**3.1 Classification**

**What is a species?**

1. What is the morphological species model?

2. What is sexual dimorphism?

3. Give the definition of a species based on the reproductive species concept.

4. What is molecular phylogeny?

5. What is a niche?

6. Give an example of an alternative to the reproductive species concept.

7. Give an example of a limitation of a species model.

8. In the science of molecular phylogeny, which molecules can be sequenced and compared?

**Challenge**

9. Why is an online database better than traditional archives?

**Identifying Individual Species**

1. What is DNA sequencing?

2. What is DNA profiling?

3. Give an example of how bioinformatics can be used.

**Challenge**

4. Give one advantage of DNA barcoding.

**New Evidence for Evolution**

1. What is proteomics?

2. What are the differences in DNA sequences?

3. If there are more differences in the DNA between two individuals, what does that tell us about the time since they had a common ancestor?

4. What is a ‘molecular clock’?

5. What do evolutionary trees show?

6. What is peer review?

7. What happens at scientific conferences?

**Challenge**

8. Draw an evolutionary tree to show species A and B being more closely related to each other than to species C.

**Domains, Kingdoms or Both?**

1. Name the technique which is used to separate DNA, RNA or amino acids based on their size and charge.

2. Name the enzymes that are used to cut DNA into fragments.

3. Name the dye that binds to DNA and fluoresces under UV.

4. Which is the positive electrode: cathode or anode?

5. What charge does a DNA molecule have?

6. Which dye is used to observe amino acids after they have been electrophoresed?

7. What is an endosymbiont?

8. Name two organelles that have thought to have evolved from endosymbionts.

9. What are extremophiles?

11. Explain the difference between heterotrophic and autotropic nutrition.

**Challenge**

12. Give an example of a characteristic that is different between organisms in Bacteria and Archaea domains.

**3.2 Natural Selection**

**Evolution and Adaptation**

1. What is this process called?

* Variation exists within a species
* Organisms produce excess offspring and not all survive to reproduce (as there is competition).
* Organisms with advantageous characteristics survive and reproduce.
* Offspring inherit these advantageous characteristics.

2. What is evolution?

3. What is a genotype?

4. What is a phenotype?

5. What is an allele?

6. What is a niche?

**Challenge**

7. Give an example of each of these types of adaptations:

(a) Anatomical

(b) Physiological

(c) Behavioural

**3.2 Natural Selection in Action**

1. What is a selection pressure?

2. What is industrial melanism?

3. What is directional selection?

4. What is the gene pool?

**Challenge**

5. Give an example of an adaptation that is selected for reproductive success.

**The Evolutionary Race between Pathogens and Medicines**

1. What are antibiotics?

2. What is drug resistance?

3. What does MRSA stand for?

4. What are multi-resistant strains of bacteria?

5. Which reaction does penicillinase catalyse?

6. Why do doctors test for infections before prescribing antibiotics?

**Challenge**

7. Give an example of a factor that contributes to the problem of antibiotic resistance.

**Speciation**

1. What is speciation?

2. What is hybridisation?

3. What is reproductive isolation?

4. What is allopatric speciation?

5. What is sympatric speciation?

6. What is adaptive radiation?

7. What is an endemic species?

**Challenge**

8. Give an example of each of the following isolating mechanisms.

(a) Geographical isolation

(b) Ecological isolation

(c) Seasonal isolation

(d) Behaviour isolation

(e) Mechanical isolation

**The Importance of Biodiversity**

1. What is biodiversity?

2. What is species richness?

3. What is a biodiversity hotspot?

4. What is an endemic species?

5. What is relative species abundance?

6. Write out the formula for measuring biodiversity. What do N and n stand for?

7. Why is biodiversity not constant?

**Challenge**

8. Why would we see higher levels of biodiversity in some areas?

**Biodiversity Within a Species**

1. What is the allele frequency?

2. What is selective breeding?

3. How is the genetic diversity within a species measured?

4. Why is it important to conserve populations with higher genetic diversity?

**Challenge**

5. Why are endemic populations more vulnerable to the introduction of disease?

**Ecosystem Services**

1. Give two ethical arguments for the maintenance of biodiversity.

2. What are ecosystem services?

3. Give an example of a:

(a) provisioning service

(b) regulating service

(c) supporting service

(d) cultural service

**Challenge**

4. Give an example of a financial implication of loss of biodiversity.

**Ex-situ and In-situ Conservation**

1. What is conservation?

2. What is ex-situ conservation?

3. What is in-situ conservation?

4. Describe how seeds are stored in seed banks.

5. Describe some limitations with captive breeding and reintroduction.

6. List some different in-situ conservation strategies.

**Challenge**

7. Give an example of a sustainable method of land use.

**3.1 Classification**

**What is a species?**

1. What is the morphological species model?

A species definition based solely on the appearance of the organisms observed.

2. What is sexual dimorphism?

When there is difference between the appearance of the male and female of the species.

3. Give the definition of a species based on the reproductive species concept.

A group of organisms with similar characteristics that interbreed to produce fertile offspring.

4. What is molecular phylogeny?

Analysis of genetic material of organisms to establish their evolutionary relationships.

5. What is a niche?

The role of an organism within its habitat.

6. Give an example of an alternative to the reproductive species concept.

Ecological species model, mate-recognition species model, genetic species model or evolutionary species model.

7. Give an example of a limitation of a species model.

Not observed mating, sexual dimorphism, time-consuming/expensive, fertile hybrids, asexual reproduction, fossils do not reproduce/contain DNA etc.

8. In the science of molecular phylogeny, which molecules can be sequenced and compared?

DNA, RNA, proteins

**Challenge**

9. Why is an online database better than traditional archives?

Searching is much easier and scientists from around the world have access to the information.

**Identifying Individual Species**

1. What is DNA sequencing?

Process by which the base sequences of all or part of the genome of an organism is worked out.

2. What is DNA profiling?

Process by which the non-coding areas of DNA are analysed to identify patterns.

3. Give an example of how informatics can be used.

Any suitable example of using IT and/or maths to organise/analyse biological data.

**Challenge**

4. Give one advantage of DNA barcoding.

Cheap, rapid, could be used in the field, used to accurately identify species, can identify species in different stages of life cycle, can use to determine evolutionary relationships etc.

**New Evidence for Evolution**

1. What is proteomics?

Science of studying the proteins in an organism.

2. What are the differences in DNA sequences?

Mutations

3. If there are more differences in the DNA between two individuals, what does that tell us about the time since they had a common ancestor?

Longer time

4. What is a ‘molecular clock’?

A way of determining evolutionary time based on no. of mutations (assuming a fixed mutation rate).

5. What do evolutionary trees show?

Evolutionary relationships between species.

6. What is peer review?

Articles are submitted to journals & read by experts to see if they are reliable before being published.

7. What happens at scientific conferences?

Scientists working in the same field get together to discuss ideas, data and techniques.

**Challenge**

8. Draw an evolutionary tree to show species A and B being more closely related to each other than to species C.

Suitable diagram shown.

**Domains, Kingdoms or Both?**

1. Name the technique which is used to separate DNA, RNA or amino acids based on their size and charge.

Gel electrophoresis.

2. Name the enzymes that are used to cut DNA into fragments.

Restriction enzymes/endonucleases.

3. Name the dye that binds to DNA and fluoresces under UV.

Ethidium bromide.

4. Which is the positive electrode: cathode or anode?

Anode

5. What charge does a DNA molecule have?

Negative

6. Which dye is used to observe amino acids after they have been electrophoresed?

Ninhydrin

7. What is an endosymbiont?

An organism that lives inside the cells or body of another organism.

8. Name two organelles that have thought to have evolved from endosymbionts.

Chloroplasts and mitochondria.

9. What are extremophiles?

Bacteria that can survive extreme conditions.

11. Explain the difference between heterotrophic and autotropic nutrition.

Heterotrophic nutrition involves eating other organisms for food, autotrophic nutrition involves organisms making their own food.

**Challenge**

12. Give an example of a characteristic that is different between organisms in Bacteria and Archaea domains.

See table on p.165 for examples.

**3.2 Natural Selection**

**Evolution and Adaptation**

1. What is this process called?

* Variation exists within a species
* Organisms produce excess offspring and not all survive to reproduce (as there is competition).
* Organisms with advantageous characteristics survive and reproduce.
* Offspring inherit these advantageous characteristics.

Natural selection

2. What is evolution?

When long-term changes in organisms that occur as a result of natural selection produce changes in species/new species.

3. What is a genotype?

Genetic make-up of an organism (for a characteristic).

4. What is a phenotype?

Characteristics expressed as a result of the interactions of the genotype with the environment.

5. What is an allele?

Version of a gene, a gene variant.

6. What is a niche?

Role of the organism in the habitat in which it lives.

**Challenge**

7. Give an example of each of these types of adaptations:

(a) Anatomical

(b) Physiological

(c) Behavioural

Any suitable examples.

**3.2 Natural Selection in Action**

1. What is a selection pressure?

Pressure exerted by a changed environment or niche on individuals in a population.

2. What is industrial melanism?

Evolution of dark-coloured individuals in a habitat that has been made darker by industrial pollution.

3. What is directional selection?

Natural selection showing a shift/change from one dominant phenotype to another.

4. What is the gene pool?

All the alleles of all the genes in a population.

**Challenge**

5. Give an example of an adaptation that is selected for reproductive success.

Any suitable example of a trait that is used to attract a mate/improve likelihood of mating.

**The Evolutionary Race between Pathogens and Medicines**

1. What are antibiotics?

Drugs that kill bacteria or halt their growth.

2. What is drug resistance?

When the drug no longer has an effect.

3. What does MRSA stand for?

Methicillin-resistant *Staphylococcus aureus*

4. What are multi-resistant strains of bacteria?

Strains of bacteria that are resistant to many different antibiotics.

5. Which reaction does penicillinase catalyse?

Splitting of penicillin so it no longer works.

6. Why do doctors test for infections before prescribing antibiotics?

To determine if infection is bacterial and then which species so that correct narrow-spectrum antibiotic can be used.

**Challenge**

7. Give an example of a factor that contributes to the problem of antibiotic resistance.

Over prescription of antibiotics, use of wide-spectrum antibiotics, non-completion of courses of antibiotics, antibiotics in the food chain, lack of hygiene, no new antibiotics developed due to lack of financial incentive etc.

**Speciation**

1. What is speciation?

Formation of a new species.

2. What is hybridisation?

Offspring produced from individuals from two different species.

3. What is reproductive isolation?

When two parts of a population are separated and cannot interbreed.

4. What is allopatric speciation?

Speciation that takes place when populations are geographically isolated.

5. What is sympatric speciation?

Speciation that takes place when populations are located in the same place.

6. What is adaptive radiation?

One species evolves rapidly to form a number of different species, which all fill different ecological niches.

7. What is an endemic species?

A species that evolves in geographical isolation and is found in only one place.

**Challenge**

8. Give an example of each of the following isolating mechanisms.

(a) Geographical isolation

Any physical barrier

(b) Ecological isolation

Different niches within same habitat

(c) Seasonal isolation

Different timings of reproductive season

(d) Behaviour isolation

Changes affecting mating behaviour/attraction

(e) Mechanical isolation

Changes in genitalia/flowers so male & female parts are no longer compatible.

**The Importance of Biodiversity**

1. What is biodiversity?

The number of different species and the variation that exists within these species.

2. What is species richness?

The number of different species in an area.

3. What is a biodiversity hotspot?

An area of unusually high biodiversity and endemism.

4. What is an endemic species?

A species that is only found in one area.

5. What is relative species abundance?

The relative numbers of different species.

6. Write out the formula for measuring biodiversity. What do *N* and n stand for?

D = *N*(*N*-1) /∑n(n-1)

N = total number of organisms of all species, n = number of organisms of each individual species

7. Why is biodiversity not constant?

Natural disasters, changes in environmental conditions, seasons, migration etc.

**Challenge**

8. Why would we see higher levels of biodiversity in some areas?

Stable ecosystems which allow complex relationships to develop and areas which support high levels of growth/reproduction/productivity.

**Biodiversity Within a Species**

1. What is the allele frequency?

The relative frequency of a particular allele in a population.

2. What is selective breeding?

Artificial selection of individuals to breed based on their favoured characteristics. Offspring are selected with these favoured characteristics and the process is repeated for multiple generations.

3. How is the genetic diversity within a species measured?

Scientists study the different alleles within the gene pool of a species and calculate the number of individuals heterozygous for particular genes.

4. Why is it important to conserve populations with higher genetic diversity?

So that more alleles in the gene pool are also conserved and not lost. The more genetic variation that exists the higher the chances are that those populations can evolve if the environment changes.

**Challenge**

5. Why are endemic populations more vulnerable to the introduction of disease?

Endemic populations have low genetic diversity. So are less able to evolve through natural selection if the selection pressure of disease is introduced.

**Ecosystem Services**

1. Give two ethical arguments for the maintenance of biodiversity.

* Denying future generations possibility to use natural resources or enjoy natural world.
* Extinctions are unethical.

2. What are ecosystem services?

Services provided by the natural environment that are of benefit to people.

3. Give an example of a:

(a) provisioning service

e.g. food, materials for clothing/building, fuel, fresh water, medicines, genetic resources for crops.

(b) regulating service

e.g. water purification, sewage treatment, maintaining air quality, disease regulation, pest control, pollination, climate control.

(c) supporting service

e.g. soil formation, nutrient cycling.

(d) cultural service

e.g. use for human health and well-being, recreation, education, ecotourism.

**Challenge**

4. Give an example of a financial implication of loss of biodiversity.

* Natural disasters cost money to put right.
* Desertification, deforestation/soil loss mean loss of farming land.
* Reduced chances of finding new drugs, new genes for crops = less profit for companies.

**Ex-situ and In-situ Conservation**

1. What is conservation?

Keeping and protecting a living and changing environment.

2. What is ex-situ conservation?

Conservation that takes place outside of the natural habitat.

3. What is in-situ conservation?

Conservation that takes place in the natural habitat.

4. Describe how seeds are stored in seed banks.

A sample/large number of seeds from each species are frozen, dried and stored in a low humidity/sealed environment. Seeds are periodically checked for viability by germinating a sample of them.

5. Describe some limitations with captive breeding and reintroduction.

* Not enough space/resources.
* Difficult to provide conditions for breeding.
* Need to deal with reason for endangerment of species.
* Animals find it difficult to adjust to life in the wild.
* Gene pool is reduced in captive populations.
* Expensive and time consuming.

6. List some different in-situ conservation strategies.

* Habitat restoration and recovery.
* Strategies for sustainable use and management of biological resources in protected areas.
* Managed recovery programmes for threatened/endangered species.
* Monitoring of genetic diversity.
* Formulation and implementation of appropriate legislation (laws).

**Challenge**

7. Give an example of a sustainable method of land use.

Any suitable example of e.g. sustainable forestry/slash and burn farming, sustainable farming etc.