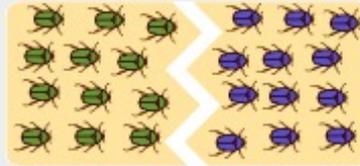


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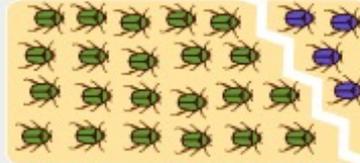
Allopatric
(allo = other,
patric = place)

geographically
isolated
populations



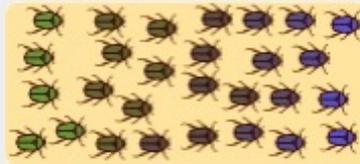
Peripatric
(peri = near,
patric = place)

a small
population
isolated at the
edge of a larger
population



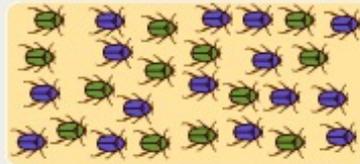
Parapatric
(para = beside,
patric = place)

a continuously
distributed
population



Sympatric
(sym = same,
patric = place)

within the range
of the ancestral
population



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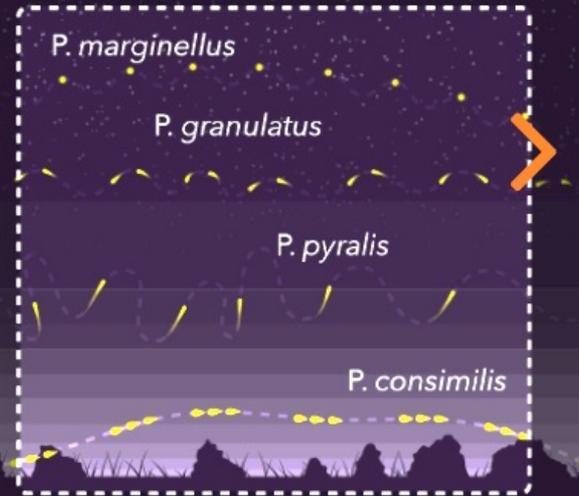
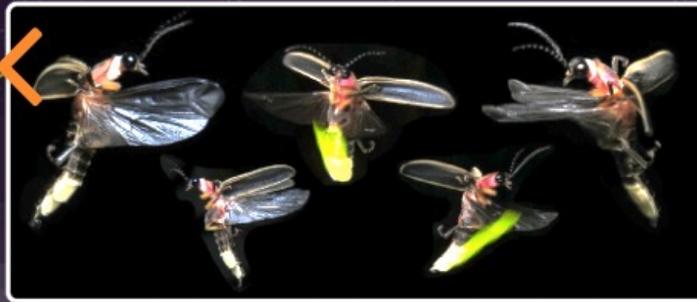
BEHAVIOR

Behavior can be a barrier to reproduction.

Other synonyms: Behavioural isolation, Prezygotic mechanism



Different types of fireflies have distinct blinking patterns. During the summer, it's not unusual to find multiple species of fireflies in the same fields mating at the same time. But because each species has its own blinking pattern, mates can easily find one another and avoid fruitless relationships.



TIMING

If groups mate at different times, they are probably not going to interbreed.

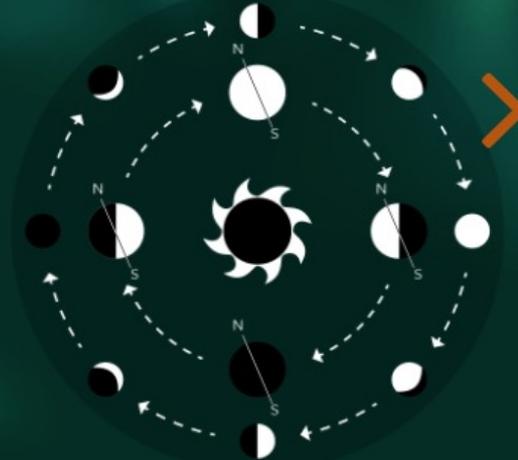
Other synonyms: Temporal isolation, Prezygotic mechanism



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To reproduce, coral releases packets of egg and sperm into the water. The gametes float to the surface and merge to make offspring. In coral reefs, very closely related species live together, and their gametes are capable of fertilizing one another. But they rarely do. Coral time their gamete release according to the seasons and the light of the moon, and some miss one another by mere hours.



ANATOMY

Reproduction requires the right kinds of anatomy, in more ways than you may think.

Other synonyms: Mechanical isolation, Prezygotic mechanism



Trigonopterus alaspurwensis Riedel



Trigonopterus aeneomicans Riedel



Trigonopterus acuminatus Riedel



Lush, tropical forests are full of insects. Researchers have identified multiple pairs of beetle species that live in overlapping areas. The pairs look virtually identical to one another, but their reproductive organs are so different that they couldn't possibly mate.





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Snail species whose genital openings cannot align

Snail species whose genital openings can align



PREZYGOTIC 5: Genetic Incompatability



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GENETIC INCOMPATABILITY

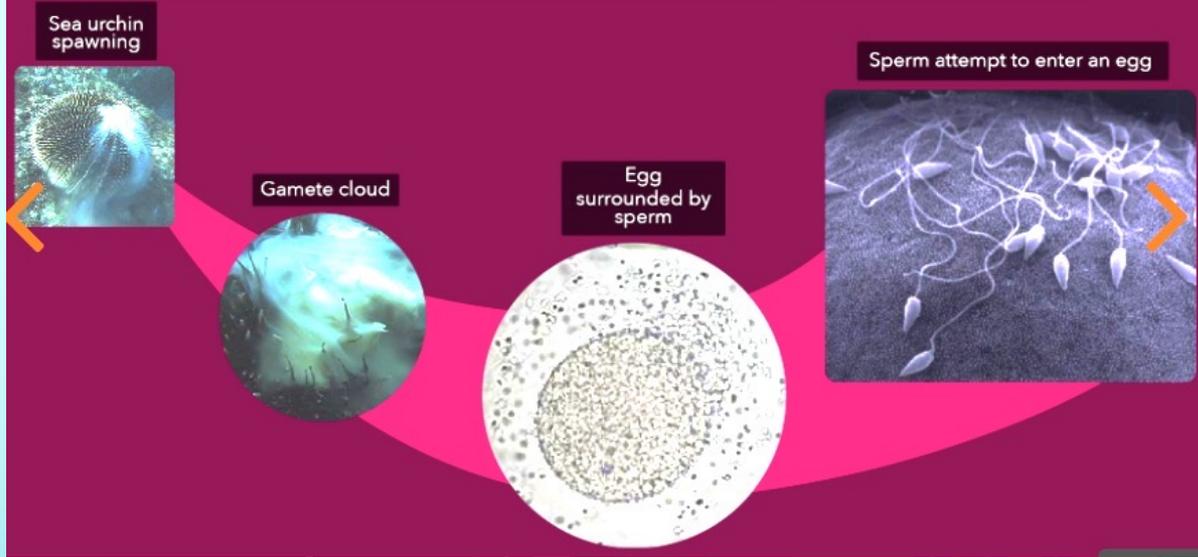
Genetic incompatibility—which can arise quickly, or gradually over time—can keep groups from producing offspring together.

Other synonyms: Gametic isolation, Prezygotic mechanism

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Sea urchins have proteins on the surface of their gametes that allow eggs and sperm to recognize one another and merge. In some closely related species, variations in these proteins make it impossible for gametes to connect.



POSTZYGOTIC 1: Zygotic Mortality

- Mating & fertilization are possible, but genetic differences result in a zygote that is unable to develop properly.
- Death of zygote

- Sheep & Goat mate, but zygote is not viable



POSTZYGOTIC 2: Hybrid Inviability



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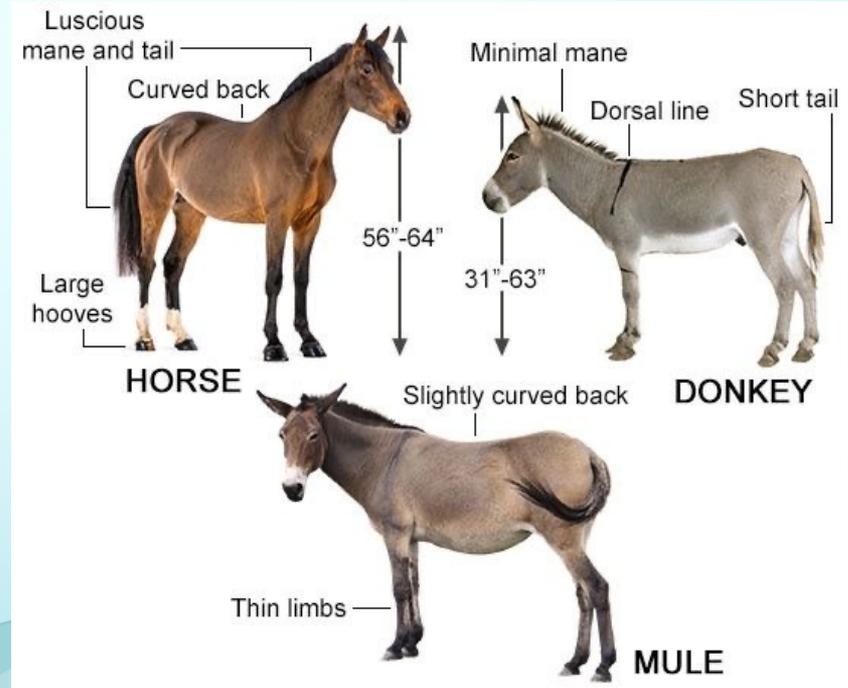


- Hybrid individual develops but either:
 - Dies before birth
 - Born alive but cannot survive to maturity
- Tiger + leopards
 - Zygote develops, but pregnancy ends in miscarriage or stillborn



POSTZYGOTIC 2: Hybrid Infertility

- Hybrid individual develops and remains healthy and viable:
 - But are sterile
- Donkey and Horse = Mule



CONTROVERSIAL INCIDENTS



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- Some organisms commonly reproduce with similar species in the wild, forming genetic hybrids.
 - In 2006, the first wild polar bear–grizzly bear hybrid was found in Canada.
 - Called “pizzly” or “grolar” bears, these hybrid bears can produce fertile offspring.
 - However, polar bears and grizzly bears are still classified as different species due to their habitat needs.

Species: *Ursus maritimus* × *Ursus arctos*





SUMMARY

- Wrap up!
- <https://learn.govdev.azure.com/websites.net/content/evolution/bears/>



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Bears, Species & DNA

