SL IB Biology

Your notes

Conservation of Biodiversity

Contents

Biodiversity

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Biodiversity

Biodiversity

- Biodiversity can be thought of as the **variety of life** that exists in a specified area
  - This can refer to global biodiversity, or to the biodiversity of a smaller region
- Biodiversity is very important for the **resilience of ecosystems**; the more biodiverse an ecosystem is, the more **stable** and **resistant to change** it will be
- Biodiversity can be studied at three different levels:
  - Ecosystem
  - Species
  - Genetic

Ecosystem diversity

- This is the **range** of different **ecosystems**, or **habitats,** within a **particular area**
- If there are a large number of different habitats within an area, then that area has high biodiversity
  - A good example of this is a coral reef; reefs are complex with many microhabitats and niches to be exploited
- If there are only one or two different habitats then an area has low biodiversity
  - Large sandy deserts typically have very low biodiversity as the conditions are very similar throughout the whole area

Species diversity

- Species diversity can be measured in two ways:
  - Species **richness** is the **number of species** within an ecosystem
  - Species **evenness** is the **number of individuals of each species** within an ecosystem
- For an ecosystem to have high species diversity it must have **high species richness and high species evenness**
  - An ecosystem would not be species diverse if it had 1000 species, but only had a few individuals of 500 of those species; this would be high richness but low evenness
  - An ecosystem would not be diverse if it had 10 species and had thousands of individuals of each species; this would be high species evenness but low species richness
- Ecosystems with **high species diversity** are usually **more stable** than those with lower species diversity as they are **more resilient** to environmental changes
  - For example in the pine forests of Florida the ecosystem is **dominated by one or two** tree species; if a pathogen comes along that targets one of the two dominant species of trees, then the whole population could be wiped out and the ecosystem it is a part of could collapse

Genetic diversity

- The genetic diversity is the **number of different** alleles **of genes** that are present
  - This can be in an entire species or in a local population

- Factors that contribute to genetic diversity include:
  - The proportion of genes that have more than one allele
  - The number of different alleles that each gene has
- There can be genetic differences or diversity **between populations** of the same species
  - This may be because the two populations live in different areas and so are subject to slightly different selection pressures that affect the allele frequencies in their populations
- There can be genetic differences **between individuals** within a population
  - Genetic diversity in a species is important as it can help the population **adapt** to, and survive, **changes in the environment**

Types of biodiversity diagram

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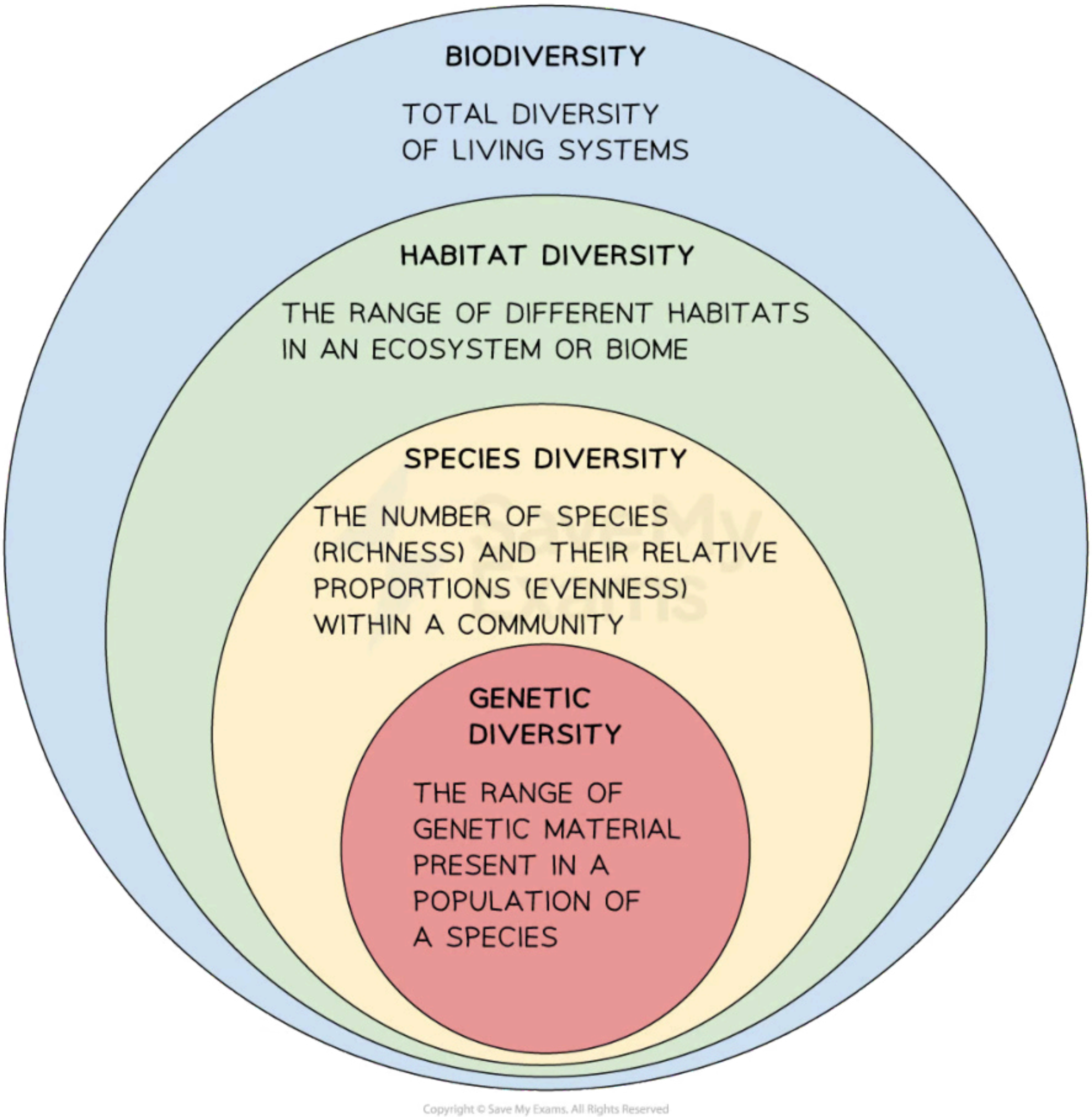
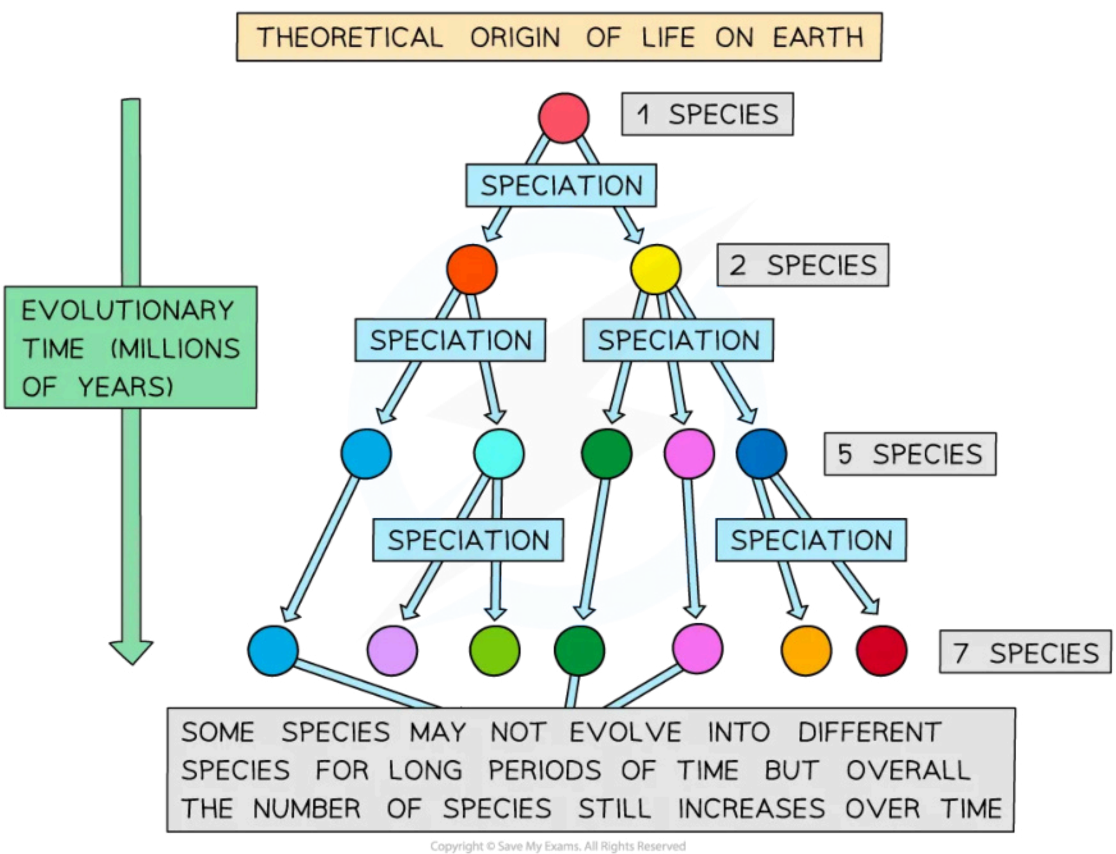


There are different levels of biodiversity, such as ecosystem (habitat) diversity, species diversity, and genetic diversity

Biodiversity Comparisons

Biodiversity change over time

- Current estimates for global species diversity vary, but recent estimates suggest that there could be around 8.7 million species on Earth
  - Around 1.2 million species have currently been recorded and classified, meaning that if estimates are correct, there are still many more species to be discovered
- The number of species on Earth has **not always been the same**; the fossil record shows that:
  - Many species that have existed in the past are no longer present
    - This is due to **extinction**
  - There are **many more species alive today** than have been alive in the past
    - The process of speciation leads to an increase in the number of species
- When speciation occurs **at a higher rate than extinction**, global **biodiversity will increase**
- Despite many extinctions occurring over recent years, periods of speciation in the past mean that global biodiversity levels are still higher than ever before



Speciation gives rise to new species over time, increasing global biodiversity

NOS: Classification is an example of pattern recognition but the same observations can be classified in different ways

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- The accuracy of the estimated number of species on Earth is dependent on the **process of classification**
  - If species are classified correctly then estimates will be more accurate
  - If species are incorrectly classified together then estimates will be too small
  - If species are incorrectly separated then estimates will be too large
- Classification can be subjective; it is not always easy to determine the **point at which one species has become two**, or whether similar organisms are of **the same species**, or are **two different species**
- It can be said that taxonomists are either
  - 'Lumpers'
    - Lumpers focus on similarities more than differences, and are more likely to **classify species together**
  - 'Splitters'
    - Splitters focus on differences, and are more likely to **classify species separately**

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Reasons for Extinction

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Anthropogenic Species Extinction

Anthropogenic extinction

- Extinction that has been caused by human activities is referred to as **anthropogenic extinction**
- Scientists believe that we are currently experiencing a **mass extinction event**, and that human activities are playing a large role
  - There have been five mass extinction events in the past, so the current round of extinctions could be the sixth

Anthropogenic extinction case study: North Island giant moas

- The North Island giant moa (*Dinornis novaezealandiae*) was a large, flightless, herbivorous bird that lived in New Zealand until the year 1300
- Humans arrived in New Zealand between 1200–1300, and it is thought that the moas were **hunted to extinction by humans** by 1300

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The North Island giant moa (Dinornis novaezealandiae) was once thought to be several different species of moa due to size differences between larger females and smaller males, hence the image here being labelled with a different species name

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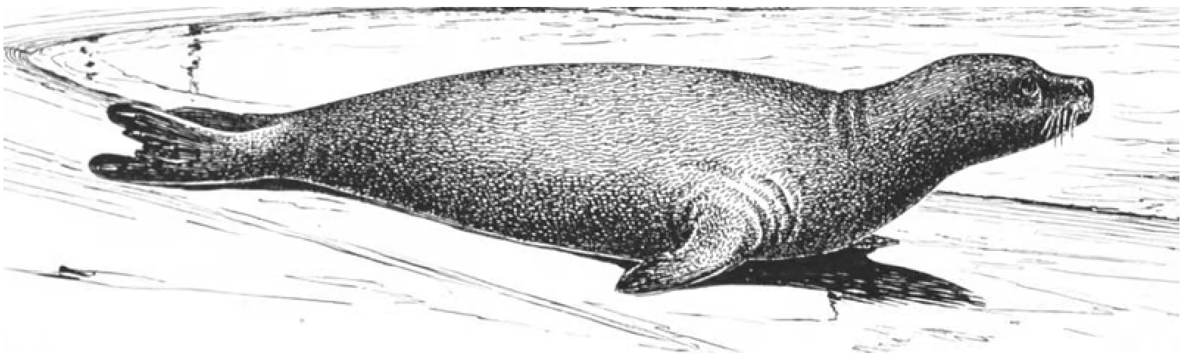
Anthropogenic extinction case study: Caribbean monk seals

- Caribbean monk seals (*Neomonachus tropicalis*) lived in the oceans around the gulf of Mexico and the Caribbean, and were declared extinct in 2008, though it is believed that they may have gone extinct before this
- Their docile nature and their habit of lying out on the rocks meant that these seals were easy for European colonists to **hunt for their oil and meat**



Caribbean monk seals were hunted to extinction to provide humans with oil and food

Anthropogenic extinction case study: student choice

- A third case study should be **chosen and researched**
- Consider the following factors
  - The species chosen should be from a **local** or **familiar region**
  - The species must have gone extinct due to **human activities**
  - The case studies above give an indication of the level of detail required
- Examples of extinct species from different parts of the world include:
  - Baiji (*Lipotes vexillifer*), a species of river dolphin
  - Passenger pigeon (*Ectopistes migratorius*)
  - Paradise parrot (*Psephotellus pulcherimus*)
  - Golden toad (*Incilius periglenes*)
  - St Helena darter (*Sympetrum dilatatum*), a species of dragonfly

Examiner Tip

You need to be able to discuss the causes of anthropogenic extinction in the context of three case studies:

- North Island giant moas
- Caribbean monk seals
- A third species of your choice

Note that you **do not** need to use Latin names when referring to species in an exam.

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Ecosystem Loss

Ecosystem Loss: Causes

- The term **ecosystem** is used to describe all of the **living organisms in an area**, along with **their interactions with each other** and the **non-living environment**
- Human activities are responsible for **damaging and destroying many ecosystems** around the world
  - E.g. the destruction of habitat during deforestation

Anthropogenic ecosystem loss case study: mixed dipterocarp forest in Southeast Asia

- Dipterocarps are a family of trees that occur in the tropics, and that once formed a crucial part of a complex rainforest ecosystem that dominated Southeast Asia
- These rainforests are being gradually lost, with some parts of Southeast Asia having lost more than 50 % of their forests
- Forest is often lost due to a practice known as clear-cutting, where all of the trees in an area are cut down and removed
  - This provides timber and clears land for agriculture, e.g. palm oil plantations

K. Yoganand, CC BY-SA 4.0, via Wikimedia Commons

Dipterocarp forests used to dominate Southeast Asia, but are being lost to deforestation

Anthropogenic ecosystem loss case study: student choice

- A **second case study** should be **chosen and researched**
- Consider the following factors
  - The ecosystem chosen should be from a **local** or **familiar region**
  - The ecosystem loss must be due to **human activities**
  - The case studies above give an indication of the level of detail required
- Examples of ecosystem loss from different parts of the world include:
  - Great Barrier Reef, Australia
  - Northern Great Plains, North America
  - Mangrove forests, various locations

Examiner Tip

You need to be able to discuss anthropogenic ecosystem loss in the context of **two case studies**:

- Mixed dipterocarp forests in Southeast Asia
- A second case study of your choice

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Loss of Biodiversity

Your notes

Biodiversity Loss: Evidence

The evidence for biodiversity loss

- To fully understand the nature and extent of the biodiversity crisis, **solid evidence** on the world's changing biodiversity is required
- For such evidence to be trustworthy, it needs to contain sufficient data and it needs to come from reliable sources:
  - **Many reliable biodiversity surveys** need to have been carried out in a **wide range of habitats**
  - **Repeat** survey data is needed over a period of time
  - Both species richness and species evenness need to be assessed
  - To maximise the volume of data, **'citizen scientists'** can help with survey work
    - Citizen scientists are members of the public who help to gather data
  - Data need to be expertly analysed
- Drawing together these large bodies of evidence is a huge task, and such work is often carried out by organisations that work across multiple governments, e.g.
  - **IPBES**
    - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
  - **IUCN**
    - International Union for the Conservation of Nature

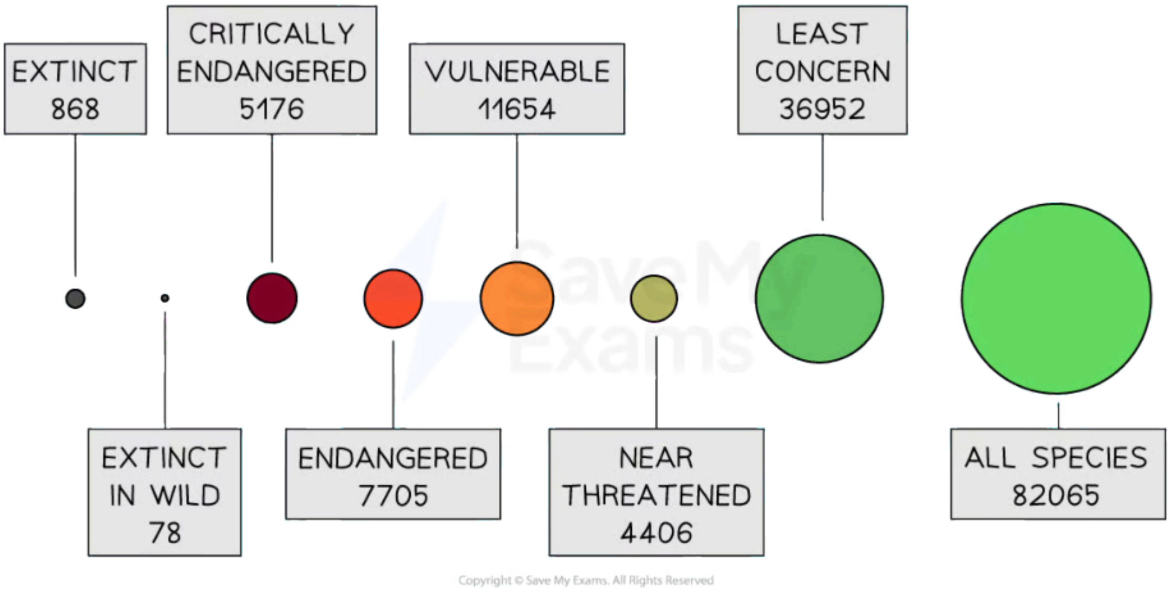
IPBES

- IPBES is an organisation that works to **gather information**, **recommend policies**, and **communicate findings** relating to global biodiversity and ecosystems
- The **2019 IPBES report** contained a comprehensive summary of findings from research as well as policy recommendations for governments
  - Data is gathered by scientists, government bodies, and local individuals
  - Studies are carried out in a range of habitats where regular samples are taken

IUCN

- The IUCN is a network of organisations and individual experts that seeks to gather knowledge of the natural world and to propose helpful environmental policies
- The **IUCN red list** is a list of the **world's most threatened species**; it has assessed more than 150 000 species, and has listed more than 42 000 as threatened
- The IUCN red list has been compiled by **scientists and scientific organisations** all around the world, and is used by many groups to inform conservation efforts
- Species that have been assessed are categorised by the IUCN as:
  - LC = least concern
  - NT = near threatened
  - VU = vulnerable
  - EN = endangered

- CR = critically endangered
- EW = extinct in the wild
- E = extinct
- Species can also be classed as DD (data deficient) when there is not enough data on which to base a category choice, or as NE (not evaluated)



The IUCN categorises species on the basis of their risk of extinction; this data can be represented visually to give an immediate picture of the level of risk being faced by many species

Note that this graphic is from 2016, so does not match the numbers given in the text above

NOS: To be verifiable, evidence usually has to come from a published source, which has been peer-reviewed and allows methodology to be checked

- Collecting data on global biodiversity is a huge task, and while qualified scientists can collect a great deal of data, this may not be enough to gain an overall picture of changes occurring at a **national** or **international level**
- To solve this problem, organisations will sometimes ask **the public** to help with data collection; such members of the public are described as **'citizen scientists'**
- Citizen scientists are **often untrained**, and may not always collect valid data as a result, so there will be a certain amount of **trade-off between the quality and the quantity of the data**
- **Good experimental design** and **high-quality data analysis** can help to mitigate the effects of using citizen scientists.

Your notes

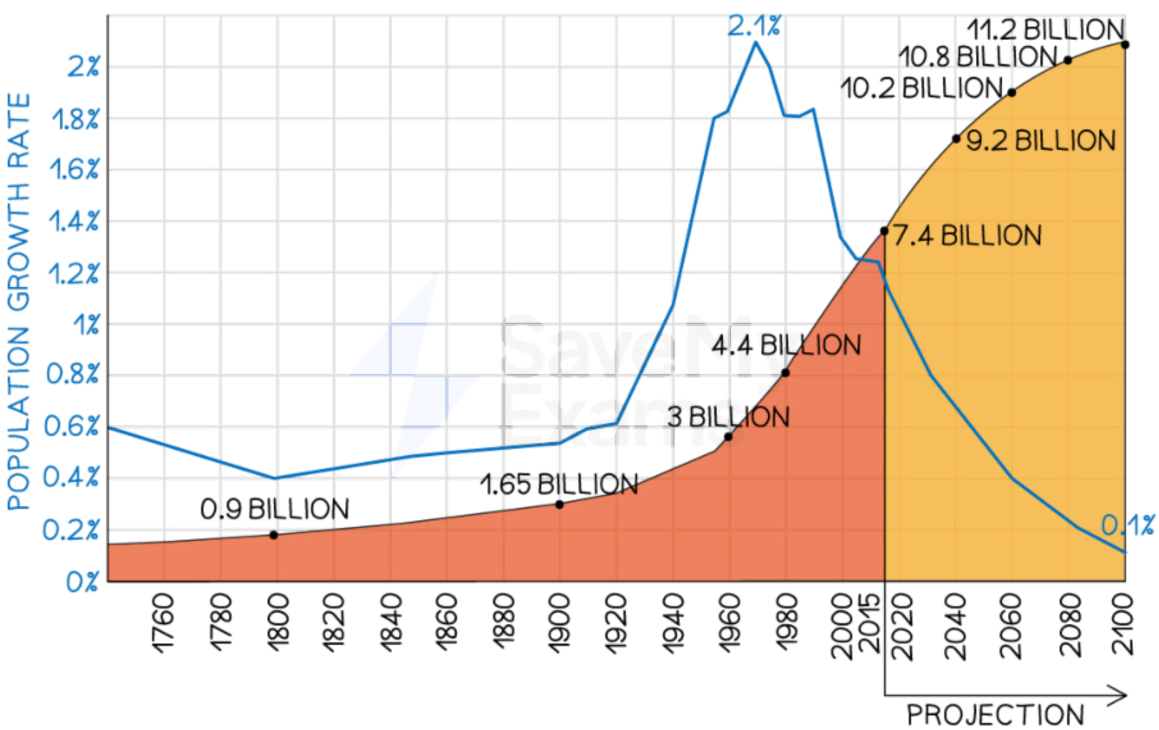
Your notes

Biodiversity Loss: Causes

The causes of biodiversity loss

- It is widely agreed among scientists that there is a **biodiversity crisis** underway due to the rate at which extinctions are occurring
- The **growth of the global human population** is likely to be the main cause of this crisis
  - There are currently more than 8 billion people on Earth
  - The global population continues to increase
  - Even though birth rates are now decreasing, people are living longer so births are occurring at a higher rate than deaths and the population continues to grow

Human population graph



Projections suggest that the human population will continue to increase until the year 2100 due to birth rates being higher than death rates

Note that the graph shows population size in red, projected population size in orange, and population growth rate in blue.

- Human population growth has led to a biodiversity crisis for multiple reasons, e.g.
  - **Overexploitation** of resources
    - Overfishing of the oceans are causing a decline in fish populations
    - Hunting of animals for resources such as ivory from tusks, oil from whales, or fur from beavers

- **Urbanisation**, or the building of towns
  - Direct **loss of habitat** for buildings
  - **Fragmentation** of habitat into smaller pieces by, e.g. roads
  - Less land is available for agriculture, so this expands elsewhere
- **Deforestation** and **habitat loss**
  - Land is cleared for agriculture, timber, mining, or quarries
  - Agriculture may *look* good for living organisms, but it often involves the planting of monocultures with very low biodiversity, and it leads to loss of soil micro-organisms
- **Pollution**
  - Microplastics have been found in remote environments
  - Fertilisers and organic waste can be washed off farmland into bodies of water
- Increase in numbers of **pests**
  - Biodiversity loss has led to an increase in pest species that damage crops, e.g. the cotton bollworm (*Helicoverpa armigera*)
    - Higher biodiversity increases the number of pest predators
    - Pests will gather in larger numbers in areas of monoculture
- **Invasive species**
  - When humans **travel around the world** they often **bring species with them**, either by accident or on purpose; these 'alien' species can have damaging effects on the habitats to which they are introduced
  - Examples include
    - Grey squirrels and signal crayfish in the UK
    - Cane toads in Australia
    - Rats in the Galapagos Islands
- **Disease**
  - Diseases can wipe out large numbers of species, e.g. the chytrid fungus is thought to have wiped out 90 species of amphibian so far
  - Human-caused climate change can increase the ranges of some diseases
  - Humans living closely with animal species can result in new diseases as pathogens transfer between hosts

Your notes

How to Preserve Biodiversity

Your notes

Conserving Biodiversity

- As human activities continue to cause a decline in biodiversity, the need for **solutions** to this problem increases
- The **problem is complex**, and there is no one simple solution, so a **mixture of different approaches** is needed
  - The complexities are often due to conflicts between the needs of the natural world and the needs of humans; these conflicts are not always easy to resolve
- Examples of different approaches to dealing with the biodiversity crisis include
  - In situ conservation, e.g.
    - Protected areas
    - Rewilding
    - Reclamation
  - Ex situ conservation, e.g.
    - Zoos
    - Botanic gardens
    - Seed banks
    - Tissue banks

In situ conservation

Protected areas

- A protected area is a **defined geographical space**, such as a national park or nature reserve, that is **managed and protected** for the purposes of conservation
- **National parks** are **government-controlled** areas within countries where the wildlife and environment are protected
- **Nature reserves** are smaller regions than national parks, and can be on **privately or publicly owned land**
- Restrictions inside protected areas could include
  - **Humans access** is strictly controlled
  - Industrial activities such as **agriculture** and **building** are tightly regulated
  - **Hunting** is limited or completely prohibited

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Kruger National park is the largest national park in South Africa

Rewilding

- This is the **restoration of ecosystems** to a point at which they can sustain themselves; such **sustainable ecosystems** are by their nature **biodiverse habitats**
- Rewilding can be allowed to occur on private or publicly owned land
- Rewilding can be **active or passive**
  - Active rewilding involves human intervention, e.g. removing human features such as roads, and reintroducing locally extinct species
  - Passive means leaving an area alone to allow ecological processes to gradually restore themselves, e.g. stopping the management of land to allow natural succession to occur
    - Note that passive rewilding will not work for the restoration of some habitat types, e.g. grassland habitats often require grazing to prevent the dominance of tree species

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Longhorn cattle at the Knepp estate in the UK mimic the action of extinct ancient grazing species, creating a diverse grassland habitat

Reclamation

- Reclamation refers to the **reclaiming and restoration of areas that have been damaged by human activities**, e.g. abandoned quarries or areas where deforestation has taken place
- Such projects aim to **restore previously existing ecosystems**

Ex situ conservation

Zoos

- **Captive breeding programmes** in zoos can increase the number of individuals of a species
  - This can be carried out by **artificial insemination**, allowing the flow of genes between individuals that may be living in different zoos
    - This prevents problems that can arise from **low genetic diversity**
    - This can avoid difficulties with captive breeding
  - Captive breeding can lead to the release of individuals **back into the wild**
- Zoos are an invaluable resource for **scientific research**
  - Scientists are able to closely study animal genetics, behaviours and habitat requirements

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Botanic gardens

- Botanic gardens are the plant equivalent of zoos
- They use cuttings and seeds collected from the wild to **establish a population of the endangered species** in captivity
  - Methods of tissue culturing and cloning can also be used to obtain large numbers of plants from a small sample size
- The captive population can be used in the future for **reintroduction into habitats** where they have become rare
- **Research** is a major role of botanic gardens
  - Scientists can investigate reproduction and growth in different plant species so that they can be grown in captivity
  - Habitat requirements can be assessed so that new habitats can be found if necessary

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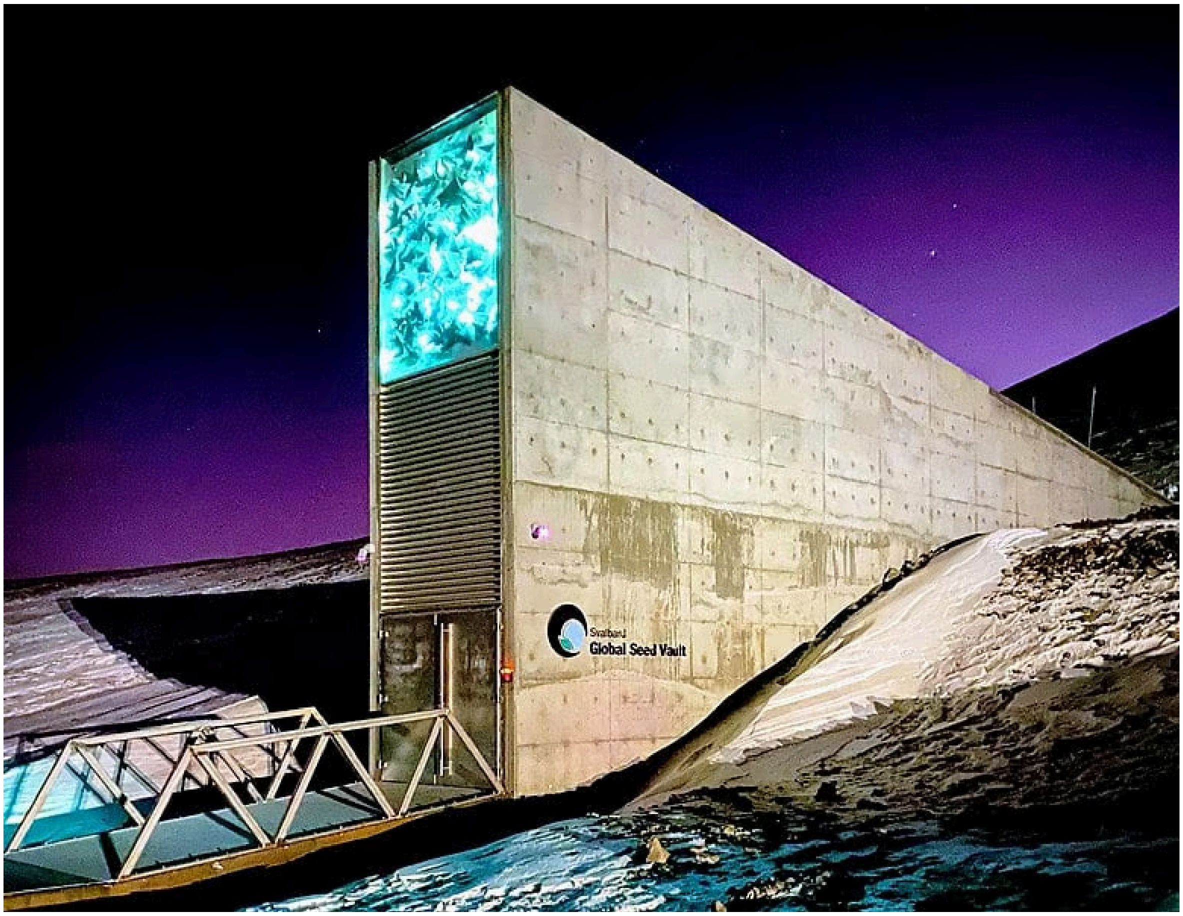
Botanic gardens, such as this one in Rio de Janeiro, Brazil, can increase the populations of threatened plant species and carry out scientific research and education

Seed banks

- A seed bank is a facility that conserves plant diversity by **drying and storing seeds** in a **temperature-controlled** environment

- **Cool, dry conditions** generally increase the length of time for which seeds remain viable
- Seeds can only be stored for so long; after a certain period of time the stored seeds are grown into plants and fresh seeds for storage are taken from those plants
- If the plant species goes extinct then the seeds can be used to grow them again
- Usually, seeds of the same species are collected from different sites to **maintain genetic diversity**
- The Svalbard Global Seed Vault in Norway contains seeds from almost 1 million plant species
  - It is located in the Arctic Circle with ideal environmental conditions
  - Many organisations send seeds from crop plants to be stored there for safekeeping



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The Svalbard Global Seed Vault in Norway contains seeds from almost 1 million plant species

Tissue banks

- Tissue banks, or frozen zoos, **store genetic material** from animals at very low temperatures
  - It is thought that properly frozen tissue samples can last indefinitely
- Ideally, samples are collected from different individuals of the same species to **maintain genetic diversity**
- Two different types of tissue can be stored in tissue banks

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- **Germplasm**
  - This includes **reproductive tissue**, such as sperm cells, egg cells, and embryos
  - This material can be used by zoos in captive breeding programmes
  - In theory, IVF could be carried out with a suitable surrogate species to bring back an extinct species from this tissue
- **Somatic tissue**
  - This is non-reproductive tissue, or **body cells**
  - This type of tissue contains the **full genome** of the species, and can be used for DNA research
  - It is thought that such tissue could be used for cloning extinct species in the future

Your notes

Conserving Biodiversity: Selecting Species

Your notes

Prioritising species for conservation

- There are so many species that need protection that it can seem like an impossible task to decide where to allocate the limited resources available
- The **Evolutionarily Distinct and Globally Endangered (EDGE) programme** works together with the **Zoological Society of London (ZSL)**, to carry out research and to highlight the needs of certain species
- Priority is decided on the basis of a species being
  - **Evolutionarily distinct**
    - Species have **few close evolutionary relatives**
    - Species are **unusual** in appearance, behaviour, and DNA
    - Species represent a part of Earth's evolutionary tree that is not represented anywhere else
  - **Globally endangered**
    - The IUCN red list is used to provide information about the **threat level** of an evolutionarily distinct species
    - A species must be globally threatened, not just threatened on a local level
- A species must be **both evolutionarily distinct and globally endangered** to be prioritised by the EDGE programme
  - Examples of priority EDGE species include
    - Largetooth sawfish
    - Chinese giant salamander
    - Purple frog
- The EDGE of existence programme highlights the needs of EDGE species to local, government, and international conservation organisations to ensure that such species are not lost before their plight is even recognised

Your notes

The Chinese giant salamander is both evolutionarily distinct and globally endangered, and is a focal species for the EDGE programme

NOS: Issues such as which species should be prioritised for conservation efforts are complex and need to be debated

- The considerations of the EDGE programme are important, but there are **complex ethical, environmental, political, social, cultural and economic issues** when it comes to making decisions about priority species for conservation, e.g.
  - Some species may not be at a very high threat level globally, but they may be important for the maintenance of an ecosystem that supports other, more threatened species
  - A species may be culturally important for a particular nation
  - There may be political reasons why conserving particular habitats is very difficult, e.g. being located in a warzone
- For this reason, EDGE do not make decisions about conservation, but they can pass on important information to stakeholders, allowing a range of people to be involved with the debate