**Topic 3 Revision Questions**

**3.1 Principles of Classification**

1. What is biodiversity?

2. What is taxonomy?

3. What do classification systems aim to do?

4. Why are valid classification systems based on the use of homologous structures rather than analogous features?

5. List the main taxonomic groups in order of their hierarchy.

6. Describe some of the main features of each of the 6 kingdoms. (see page 167)

(a) Archaebacteria –

(b) Eubacteria –

(c) Protoctista –

(d) Fungi –

(e) Plantae –

(f) Animalia –

7. List the rules for writing binomial names.

**3.1 What is a Species?**

1. Explain why sexual dimorphism is a limitation of the morphological species concept.

2. What is the definition of a species based on the reproductive/biological species concept?

3. Describe two limitations of the biological species concept.

4. What is molecular phylogeny?

5. Describe what each species model is based on and a limitation for each one.

(a) Ecological species model –

(b) Mate-recognition species model –

(c) Genetic species model –

(d) Evolutionary species model –

**3.1 Identifying Individual Species**

1. What is DNA sequencing?

2. What is DNA profiling?

3. Explain the role of bioinformatics in classification.

4. Explain how DNA barcoding will support traditional taxonomy.

**3.1 New Evidence for Evolution**

1. Describe how comparison of DNA sequences can produce a ‘molecular clock’ to estimate how long ago a common ancestor lived.

2. What can the polymerase chain reaction do?

3. Explain how new evidence from DNA analysis could lead scientists to rethink their original ideas of evolutionary relationships based on morphology.

4. What is the role of the scientific community in validating new evidence?

**3.1 Domains, Kingdoms or Both?**

1. What is gel electrophoresis?

2. Which special enzymes are used to cut DNA into fragments at specific sequences?

3. Describe the theory of endosymbiosis.

4. What are some of the key differences between the Archaea and Bacteria domains?

**3.2 Evolution and Adaptation**

1. Describe the main ideas in Darwin’s theory of evolution by natural selection.

2. Describe the modern day theory of evolution by natural selection including the evidence that scientists now have to support Darwin’s theory.

3. What is a niche?

4. Can a number of different species occupy a single niche?

5. Define each of the following types of adaptations and give one example for each.

Anatomical adaptations –

Physiological adaptations –

Behavioural adaptations –

**3.2 Natural Selection in Action**

1. What is a selection pressure? Give an example.

2. Explain how industrial melanism has occurred in peppered moths.

3. Explain how natural selection operates on adaptations that increase reproductive success.

4. What is directional selection?

**3.2 The Evolutionary Race between Pathogens and Medicines**

1. What are pathogens?

2. What are antibiotics?

3. Explain how bacteria can become resistant to antibiotics.

4. Which factors have led to the development of multi-drug resistant strains of bacteria?

5. Outline some of the ways in which scientists hope to overcome the antibiotic resistance problem.

**3.2 Speciation**

1. What is speciation?

2. Explain how speciation occurs as a result of:

(a) reproductive isolation –

(b) hybridisation -

3. Explain how each of these reproductive isolating mechanisms prevents interbreeding and reduces gene flow between populations.

(a) Geographical isolation –

(b) Ecological isolation –

(c) Seasonal/temporal isolation –

(d) Behavioural isolation –

(e) Mechanical isolation –

4. Explain the difference between allopatric and sympatric speciation.

5. What is an endemic species?

6. What is adaptive radiation?

**3.3 The Importance of Biodiversity**

1. What is meant by biodiversity?

2. What is species richness?

3. What is relative species abundance?

4. Calculate the index of diversity for the area of woodland in Question 2 (p.148). 

5. Explain why in each of these cases we observe high levels of biodiversity:

(a) Very stable ecosystems –

(b) Areas where there are high levels of productivity/photosynthesis –

(c) Areas where organisms can grow and reproduce rapidly –

6. Which types of habitats are more vulnerable to loss of biodiversity?

7. Explain why it is important to assess biodiversity at different times.

**3.3 Biodiversity within a Species**

1. What is a gene pool?

2. What are mutations?

3. Explain how mutations can increase the gene pool of a population.

4. What is the allele frequency?

5. What is genetic diversity?

6. Explain why populations with low levels of genetic diversity are vulnerable.

7. How can genetic diversity in populations be measured?

8. Explain why endemic populations are very vulnerable to the introduction of disease.

**3.3 Ecosystem Services**

1. List some ethical reasons for maintaining biodiversity.

2. What are ecosystem services? Give examples.

**3.3 Ex-Situ and In-Situ Conservation**

1. What is conservation?

2. Explain the difference between ex-situ and in-situ conservation. Give examples.

3. How are seeds stored in seed banks?

4. Describe some of the issues associated with captive breeding programmes.

5. Explain why poachers are a problem.

6. Give examples of some threats to biodiversity.

7. What is sustainability?

**Topic 3 Revision Questions**

**3.1 Principles of Classification**

1. What is biodiversity?

A measure of the variety of living organisms and their genetic differences.

2. What is taxonomy?

The science of describing, classifying and naming living organisms.

3. What do classification systems aim to do?

Group organisms in a way that accurately identifies them and represents their ancestral relationships.

4. Why are valid classification systems based on the use of homologous structures rather than analogous features?

* Analogous features are features that look similar or have the same function, but are not in fact of the same biological origin.
* Homologous structures have common ancestry and must be used if the classification system is to represent the ancestral relationships.

5. List the main taxonomic groups in order of their hierarchy.

Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species.

6. Describe some of the main features of each of the 6 kingdoms. (see page 167)

(a) Archaebacteria – prokaryotic microorganisms, include extremophiles

(b) Eubacteria – prokaryotic microorganisms, include cyanobacteria

(c) Protoctista – microscopic unicelluar organisms, heterotrophs or autotrophs, asexually reproduce (mostly), contains green and brown algae and slime moulds

(d) Fungi – multicellular/unicellular, heterotrophs, mostly saprophytic, chitin cell walls, asexual/sexual reproduction

(e) Plantae – multicellular, autotrophs, cellulose cell walls, asexual/sexual reproduction

(f) Animalia – multicellular, heterotrophs, can move, sexual and some asexual reproduction

7. List the rules for writing binomial names.

* Two names – genus first then species.
* Use italics (or underline if handwritten).
* The genus name has an upper-case letter and the species name a lower-case letter
* After the first use, genus names abbreviated to the initial e.g. *H. sapiens* or *E. coli*.

**3.1 What is a Species?**

1. Explain why sexual dimorphism is a limitation of the morphological species concept.

Sexual dimorphism is when there are many differences between the male and female of the same species. The morphological species concept relies on classifying organisms as the same species based on their appearance/morphology. Therefore, a male and female of the same species may be misclassified as different species.

2. What is the definition of a species based on the reproductive/biological species concept?

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

3. Describe two limitations of the biological species concept.

* Two different species can sometimes interbreed to produce fertile offspring/hybrids.
* Populations of organisms of the same species may not interbreed because they are in different places.

4. What is molecular phylogeny?

The analysis of the genetic material (DNA/RNA) of organisms to establish their evolutionary relationships.

5. Describe what each species model is based on and a limitation for each one.

(a) Ecological species model – based on the ecological niche occupied. Limitation: Niche definitions vary, many species occupy more than one niche.

(b) Mate-recognition species model – based on unique fertilisation systems including mating behaviour. Limitation: Many species mate with or cross-pollinate other species. Asexual reproduction. Need to observe mating.

(c) Genetic species model – based on DNA evidence. Limitation: costly/can be difficult to obtain DNA e.g. fossils.

(d) Evolutionary species model – based on shared evolutionary relationships between species. Limitation: there is not always a clear evolutionary pathway for a particular organism.

**3.1 Identifying Individual Species**

1. What is DNA sequencing? A process by which the base sequences of all or part of the genome of an organism is worked out.

2. What is DNA profiling?

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

3. Explain the role of bioinformatics in classification.

It is the development of the software and computing tools needed to organise and analyse raw biological data, including the development of algorithms, mathematical models and statistical tests that help us to make sense of the enormous quantities of data being generated (from techniques such as DNA sequencing protein analysis and DNA profiling). This data is processed/analysed to help identify species and determine evolutionary relationships.

4. Explain how DNA barcoding will support traditional taxonomy.

Scientists are developing databases with comparative information on different species using DNA sequencing information from the same set of genes. They hope to produce a standard barcode for species identification.

**3.1 New Evidence for Evolution**

1. Describe how comparison of DNA sequences can produce a ‘molecular clock’ to estimate how long ago a common ancestor lived.

If the average rate of mutations is known/estimated then a comparison of the number of differences/mutations between two different species can be used to estimate how long ago a common ancestor lived.

2. What can the polymerase chain reaction do?

Amplifies/copies minute traces of DNA.

3. Explain how new evidence from DNA analysis could lead scientists to rethink their original ideas of evolutionary relationships based on morphology.

New DNA evidence may show relationships that were not obvious based on appearance/morphology and so show that some species are more closely related than originally thought.

4. What is the role of the scientific community in validating new evidence?

* The scientific community will peer review articles that are submitted for publication in scientific journals. Experts in the field of study will check if data and conclusions are reliable and valid before approving the article for publications.
* The scientific community will get together at scientific conferences/meetings to discuss ideas and review evidence face-to-face in order to exchange ideas and challenge the validity of results that are presented.

**3.1 Domains, Kingdoms or Both?**

1. What is gel electrophoresis?

A technique used to separate fragments of DNA, RNA or proteins/amino acids according to their size and electrical charge.

2. Which special enzymes are used to cut DNA into fragments at specific sequences?

Restriction endonucleases

3. Describe the theory of endosymbiosis.

It is thought that mitochondria and chloroplasts have evolved from prokaryotic organisms that started living within an ancestral eukaryotic cell.

4. What are some of the key differences between the Archaea and Bacteria domains?

* Replication in Archaea is similar to the cell cycle of eukaryotes.
* Membrane structure and membrane proteins of Archaea are unique.
* Very different biochemistry.
* Archaea include the extremophiles (survive in extreme conditions).

**3.2 Evolution and Adaptation**

1. Describe the main ideas in Darwin’s theory of evolution by natural selection.

* Variation – differences between organisms, particularly those that reproduce sexually.
* More offspring produced than survive to reproduce – results in competition/struggle for survival.
* Organisms that have adaptations/characteristics that give a survival advantage are more likely to survive and reproduce.
* Those advantageous adaptations/characteristics are therefore more likely to be inherited by offspring.
* Long-term changes in organisms that occur as a result of natural selection is evolution, can produce new species.

2. Describe the modern day theory of evolution by natural selection including the evidence that scientists now have to support Darwin’s theory.

* More evidence/understanding of genetics, genomics, molecular biology, ecology and palaeontology.
* Includes understanding of variation due to different alleles (gene variants) that are inherited.
* Individuals with adaptations have advantageous alleles that are more likely to be passed onto offspring
* Different genotypes (combinations of alleles) can lead to different phenotypes (characteristics).
* Natural selection leads to changes in frequencies of alleles in populations over time.
* Natural selection is driven by selection pressures – changes in the environment of an organism.

3. What is a niche?

The role of an organism within the habitat in which it lives.

4. Can a number of different species occupy a single niche?

No, one species per unique niche only.

5. Define each of the following types of adaptations and give one example for each.

Anatomical adaptations – form and structure of an organism. Any appropriate example.

Physiological adaptations – the way the body of the organism works. Any appropriate example.

Behavioural adaptations – changes to programmed or instinctive behaviour to make organisms better adapted for survival. Any appropriate example.

**3.2 Natural Selection in Action**

1. What is a selection pressure? Give an example.

Pressure exerted by a changed environment or niche on individuals in a population, causing changes in the population as a result of natural selection. Any appropriate example e.g. exposure to antibiotics.

2. Explain how industrial melanism has occurred in peppered moths.

Natural selection (directional selection) has led to the evolution of dark-coloured individuals in habitats that have been made darker by industrial pollution, e.g. soot. The selection pressure is the change in the environment, i.e. soot or absence of lichen – a darker background, so darker moths are more camouflaged and therefore have a selective advantage over lighter forms. Darker moths are more likely to survive, reproduce and pass on their alleles. Therefore, the allele frequency for the melanic form has increased within the gene pool of the population of moths and the frequency of darker moth phenotypes has also increased.

3. Explain how natural selection operates on adaptations that increase reproductive success.

Individuals that have adaptations that increase their reproductive success are more likely to reproduce and pass on their alleles that confer this advantage. Therefore, the allele frequencies for these adaptations increase in the gene pools of these populations and there will be a higher proportion of individuals within the population over time which have those adaptations that increase reproductive success.

4. What is directional selection?

Natural selection showing a change from one dominant phenotype to another in response to a change in the environment – one phenotype is selected for over all the others.

**3.2 The Evolutionary Race between Pathogens and Medicines**

1. What are pathogens?

Disease-causing organisms.

2. What are antibiotics?

Drugs/medicines that kill bacteria or prevent their reproduction by targeting features of bacterial cells that differ from those of eukaryotic cells, including the bacterial cell walls and the 70S ribosomes.

3. Explain how bacteria can become resistant to antibiotics.

The antibiotic is the selective pressure. There is variation in populations of bacteria due to mutations arising. Individual bacteria which survive the antibiotics have alleles which give a selective advantage. These bacteria survive, reproduce (binary fission) and pass on their antibiotic-resistance alleles. Other bacteria without these alleles do not survive exposure to antibiotics. Therefore, the allele frequency for resistance increases in the population.

4. Which factors have led to the development of multi-drug resistant strains of bacteria?

* Overuse of antibiotics.
* Wide-spectrum antibiotic use.
* Patients not completing courses of treatment.
* Use of antibiotics in agriculture.
* Lack of hygiene.
* Fewer new drugs being developed.

5. Outline some of the ways in which scientists hope to overcome the antibiotic resistance problem.

* Reduce antibiotic use.
* Education.
* Targeted/personalised medicines.
* New drugs produced using molecular biology/new research.
* Inspiration from natural world to find new drugs e.g. plant-based antimicrobial chemicals.

**3.2 Speciation**

1. What is speciation?

Formation of a new species.

2. Explain how speciation occurs as a result of:

(a) reproductive isolation – parts of a population become isolated and can experience different selective pressures so natural selection acts on both populations differently. Gene flow is restricted if the populations are reproductively isolated. If the two populations accumulate many differences over time so they could no longer interbreed to produce fertile offspring, they have become new species.

(b) hybridisation - fertile hybrids can be produced as a result of breeding between two different species. These hybrids will no longer successfully reproduce with parent plants to produce fertile offspring so are considered to be a new species of their own.

3. Explain how each of these reproductive isolating mechanisms prevents interbreeding and reduces gene flow between populations.

(a) Geographical isolation – physical barrier separating individuals.

(b) Ecological isolation – individuals have different preferences & occupy different regions within habitats.

(c) Seasonal/temporal isolation – breeding seasons differ.

(d) Behavioural isolation – mating rituals differ/mate recognition changes.

(e) Mechanical isolation – physical changes that prevent successful mating/pollination.

4. Explain the difference between allopatric and sympatric speciation.

Allopatric – speciation that takes place when populations are physically or geographically separated and there can be no interbreeding or gene flow between the populations.

Sympatric – speciation that takes place between populations of a species living in the same place. They become reproductively isolated by mechanical, behavioural or seasonal mechanisms and gene flow continues between the populations to some extent as speciation takes place.

5. What is an endemic species?

When a species evolves in geographical isolation and is found in only one place.

6. What is adaptive radiation?

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

**3.3 The Importance of Biodiversity**

1. What is meant by biodiversity?

Measure of the variety of living organisms and their genetic differences.

2. What is species richness?

The number of different species in an area.

3. What is relative species abundance?

Relative numbers of species in an area.

4. Calculate the index of diversity for the area of woodland in Question 2 (p.148).

 

5. Explain why in each of these cases we observe high levels of biodiversity:

(a) Very stable ecosystems – allows many complex relationships to develop between species.

(b) Areas where there are high levels of productivity/photosynthesis – can support more niches.

(c) Areas where organisms can grow and reproduce rapidly – more likely that more mutations occur, leading to adaptations that allow organisms to exploit more niches.

6. Which types of habitats are more vulnerable to loss of biodiversity?

Extreme environments and small isolated ecosystems (e.g. islands, coral reefs, bogs and wetlands).

7. Explain why it is important to assess biodiversity at different times.

Biodiversity can vary throughout the year (seasons) or even throughout the day.

**3.3 Biodiversity within a Species**

1. What is a gene pool?

All alleles of all of the genes in the genome in a population.

2. What are mutations?

Changes in the DNA structure/sequence.

3. Explain how mutations can increase the gene pool of a population.

By increasing the number of different alleles available.

4. What is the allele frequency?

The relative frequency of a particular allele in a population.

5. What is genetic diversity?

A measure of the level of difference in the genetic make-up of a population.

6. Explain why populations with low levels of genetic diversity are vulnerable.

They do not have the variety of alleles in the gene pool that could be selected for if there is environmental change / selective pressures. These populations cannot evolve easily.

7. How can genetic diversity in populations be measured?

By analysing DNA sequences/protein sequences and comparing regions to look for similarities/differences.

8. Explain why endemic populations are very vulnerable to the introduction of disease.

They often evolve from a small group of founder organisms and although through adaptive radiation the species richness is high, they often have relatively low genetic diversity.

**3.3 Ecosystem Services**

1. List some ethical reasons for maintaining biodiversity.

* So future generations can use the renewable natural resources.
* Natural world is a source of pleasure/ for well-being.
* Avoid extinctions.

2. What are ecosystem services? Give examples.

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

* Resources – fuel, building materials, genetic resources for development of crops/medicines, fresh water and medicines.
* Maintain and regulate environment – water purification/sewage treatment, maintaining air quality, maintaining climate, disease regulation, pest control and pollination.
* Supporting – soil formation, nutrient cycling.
* Cultural – human health/well-being, recreation, education, ecotourism.

**3.3 Ex-Situ and In-Situ Conservation**

1. What is conservation?

Refers to maintaining and protecting a living and changing environment.

2. Explain the difference between ex-situ and in-situ conservation. Give examples.

Ex-situ conservation takes place outside of their natural habitat (e.g. zoos or seed banks) and in-situ conservation takes place in the natural habitat of the organism (e.g. creating National Parks).

3. How are seeds stored in seed banks?

Checked using X-rays to determine viability of embryo. Large numbers of viable seed samples stored in dry, cold conditions.

4. Describe some of the issues associated with captive breeding programmes.

* Difficult to provide right conditions for breeding.
* Reintroduction programmes are expensive and time-consuming. Not always successful.
* Reintroduction is difficult for animals bred in captivity - they have problems adjusting to life in the wild.
* Original reason for species becoming endangered must be identified and addressed before reintroduction into the wild.
* Genetic diversity of small captivity bred populations can be low. Zoos maintain stud books (detailed breeding records) and swap animals or sperm (for artificial insemination) with other zoos.

5. Explain why poachers are a problem.

Poachers are people who kill protected species to make money from the animal products. Illegal in protected National Parks/Nature Reserves. Difficult to conserve species in-situ if they are being hunted and needs to be addressed before reintroducing any captivity bred animals.

6. Give examples of some threats to biodiversity.

* Invasion of alien species – could outcompete native species.
* Overexploitation of a resource e.g. overfishing.
* Climate change.
* Poaching/illegal trade in products from wildlife.
* Deforestation etc.

7. What is sustainability?

Methods for maintaining biodiversity and minimising damage to the environment whilst allowing people to use land/resources/ecosystem services.