DP IB Environmental Systems & Societies (ESS): SL

Your notes

Origins of Biodiversity

Contents

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Biodiversity Arises from Evolutionary Processes

- Biodiversity arises from evolutionary processes
- Biological variation arises randomly and can either be beneficial to, damaging to, or have no impact on, the survival of the individual

Natural Selection

- In any environment, the individuals that have the best adaptive features are the ones most likely to survive and reproduce
- This results in natural selection:
  - Individuals in a species show a range of variation caused by **differences in genes**
  - When organisms reproduce, they produce more offspring than the environment is able to support
  - This leads to **competition** for food and other resources which results in a 'struggle for survival'
  - Individuals with **characteristics** most **suited** to the environment have a higher chance of survival and more chances to **reproduce**
  - Therefore the genes resulting in these characteristics are **passed on** to their **offspring** at a higher rate than those with characteristics less suited to survival
  - This means that in the next generation, there will be a greater number of individuals with the better adapted variations in characteristics
- This theory of natural selection was put forward by Charles Darwin and became known as 'survival of the fittest'

Example of Natural Selection

- Variation in fur colour exists within rabbit populations
- Rabbits have natural predators like foxes which act as a selection pressure
- Rabbits with a white coat do not camouflage as well as rabbits with brown fur, meaning predators are more likely to see white rabbits when hunting
- As a result, rabbits with white fur are less likely to survive than rabbits with brown fur
- The rabbits with brown fur therefore have a selection advantage, so they are more likely to survive to reproductive age and be able to pass on their genes to their offspring

- Over many generations, the frequency of the gene for brown fur will increase and the frequency of the gene for white fur will decrease

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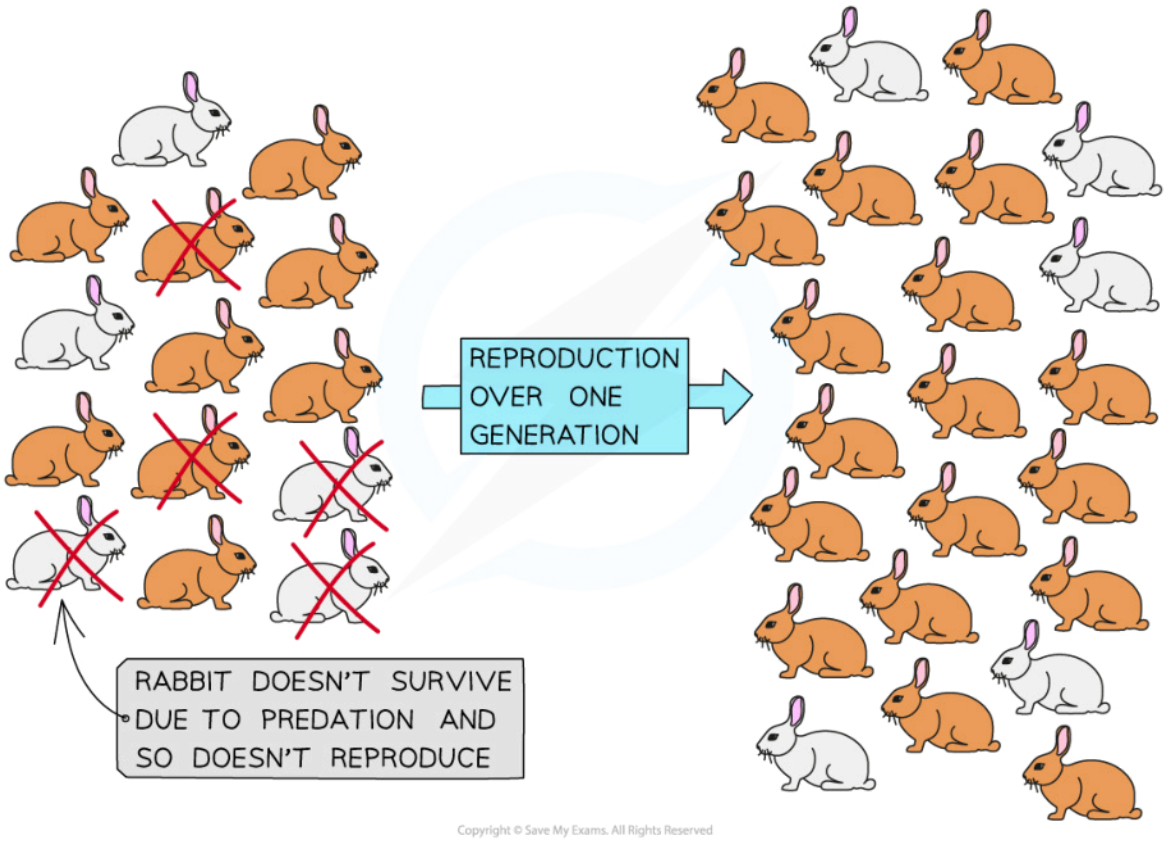
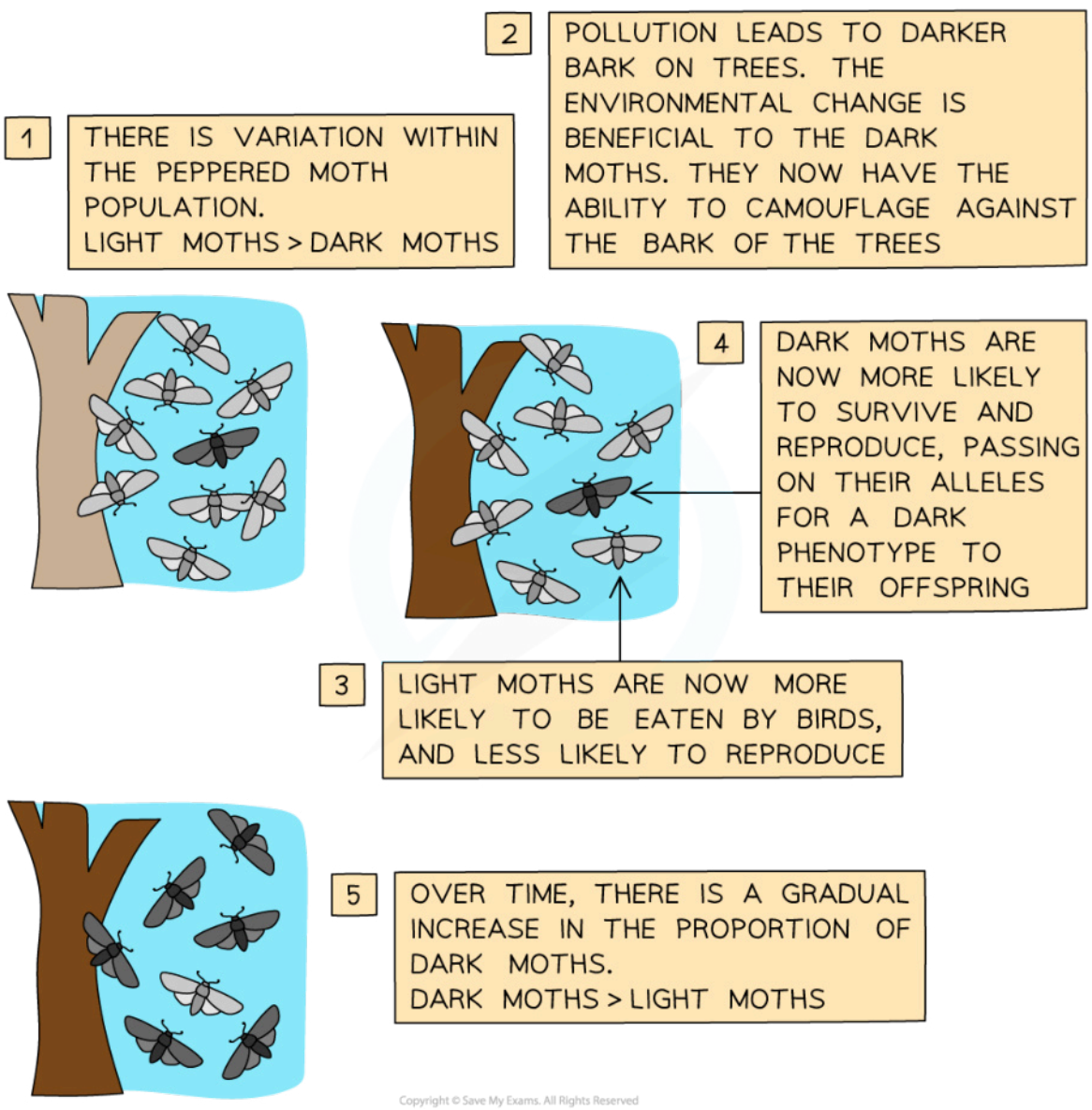


Selective pressures acting on a rabbit population for one generation – predation by foxes causes the frequency of rabbits with brown fur to increase and the frequency rabbits with white fur to decrease

- Remember that organisms better suited to their environments are more likely to survive, but survival is not guaranteed
- Organisms that are less suited to an environment are still able to survive and potentially reproduce within it, but their chance of survival and reproduction is lower than the individuals that are better-adapted
- Also, it is important to be aware that an environment, and the selection pressures it exerts on an organism, can change over time
  - When a change occurs then a different characteristic may become more advantageous
- Finally, remember that all organisms (not just animals) experience selection pressures as a result of the environment they are in



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Another good example of natural selection is the evolution of the peppered moth

Examiner Tips and Tricks

There are many examples of natural selection and you cannot possibly be familiar with all of them, however, they ALL follow the same sequence:

Based on the idea that within a species there is always variation due to chance mutations, some individuals will develop a characteristic that gives them a survival advantage that allow them to live longer, breed more, and be more likely to pass their genes on. Repeated over generations, the advantageous characteristic will become the norm within a population.

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The Role of Isolation in Forming New Species

- The theory of evolution states that species do not stay the same, but change over time; this can lead to the process of speciation
  - Speciation can be defined as **the development of new species from pre-existing species over time**
- In order for speciation to occur two populations of the same species must be **genetically isolated** from each other in some way
  - When this happens, there can no longer be an **exchange of genes** between the two populations
  - The exchange of genes is sometimes known as **gene flow**
- Isolation of populations usually occurs due to **geographical isolation**, which can be caused by environmental changes forming **barriers** such as:
  - Mountain formation
  - Changes in rivers
  - Sea level change
  - Climatic change
  - Plate movements
- Populations that become isolated from each other may face **different selection pressures** in their environment e.g. different predators or different food sources
  - The different environmental conditions for the two populations might mean that different genes are advantageous, so different genes are more likely to be passed on and become more frequent in each population; this is the process of natural selection
  - The gene frequencies in the two populations change over time
- Over time, the two populations may begin to differ physiologically, behaviourally and morphologically to such an extent that they can no longer interbreed to produce fertile offspring; speciation has occurred

Example of Geographic isolation Leading to Speciation

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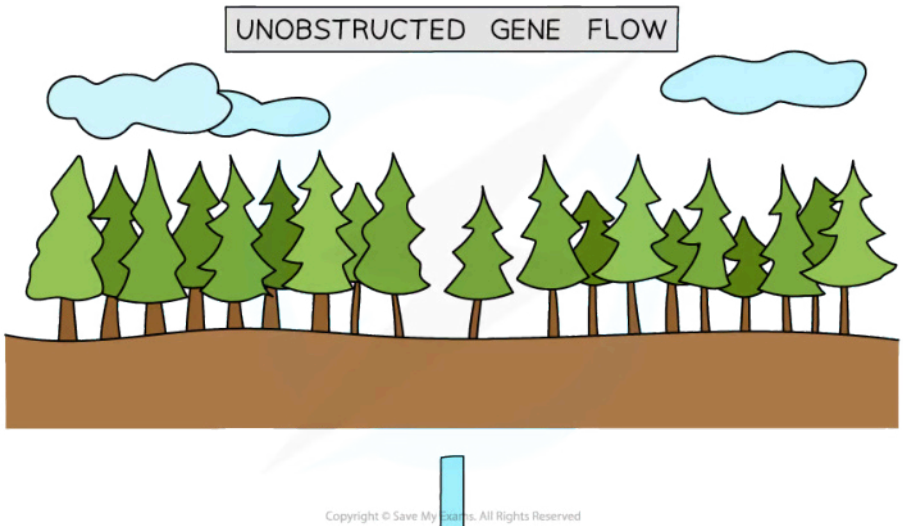

The geographical barrier created by a newly formed mountain range can lead to speciation in trees

- An area contains a large single population of trees
- A new mountain range forms that divides this single population into two separate populations (A and B)
- The geographical barrier prevents the two populations from interbreeding so there is no gene flow between them
- The two populations experience different environments, so different genes become advantageous
  - For example, population B is now partially shaded by the mountains, so the trees in this population need to grow taller and contain more chlorophyll, in order to maximise the amount of sunlight they can absorb for photosynthesis
  - Genes that contribute to greater tree height and increased chlorophyll production become advantageous for population B
- Different genes are therefore more likely to be passed on in each population
- Different genes become more frequent in each population
  - Over time, this causes the tree in population B to become taller and darker (the leaves contain a higher concentration of chlorophyll)
- Over thousands of years the divided populations form two distinct species that can no longer interbreed to produce fertile offspring

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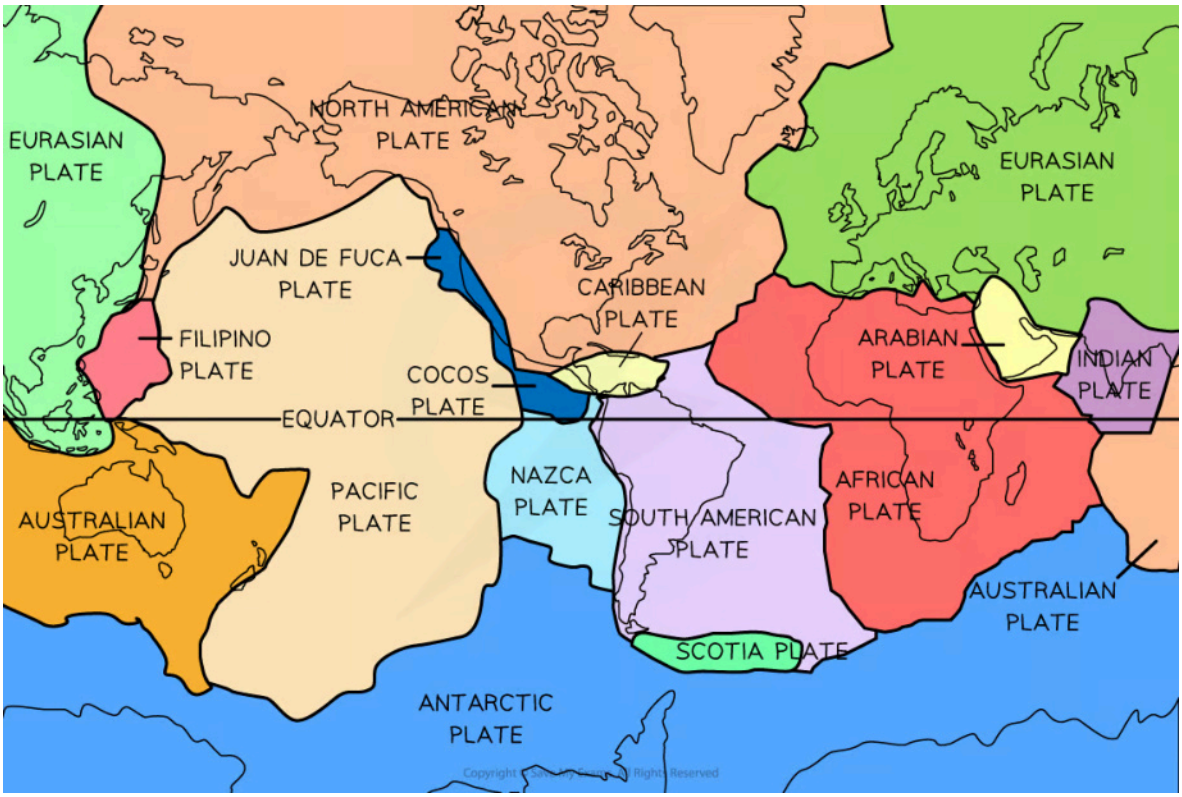
Plate Activity

- The surface of the Earth is divided into crustal, tectonic plates that have moved throughout geological time
  - This has led to the creation of both land bridges and physical barriers with evolutionary consequences
  - The Earth's crust is broken into 15 large tectonic plates and a number of smaller ones
  - The place where the plates meet is called a plate margin
- Tectonic plates move apart, slide against each other, or collide
  - Plates move apart at constructive plate margins
  - Plates slide against each other at destructive plate margins
  - Plates collide at collision plate margins



Tectonic plates

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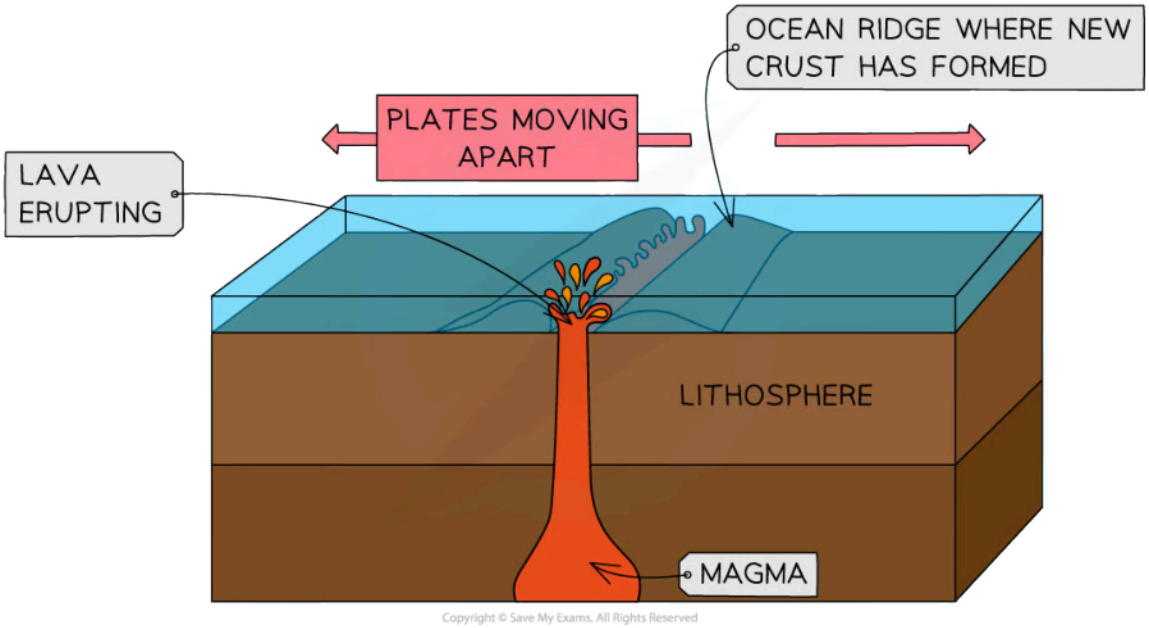
Constructive (Divergent) Plate Margin

- At the constructive boundary the plates are moving apart
- The Mid Atlantic Ridge is an example of a constructive plate boundary
- Volcanic eruptions and earthquakes can occur at this type of plate boundary



Constructive (divergent) plate margin

Destructive (Convergent) Plate Margin

- At a destructive (convergent) plate boundary the plates are moving together
- The denser, heavier oceanic plate **subducts** under the lighter, less dense continental plate
- The boundary between the Nazca plate and the South American plate is an example
- Volcanic eruptions and earthquakes can occur at this type of plate boundary

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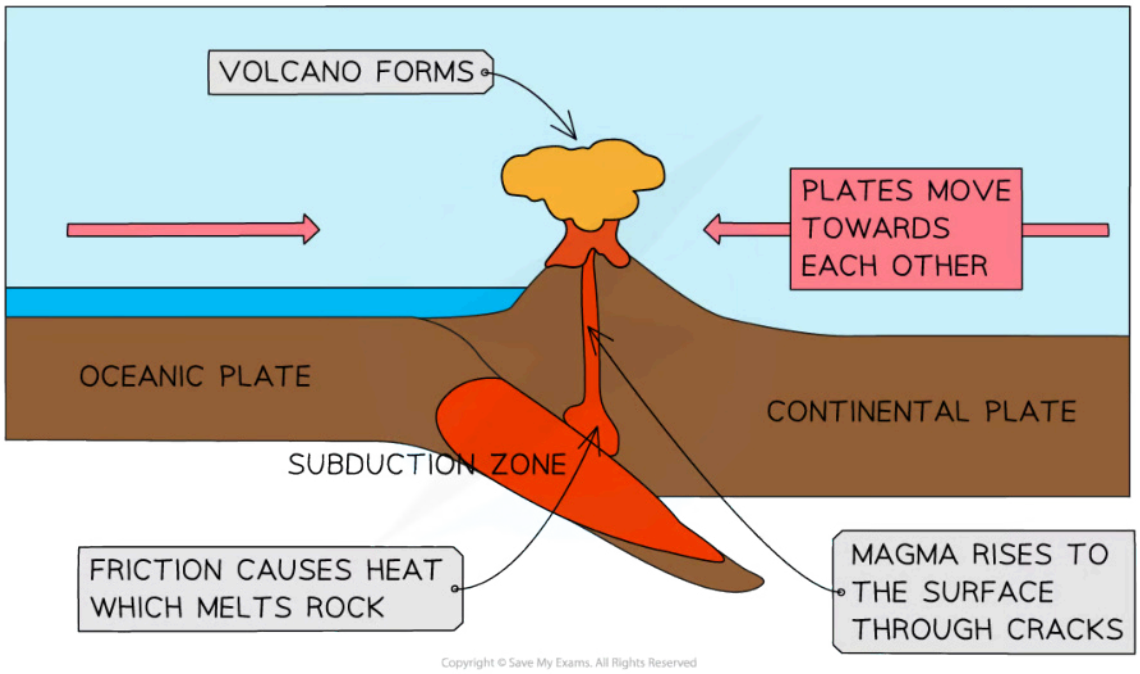

Destructive (convergent) plate margin

Collision Plate Margin

- At a collision boundary two plates of similar density move towards each other
- Neither is dense enough to subduct so the land is pushed upwards
- This forms fold mountains such as the Himalayas
- Earthquakes can occur at this type of plate boundary

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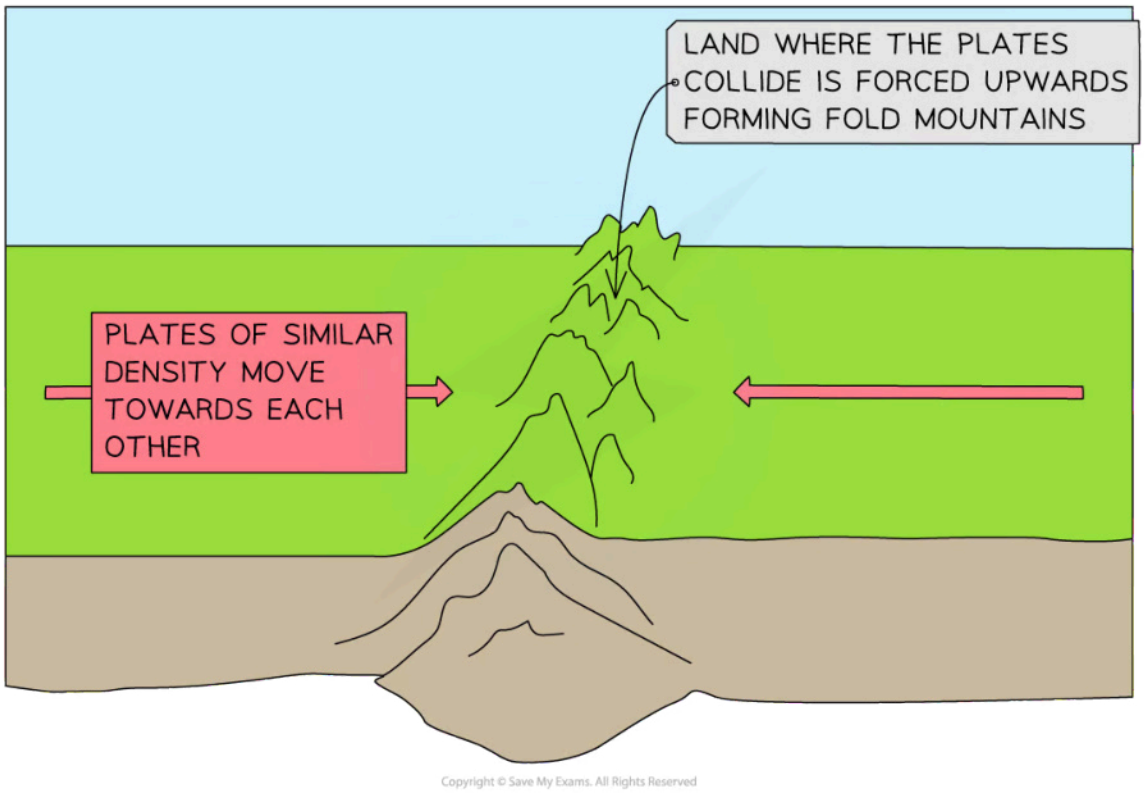

Collision Boundary

Evolutionary Consequences of Tectonic Plate Movement

- Tectonic plate movement has had a profound impact on the evolution of life on Earth
    - Plate movement has led to the creation of land bridges and physical barriers, and the changing distribution of continents has affected climate and food supply

Land bridges and physical barriers:

- PlateTectonic plate movement has led to the creation of land bridges, which connect previously isolated landmasses and allow for the movement of organisms between them
- For example, the Bering land bridge connected Asia and North America during the last ice age, allowing for the migration of animals such as mammoths and humans
- Similarly, the formation of the Isthmus of Panama created a physical barrier between the Atlantic and Pacific Oceans, leading to the evolution of distinct marine species on either side

Climate and food supply:

- The distribution of continents has also had a significant impact on climate and food supply, which has contributed to evolution
- For example, the separation of Africa and South America led to the formation of the Atlantic Ocean, which created a drier climate in Africa due to reduced moisture transport
- This led to the evolution of savannah ecosystems and the expansion of grassland habitats, which in turn influenced the evolution of grazing animals such as antelopes and zebras
- Similarly, the movement of Antarctica to its current position has led to the formation of the Antarctic Circumpolar Current, which has had a major impact on global ocean currents and climate

Genetic isolation:

- Tectonic plate movement has also led to the genetic isolation of populations, which can lead to the formation of new species over time
- For example, the separation of Australia from the rest of the Gondwana supercontinent led to the evolution of unique flora and fauna, such as the marsupials and eucalyptus trees, that are found only in Australia

Conservation implications:

- Understanding the evolutionary consequences of tectonic plate movement can inform conservation efforts
- For example, land bridges can provide important migration routes for species, while physical barriers can lead to genetic isolation and unique evolutionary trajectories
- Similarly, changes in climate and food supply can affect the distribution and abundance of species, highlighting the importance of protecting and restoring natural habitats


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Photo by suzie maclean on Unsplash

The separation of Australia from Gondwana lead to the evolution of unique species such as kangaroos

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What Caused Mass Extinctions on Earth?

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Mass Extinctions

- **Mass extinctions** of the past have been caused by various factors, such as:
  - Tectonic plate movements
  - Super-volcanic eruption
  - Climatic changes (including drought and ice ages)
  - Meteorite impact
- All of these have resulted in new directions in evolution and therefore led to increased biodiversity

How many mass extinctions have there been?

Name	Time Period	Causes	Results for Biodiversity
Ordovician–Silurian	443–485 million yrs ago	A series of glaciations caused a global cooling event which led to a sea-level fall and the contraction of shallow water habitats. This, in turn, caused the widespread extinction of marine life. Additionally, the cooling of the ocean led to a reduction in oxygen levels, which caused widespread oceanic anoxia.	85% of marine species were lost, including many brachiopods, bryozoans, and trilobites. The extinction of brachiopods paved the way for the evolution of the bivalves in the succeeding periods.
Late Devonian	364–375 million yrs ago	Climate change caused by the spread of land plants reduced the amount of CO_2 in the atmosphere. This, in turn, led to global cooling and a decline in sea levels, which caused widespread marine extinction.	70% of marine species were lost, including many brachiopods, corals, and trilobites.
Permian–Triassic	251 million yrs ago	Massive volcanic activity in Siberia, covering an area equivalent to the size of Western Europe, released huge amounts of greenhouse gases and other toxins into the atmosphere and	96% of marine species were lost, including almost all trilobites and corals. 70% of terrestrial vertebrate species were also lost, including many reptiles and

		ocean, causing global warming, oceanic anoxia, and ocean acidification.	amphibians. The event marked the end of the Paleozoic Era and the beginning of the Mesozoic Era.
Triassic–Jurassic	199–214 million yrs ago	Climate change caused by massive volcanic activity led to global warming and a decline in sea levels, which caused widespread marine extinction. The resulting loss of habitat, along with the changes in temperature and precipitation, also led to the extinction of many terrestrial species.	50% of marine species were lost, including many corals, molluscs, and ammonites. Many terrestrial species were also lost, including many crocodile-like reptiles, mammal-like reptiles, and early dinosaurs. The extinction paved the way for the diversification of the dinosaurs in the succeeding periods.
Cretaceous–Paleogene	65 million yrs ago	An asteroid impact in the Yucatan Peninsula, combined with massive volcanic activity in India, caused global cooling, acid rain, and widespread wildfires. The impact also caused a global tsunami and triggered earthquakes, which caused widespread destruction. The resulting loss of habitat and changes in temperature and precipitation contributed to the extinction.	75% of all species were lost, including all non-avian dinosaurs, pterosaurs, and ammonites.


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