SCQF level 7
Unit Specification

Biology: Organisms and Evolution

SCQF: level 7 (8 SCQF credit points)

Unit code: J72V 77

Unit outline

The general aim of this Unit is to develop skills of scientific inquiry, investigation, and analytical thinking, along with knowledge and understanding of organisms and evolution. Learners will use these skills when considering how applications of our understanding of organisms and evolution can impact our lives, the environment, and society. Learners can develop and apply these skills through a variety of approaches, including investigating and problem solving.

The Unit covers the key areas of: field techniques for biologists; evolution; variation and sexual reproduction; sex and behaviour; and parasitism. Learners will research issues, apply scientific skills, and communicate information related to their findings, which will develop skills of scientific literacy.

Learners who complete this Unit will be able to:

1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment or practical investigation
2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills

This Unit is a free-standing Unit. The Unit Support Notes in the Appendix provide advice and guidance on delivery, assessment approaches and development of skills for learning, skills for life and skills for work. Exemplification of the standards in this Unit is given in Unit Assessment Support.

Recommended entry

Entry to this Unit is at the discretion of the centre. However, learners would normally be expected to have attained the skills, knowledge and understanding required by one or more of the following or equivalent qualifications and/or experience:

- Higher Biology or Higher Human Biology Course or relevant Units

Equality and inclusion

This Unit Specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. For further information, please refer to the Appendix: Unit Support Notes.

Standards

Outcomes and Assessment Standards

Outcome 1

The learner will:

1 Apply skills of scientific inquiry and draw on knowledge and understanding of the key areas of this Unit to carry out an experiment or practical investigation by:

1.1 Planning and designing an experiment or practical investigation
1.2 Following procedures safely
1.3 Making and recording observations and measurements correctly
1.4 Analysing and presenting the results in an appropriate format
1.5 Drawing valid conclusions and giving explanations supported by evidence
1.6 Evaluating experimental procedures with justification

Outcome 2

The learner will:

2 Draw on knowledge and understanding of the key areas of this Unit and apply scientific skills by:

2.1 Making accurate statements and giving clear descriptions or explanations
2.2 Solving problems

Evidence Requirements for the Unit

Assessors should use their professional judgement, subject knowledge and experience, and understanding of their learners, to determine the most appropriate ways to generate evidence and the conditions and contexts in which they are used.

The key areas covered in this Unit are field techniques for biologists; evolution; variation and sexual reproduction; sex and behaviour; and parasitism.

The following table describes the evidence for the Assessment Standards. Exemplification of assessment is provided in Unit Assessment Support.

Assessment Standard	Evidence required
1.1 Planning and designing an experiment or practical investigation	The plan and design must include: ♦ a clear statement of the aim ♦ a hypothesis ♦ a dependent and independent variable ♦ variables to be kept constant ♦ measurements and observations to be made ♦ the equipment and materials ♦ a clear and detailed description of how the experiment or practical investigation should be carried out, including safety considerations
1.2 Following procedures safely	The learner must follow procedures safely.
1.3 Making and recording observations and measurements correctly	The learner must: ♦ make appropriate observations and measurements and repeat these, as appropriate ♦ record observations and measurements in an appropriate format
1.4 Analysing and presenting the results in an appropriate format	The learner must: ♦ analyse the results, process (including averages where appropriate) **and** present them in an appropriate format from: table, bar graph, line graph, chart, key, diagram, flow chart, summary, or other appropriate format

<table>
<tr><th>Assessment Standard</th><th>Evidence required</th></tr>
<tr><td>1.5
Drawing valid conclusions and giving explanations supported by evidence</td><td>Conclusions must refer to the aim of the experiment or practical investigation and be supported by the results.

If results are inconclusive and the learner refers to evidence and the aim, to say that no conclusion can be drawn, then this would be valid and sufficient.</td></tr>
<tr><td>1.6
Evaluating experimental procedures with justification</td><td>The learner must:

♦ support their evaluation with justification(s)
♦ provide at least two possible improvements for the experiment or practical investigation</td></tr>
<tr><td>2.1
Making accurate statements and giving clear descriptions or explanations

and

2.2
Solving problems</td><td>Achieve at least 50% of the total marks available in a holistic assessment.

A holistic assessment must include:

♦ an appropriate number of opportunities for the learner to make accurate statements for each key area of the Unit
♦ at least one opportunity for the learner to demonstrate each of the following problem-solving skills:
— making generalisations and predictions
— processing information
— analysing information</td></tr>
</table>

Assessment standards thresholds

Outcome 1

To pass Outcome 1, learners must achieve five out of the six Assessment Standards. This threshold reduces the volume of re-assessment, if it is required.

Assessors must give learners the opportunity to meet all Assessment Standards.

Transfer of evidence

Evidence for Outcome 1 in this Unit can be used as evidence for Outcome 1 in the SCQF level 7 Unit: Biology: Cells and Proteins (J72Y 77).

Evidence for the SCQF level 7 Unit: Investigative Biology (J730 77) can be used as evidence for Outcome 1 in this Unit. There is no requirement to match Assessment Standards.

Re-assessment

Learners can re-draft their original Outcome 1 report or carry out a new experiment or practical investigation.

Outcome 2

Assessment Standards 2.1 and 2.2 are assessed holistically. To pass Outcome 2, learners must achieve 50% or more of the marks available in the holistic assessment.

Re-assessment

SQA's guidance on re-assessment is there should only be one or, in exceptional circumstances, two re-assessment opportunities. Re-assessment should be carried out under the same conditions as the original assessment. It is at the teacher or lecturer's discretion how they re-assess their learners.

Learners must have a full re-assessment opportunity (a holistic assessment). To achieve Outcome 2, learners must achieve 50% of the total marks available in the re-assessment.

Development of skills for learning, skills for life and skills for work

It is expected that learners will develop broad, generic skills through this Unit. The skills that learners will be expected to improve on and develop through the Unit are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and drawn from the main skills areas listed below. These must be built into the Unit where there are appropriate opportunities.

1 Literacy

1.1 Reading
1.2 Writing

2 Numeracy

2.1 Number processes
2.2 Money, time and measurement
2.3 Information handling

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating
5.5 Creating

Amplification of these is given in SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work. The level of these skills should be at the same SCQF level as the Unit and be consistent with the SCQF level descriptor. Further information on building in skills for learning, skills for life and skills for work is given in the Appendix: Unit Support Notes.

Appendix: Unit Support Notes

Introduction

These support notes are not mandatory. They provide advice and guidance on approaches to delivering and assessing this Unit. They are intended for teachers and lecturers who are delivering this Unit. They should be read in conjunction with:

- Unit Assessment Support

Developing skills, knowledge and understanding

Teachers and lecturers are free to select the skills, knowledge, understanding and contexts that are most appropriate for delivery in their centres.

Approaches to learning and teaching

Key area	Depth of knowledge required	Suggested learning activities
1 Field techniques for biologists (a) Health and safety Aspects of fieldwork can present a hazard	Hazards in fieldwork include adverse weather conditions, difficult terrain, problems associated with isolation, and contact with harmful organisms.	Discuss standard rules for fieldwork safety.
Hazard, risk, and control of risk by risk assessment	Risk is the likelihood of harm arising from exposure to a hazard. Risk assessment involves identifying control measures to minimise risk. Control measures include appropriate equipment, clothing, footwear, and means of communication.	

Key area	Depth of knowledge required	Suggested learning activities
(b) Sampling of wild organisms Sampling should be carried out in a manner that minimises impact on wild species and habitats Consideration must be given to rare and vulnerable species and habitats that are protected by legislation The chosen technique, point count, transect or remote detection must be appropriate to the species being sampled Quadrats, of suitable size and shape, or transects are used for plants and other sessile or slow-moving organisms Capture techniques, such as traps and nets, are used for mobile species Elusive species can be sampled directly using camera traps or an indirect method, such as scat sampling	A point count involves the observer recording all individuals seen from a fixed point count location. This can be compared to other point count locations or with data from the same location gathered at other times.	Participate in fieldwork, using a variety of techniques. Research protected species in Scotland.

Key area	Depth of knowledge required	Suggested learning activities
(c) Identification and taxonomy Identification of an organism in a sample can be made using classification guides, biological keys, or analysis of DNA or protein Organisms can be classified by both taxonomy and phylogenetics		In the context of fieldwork, sample organisms from a variety of habitats and attempt to classify and catalogue them using keys, guides, and other materials.
Taxonomy involves the identification and naming of organisms and their classification into groups based on shared characteristics	Classic taxonomy classification is based on morphology.	Research the taxonomic groups. Visit a botanic garden to learn more about the major divisions of plants. Visit a zoological park to learn more about the animal phyla.
Phylogenetics is the study of the evolutionary history and relationships among individuals or groups of organisms Phylogenetics is changing the traditional classification of many organisms	Phylogenetics uses heritable traits such as morphology, DNA sequences, and protein structure to make inferences about an organism's evolutionary history and create a phylogeny (or phylogenetic tree) — a diagrammatic hypothesis of its relationships to other organisms. Genetic evidence can reveal relatedness obscured by divergent or convergent evolution.	Read excerpts from Bryan Sykes's book, *The Seven Daughters of Eve*. [Sykes B. (2001), *The Seven Daughters of Eve*, New York: W. W. Norton & Company] Research the evolution of the pentadactyl limb.

Key area	Depth of knowledge required	Suggested learning activities
Familiarity with taxonomic groupings allows predictions and inferences to be made about the biology of an organism from better-known (model) organisms	Nematodes, arthropods and chordates are examples of taxonomic groups.	
Model organisms are those that are either easily studied or have been well studied	Model organisms, such as the bacterium *E. coli*; the flowering plant *Arabidopsis thaliana*; the nematode *C. elegans*; the arthropod *Drosophila melanogaster* (a fruit fly); mice, rats, and zebrafish, which are all chordates, have been very important in the advancement of modern biology.	
Information obtained from them can be applied to other species that are more difficult to study directly		

Key area	Depth of knowledge required	Suggested learning activities
(d) Monitoring populations Presence, absence or abundance of indicator species can give information of environmental qualities, such as presence of a pollutant		Identify relevant indicator species to classify a habitat, using the British National Vegetation Classification.
Susceptible and favoured species can be used to monitor an ecosystem	Absence or reduced population indicates a species is susceptible to some factor in the environment. Abundance or increased population indicates it is favoured by the conditions.	
Procedure for the mark and recapture technique as a method for estimating population size using the formula $N=\frac{MC}{R}$	A sample of the population is captured and marked (M) and released. After an interval of time, a second sample is captured (C). If some of the individuals in this second sample are recaptured (R), then the total population $N=\frac{MC}{R}$ This method assumes that all individuals have an equal chance of capture, that there is no immigration or emigration, and that individuals that are marked and released can mix fully and randomly with the total population.	Carry out a mark and recapture experiment using a wild species. Carry out a mark and recapture simulation in the laboratory.

Key area	Depth of knowledge required	Suggested learning activities
Methods of marking animals such as: banding, tagging, surgical implantation, painting and hair clipping The method of marking and subsequent observation must minimise the impact on the study species		

Key area	Depth of knowledge required	Suggested learning activities
(e) Measuring and recording animal behaviour Some of the measurements used to quantify animal behaviour are latency, frequency and duration	Latency is the time between the stimulus occurring and the response behaviour. Frequency is the number of times a behaviour occurs within the observation period. Duration is the length of time each behaviour occurs during the observation period.	
An ethogram of the behaviours shown by a species in a wild context allows the construction of time budgets	An ethogram lists species-specific behaviours to be observed and recorded in the study. Recording the duration of each of the behaviours in the ethogram, together with the total time of observation, allows the proportion of time spent on each behaviour to be calculated in the time budget.	Use an ethogram and time sampling to compare the behaviour of different individuals of a species.
The importance of avoiding anthropomorphism when analysing behaviour	Anthropomorphism can lead to invalid conclusions.	

Key area	Depth of knowledge required	Suggested learning activities
2 Evolution (a) Drift and selection Evolution is the change over time in the proportion of individuals in a population differing in one or more inherited traits During evolution, changes in allele frequency occur through the non-random processes of natural selection and sexual selection, and the random process of genetic drift		
Natural selection acts on genetic variation in populations	Variation in traits arises as a result of mutation. Mutation is the original source of new sequences of DNA. These new sequences can be novel alleles. Most mutations are harmful or neutral, but in rare cases they may be beneficial to the fitness of an individual.	
Populations produce more offspring than the environment can support		
Individuals with variations that are better suited to their environment tend to survive longer and produce more offspring, breeding to pass on those alleles that conferred an advantage to the next generation	Selection results in the non-random increase in the frequency of advantageous alleles and the non-random decrease in the frequency of deleterious alleles.	

Key area	Depth of knowledge required	Suggested learning activities
Sexual selection is the non-random process involving the selection of alleles that increase the individual's chances of mating and producing offspring		
Sexual selection may lead to sexual dimorphism		
Sexual selection can be due to male-male rivalry and female choice	Male-male rivalry: large size or weaponry increases access to females through conflict. Female choice involves females assessing the fitness of males.	
Genetic drift occurs when chance events cause unpredictable fluctuations in allele frequencies from one generation to the next		
Genetic drift is more important in small populations, as alleles are more likely to be lost from the gene pool		

Key area	Depth of knowledge required	Suggested learning activities
The importance of bottleneck and founder effects on genetic drift	Population bottlenecks occur when a population size is reduced for at least one generation. Founder effects occur through the isolation of a few members of a population from a larger population. The gene pool of the new population is not representative of that in the original gene pool.	
A gene pool is altered by genetic drift because certain alleles may be under-represented or over-represented and allele frequencies change		
Where selection pressures are strong, the rate of evolution can be rapid	Selection pressures are the environmental factors that influence which individuals in a population pass on their alleles. They can be biotic: competition, predation, disease, parasitism; or abiotic: changes in temperature, light, humidity, pH, salinity.	Study cladograms of MRSA and primate evolution to compare the effect of generation time on rates of evolution.
The Hardy-Weinberg (HW) principle states that, in the absence of evolutionary influences, allele and genotype frequencies in a population will remain constant over the generations	The conditions for maintaining the HW equilibrium are: no natural selection, random mating, no mutation, large population size and no gene flow (through migration, in or out).	

Key area	Depth of knowledge required	Suggested learning activities
The HW principle can be used to determine whether a change in allele frequency is occurring in a population over time Changes suggest evolution is occurring	Use the HW principle to calculate allele, genotype and phenotype frequencies in populations. $p^2 + 2pq + q^2 = 1$ p = frequency of dominant allele q = frequency of recessive allele p^2 = frequency of homozygous dominant genotype $2pq$ = frequency of heterozygous genotype q^2 = frequency of homozygous recessive genotype	Research the application of the HW principle in medical research.

Key area	Depth of knowledge required	Suggested learning activities
(b) Fitness Fitness is an indication of an individual's ability to be successful at surviving and reproducing	Fitness is a measure of the tendency of some organisms to produce more surviving offspring than competing members of the same species.	
It refers to the contribution made to the gene pool of the next generation by individual genotypes		
Fitness can be defined in absolute or relative terms		
Absolute fitness is the ratio between the frequency of individuals of a particular genotype after selection, to those before selection	$\frac{\text{frequency of a particular genotype after selection}}{\text{frequency of a particular genotype before selection}}$ If the absolute fitness is 1, then the frequency of that genotype is stable. A value greater than 1 conveys an increase in the genotype and a value less than 1 conveys a decrease.	
Relative fitness is the ratio of the number of surviving offspring per individual of a particular genotype to the number of surviving offspring per individual of the most successful genotype	$\frac{\text{number of surviving offspring per individual of a particular genotype}}{\text{number of surviving offspring per individual of the most successful genotype}}$	

Key area	Depth of knowledge required	Suggested learning activities
(c) Co-evolution Co-evolution is the process by which two or more species evolve in response to selection pressures imposed by each other A change in the traits of one species acts as a selection pressure on the other species		
Co-evolution is frequently seen in pairs of species that have symbiotic interactions The impacts of these relationships can be positive (+), negative (-) or neutral (0) for the individuals involved	Symbiosis: co-evolved intimate relationships between members of two different species.	Research examples of co-evolved symbiotic relationships.
Mutualism, commensalism, and parasitism are types of symbiotic interactions	Mutualism: both organisms in the interaction are interdependent on each other for resources or other services. As both organisms gain from the relationship, the interaction is (+/+). Commensalism: only one of the organisms benefits (+/0). Parasitism: the parasite benefits in terms of energy or nutrients and the host is harmed as the result of the loss of these resources (+/-).	

Key area	Depth of knowledge required	Suggested learning activities
The Red Queen hypothesis states that, in a co-evolutionary relationship, change in the traits of one species can act as a selection pressure on the other species This means that species in these relationships must adapt to avoid extinction		Read excerpts from Matt Ridley's book, *The Red Queen: Sex and the Evolution of Human Nature*. [Ridley M. (2003), *The Red Queen: Sex and the Evolution of Human Nature*, London: Harper Perennial]

Key area	Depth of knowledge required	Suggested learning activities
3 Variation and sexual reproduction (a) Costs and benefits of sexual and asexual reproduction Costs of sexual reproduction: males unable to produce offspring; only half of each parent’s genome passed onto offspring, disrupting successful parental genomes Benefits outweigh costs due to an increase in genetic variation in the population Genetic variation provides the raw material required for adaptation, giving sexually reproducing organisms a better chance of survival under changing selection pressures The Red Queen hypothesis to explain the persistence of sexual reproduction		Research how the evolutionary importance of sexual reproduction influences experimental design in the life sciences. The natural variation generated means that biologists have to take care when sampling a population and analysing data to make sure that they can distinguish this ‘noise’ from any experimental result or ‘signal’. Investigate the paradox of the existence of males.

Key area	Depth of knowledge required	Suggested learning activities
Co-evolutionary interactions between parasites and hosts may select for sexually reproducing hosts If hosts reproduce sexually, the genetic variability in their offspring reduces the chances that all will be susceptible to infection by parasites Asexual reproduction can be a successful reproductive strategy as whole genomes are passed on from parent to offspring Maintaining the genome of the parent is an advantage particularly in very narrow, stable niches or when re-colonising disturbed habitats Vegetative cloning in plants and parthenogenesis in lower plants and animals that lack fertilisation are examples of asexual reproduction in eukaryotes Offspring can be reproduced more often and in larger numbers with asexual reproduction	Hosts better able to resist and tolerate parasitism have greater fitness. Parasites better able to feed, reproduce and find new hosts have greater fitness. In asexual reproduction, just one parent can produce daughter cells and establish a colony of virtually unlimited size over time. Parthenogenesis is reproduction from a female gamete without fertilisation.	

Key area	Depth of knowledge required	Suggested learning activities
Parthenogenesis is more common in cooler climates, which are disadvantageous to parasites, or regions of low parasite density or diversity Asexually reproducing populations are not able to adapt easily to changes in their environment, but mutations can occur that provide some degree of variation and enable some natural selection and evolution to occur		Examine reproduction in a parthenogenic organism, such as the laboratory stick insect *Carausius morosus* (in which offspring are female), and compare with the Komodo dragon (in which offspring are male).
Organisms that reproduce principally by asexual reproduction also often have mechanisms for horizontal gene transfer between individuals to increase variation, for example the plasmids of bacteria and yeasts	Prokaryotes can exchange genetic material horizontally, resulting in faster evolutionary change than in organisms that only use vertical transfer. Mechanisms of horizontal gene transfer are not required.	

Key area	Depth of knowledge required	Suggested learning activities
(b) Meiosis	Names of stages are not required.	Use microscopy to examine gamete formation or gametes in plants or invertebrates.
Meiosis is the division of the nucleus that results in the formation of haploid gametes from a diploid gametocyte		
In diploid cells, chromosomes typically appear as homologous pairs	Homologous chromosomes are chromosomes of the same size, same centromere position and with the same sequence of genes at the same loci.	
Meiosis I The chromosomes, which have replicated prior to meiosis I, each consist of two genetically identical chromatids attached at the centromere		
The chromosomes condense and the homologous chromosomes pair up		
Chiasmata form at points of contact between the non-sister chromatids of a homologous pair and sections of DNA are exchanged	Linked genes are those on the same chromosome. Crossing over can result in new combinations of the alleles of these genes.	

Key area	Depth of knowledge required	Suggested learning activities
This crossing over of DNA is random and produces genetically different recombinant chromosomes		
Spindle fibres attach to the homologous pairs and line them up at the equator of the spindle		
The orientation of the pairs of homologous chromosomes at the equator is random	Each pair of homologous chromosomes is positioned independently of the other pairs, irrespective of their maternal and paternal origin. This is known as independent assortment.	Breed model organisms in the laboratory (for example *Drosophila* or rapid-cycling *Brassica*) to demonstrate independent assortment or, if possible, recombination.
The chromosomes of each homologous pair are separated and move towards opposite poles		
Cytokinesis occurs and two daughter cells form		
Meiosis II Each of the two cells produced in meiosis I undergoes a further division during which the sister chromatids of each chromosome are separated	A total of four haploid cells are produced.	

Key area	Depth of knowledge required	Suggested learning activities
(c) Sex determination The sex of birds, mammals and some insects is determined by the presence of sex chromosomes In most mammals the SRY gene on the Y chromosome determines development of male characteristics Heterogametic (XY) males lack most of the corresponding homologous alleles on the shorter (Y) chromosome This can result in sex-linked patterns of inheritance as seen with carrier females (X^BX^b) and affected males (X^bY) In homogametic females (XX) one of the two X chromosomes present in each cell is randomly inactivated at an early stage of development X chromosome inactivation prevents a double dose of gene products, which could be harmful to cells	X chromosome inactivation is a process by which most of one X chromosome is inactivated.	Examine data on sex determination in a variety of organisms. Use *Drosophila* to investigate sex-linked inheritance patterns. Examine data on inheritance patterns of tortoiseshell cats. Research X-linked agammaglobulinemia and colour vision defect.

Key area	Depth of knowledge required	Suggested learning activities
Carriers are less likely to be affected by any deleterious mutations on these X chromosomes As the X chromosome inactivated in each cell is random, half of the cells in any tissue will have a working copy of the gene in question Hermaphrodites are species that have functioning male and female reproductive organs in each individual They produce both male and female gametes and usually have a partner with which to exchange gametes The benefit to the individual organism is that if the chance of encountering a partner is an uncommon event, there is no requirement for that partner to be of the opposite sex For other species, environmental rather than genetic factors determine sex and sex ratio	 Environmental sex determination in reptiles is controlled by environmental temperature of egg incubation.	 Compare the flowers of hermaphroditic and unisexual plants.

Key area	Depth of knowledge required	Suggested learning activities
Sex can change within individuals of some species as a result of size, competition, or parasitic infection In some species the sex ratio of offspring can be adjusted in response to resource availability		

Key area	Depth of knowledge required	Suggested learning activities
4 Sex and behaviour (a) Parental investment Comparison of sperm and egg production in relation to number and energy store		
Greater investment by females	Female investment in the egg structure in non-mammals or in the uterus and during gestation in mammals.	
Parental investment is costly but increases the probability of production and survival of young		
Classification of r-selected (r-strategists) and K-selected (K-strategists) organisms based on level of parental investment in offspring and number of offspring produced	Characteristics of r-selected species: smaller; have a shorter generation time; mature more rapidly; reproduce earlier in their lifetime, often only once; produce a larger number of smaller offspring, each of which receives only a smaller energy input; limited parental care; most offspring will not reach adulthood. Characteristics of K-selected species: larger and live longer; mature more slowly; can reproduce many times in their lifetime; produce relatively few, larger offspring; high level of parental care; many offspring have a high probability of surviving to adulthood.	

Key area	Depth of knowledge required	Suggested learning activities
r-selection tends to occur in unstable environments where the species has not reached its reproductive capacity, whereas K-selection tends to occur in stable environments		
Comparison of costs and benefits of external and internal fertilisation	External fertilisation ♦ benefits: very large numbers of offspring can be produced ♦ costs: many gametes predated or not fertilised; no or limited parental care; few offspring survive Internal fertilisation ♦ benefits: increased chance of successful fertilisation; fewer eggs needed; offspring can be retained internally for protection and/or development; higher offspring survival rate ♦ costs: a mate must be located, which requires energy expenditure; requires direct transfer of gametes from one partner to another	

Key area	Depth of knowledge required	Suggested learning activities
(b) Reproductive behaviours and mating systems in animals Mating systems are based on how many mates an individual has during one breeding season		
These range from polygamy (polygyny and polyandry) to monogamy	Monogamy: the mating of a pair of animals to the exclusion of all others. Polygamy: individuals of one sex have more than one mate. Polygyny: one male mates exclusively with a group of females. Polyandry: one female mates with a number of males in the same breeding season.	
Many animals have mate-selection courtship rituals		Courtship in the field: create an ethogram observing the ritualised courtship displays of water birds, such as grebes or ducks.
Successful courtship behaviour in birds and fish can be a result of species-specific sign stimuli and fixed action pattern responses		

Key area	Depth of knowledge required	Suggested learning activities
Sexual selection selects for characteristics that have little survival benefit for the individual, but increase their chances of mating		Courtship in the laboratory: observe stickleback or *Drosophila* courtship; investigate sexual selection in different *Drosophila* varieties.
Many species exhibit sexual dimorphism as a product of sexual selection	Females are generally inconspicuous; males usually have more conspicuous markings, structures and behaviours.	
Reversed sexual dimorphism occurs in some species		
Female choice involves females assessing honest signals of the fitness of males	Honest signals can indicate favourable alleles that increase the chances of survival of offspring (fitness) or a low parasite burden suggesting a healthy individual.	Research honest signalling in lekking species.
In lekking species, males gather to display at a lek, where female choice occurs	Some bird species exhibit lekking behaviour. Dominant males occupy the centre of the lek, with subordinates and juveniles at the fringes as 'satellite' males. During the display, female choice occurs.	
Success in male-male rivalry through conflict (real or ritualised), increases access to females for mating	Males will fight for dominance and access to females, often using elaborate 'weapons' such as antlers, tusks, horns.	

Key area	Depth of knowledge required	Suggested learning activities
5 Parasitism (a) (i) Niche An ecological niche is a multi-dimensional summary of tolerances and requirements of a species A species has a fundamental niche that it occupies in the absence of any interspecific competition A realised niche is occupied in response to interspecific competition As a result of interspecific competition, competitive exclusion can occur, where the niches of two species are so similar that one declines to local extinction Where the realised niches are sufficiently different, potential competitors can co-exist by resource partitioning		

Key area	Depth of knowledge required	Suggested learning activities
(ii) The parasite niche Parasitism is a symbiotic interaction between a parasite and its host (+/-) A parasite gains benefit in terms of nutrients at the expense of its host Unlike in a predator–prey relationship, the reproductive potential of the parasite is greater than that of the host Most parasites have a narrow (specialised) niche as they are very host-specific As the host provides so many of the parasite's needs, many parasites are degenerate, lacking structures and organs found in other organisms An ectoparasite lives on the surface of its host, whereas an endoparasite lives within the tissues of its host		Research the niche of *C. difficile* and the use of faecal transplants. Research the ecology, evolution, reproduction, and physiology of a selected human parasite.

Key area	Depth of knowledge required	Suggested learning activities
(b) Parasitic life cycles Some parasites require only one host to complete their life cycle		
Many parasites require more than one host to complete their life cycle	The definitive host is the organism on or in which the parasite reaches sexual maturity. Intermediate hosts may also be required for the parasite to complete its life cycle.	
A vector plays an active role in the transmission of the parasite and may also be a host		
The human disease malaria is caused by Plasmodium	An infected mosquito, acting as a vector, bites a human. Plasmodium enters the human bloodstream. Asexual reproduction occurs in the liver and then in the red blood cells. When the red blood cells burst gametocytes are released into the bloodstream. Another mosquito bites an infected human and the gametocytes enter the mosquito, maturing into male and female gametes, allowing sexual reproduction to now occur. The mosquito can then infect another human host.	

Key area	Depth of knowledge required	Suggested learning activities
Schistosomes cause the human disease schistosomiasis	Schistosomes reproduce sexually in the human intestine. The fertilised eggs pass out via faeces into water where they develop into larvae. The larvae then infect water snails, where asexual reproduction occurs. This produces another type of motile larvae, which escape the snail and penetrate the skin of a human, entering the bloodstream.	
Viruses are parasites that can only replicate inside a host cell Viruses contain genetic material in the form of DNA or RNA, packaged in a protective protein coat Some viruses are surrounded by a phospholipid membrane derived from host cell materials The outer surface of a virus contains antigens that a host cell may or may not be able to detect as foreign	Specific examples of viral life cycles are not required.	Investigate the effects of a phage virus on bacterial growth.

Key area	Depth of knowledge required	Suggested learning activities
Viral life cycle stages: infection of host cell with genetic material, host cell enzymes replicate viral genome, transcription of viral genes and translation of viral proteins, assembly and release of new viral particles RNA retroviruses use the enzyme reverse transcriptase to form DNA, which is then inserted into the genome of the host cell Viral genes can then be expressed to form new viral particles		

Key area	Depth of knowledge required	Suggested learning activities
(c) Transmission and virulence Transmission is the spread of a parasite to a host Virulence is the harm caused to a host species by a parasite Ectoparasites are generally transmitted through direct contact Endoparasites of the body tissues are often transmitted by vectors or by consumption of intermediate hosts Factors that increase transmission rates: ♦ the overcrowding of hosts when they are at high density ♦ mechanisms, such as vectors and waterborne dispersal stages, that allow the parasite to spread even if infected hosts are incapacitated		Investigate the spread of a plant pathogen in a variety of planting densities and humidities.
Host behaviour is often exploited and modified by parasites to maximise transmission	Alteration of host foraging, movement, sexual behaviour, habitat choice or anti-predator behaviour.	

Key area	Depth of knowledge required	Suggested learning activities
The host behaviour becomes part of the extended phenotype of the parasite Parasites often suppress the host immune system and modify host size and reproductive rate in ways that benefit the parasite growth, reproduction or transmission		

Key area	Depth of knowledge required	Suggested learning activities
(d) Defence against parasitic attack Immune response in mammals has both non-specific and specific aspects Non-specific defences Physical barriers, chemical secretions, inflammatory response, phagocytes, and natural killer cells destroying cells infected with viruses are examples of non-specific defences	Epithelial tissue blocks the entry of parasites; hydrolytic enzymes in mucus, saliva and tears destroy bacterial cell walls; low pH environments of the secretions of stomach, vagina and sweat glands denatures cellular proteins of pathogens. Injured cells release signalling molecules. This results in enhanced blood flow to the site, bringing antimicrobial proteins and phagocytes. Killing of parasites using powerful enzymes contained in lysosomes, by engulfing them and storing them inside a vacuole in the process of phagocytosis. Natural killer cells can identify and attach to cells infected with viruses, releasing chemicals that lead to cell death by inducing apoptosis.	

Key area	Depth of knowledge required	Suggested learning activities
Specific cellular defences A range of white blood cells constantly circulate, monitoring the tissues If tissues become damaged or invaded, cells release cytokines that increase blood flow resulting in non-specific and specific white blood cells accumulating at the site of infection or tissue damage Mammals contain many different lymphocytes, each possessing a receptor on its surface, which can potentially recognise a parasite antigen Binding of an antigen to a lymphocyte's receptor selects that lymphocyte to then divide and produce a clonal population of this lymphocyte Some selected lymphocytes will produce antibodies, others can induce apoptosis in parasite-infected cells Antibodies possess regions where the amino acid sequence varies greatly between different antibodies	 Specific lymphocyte names are not required.	

Key area	Depth of knowledge required	Suggested learning activities
This variable region gives the antibody its specificity for binding antigen When the antigen binds to this binding site the antigen-antibody complex formed can result in inactivation of the parasite, rendering it susceptible to a phagocyte, or can stimulate a response that results in cell lysis		
Memory lymphocyte cells are also formed	Initial antigen exposure produces memory lymphocyte cells specific for that antigen that can produce a secondary response when the same antigen enters the body in the future. When this occurs antibody production is enhanced in terms of speed of production, concentration in blood and duration.	

Key area	Depth of knowledge required	Suggested learning activities
(e) Immune evasion Parasites have evolved ways of evading the immune system Endoparasites mimic host antigens to evade detection and modify host immune response to reduce their chances of destruction Antigenic variation in some parasites allows them to change between different antigens during the course of infection of a host It may also allow re-infection of the same host with the new variant Some viruses escape immune surveillance by integrating their genome into host genomes, existing in an inactive state known as latency The virus becomes active again when favourable conditions arise		Compare antigenic variation in trypanosomes with antigenic variation in the influenza virus.

Key area	Depth of knowledge required	Suggested learning activities
(f) Challenges in treatment and control		Research how attempts to disrupt the lifecycle of Plasmodium in the control of malaria have resulted in the loss of apex predators due to bio-magnification of the organochloride insecticide, DDT.
Epidemiology is the study of the outbreak and spread of infectious disease The herd immunity threshold is the density of resistant hosts in the population required to prevent an epidemic Vaccines contain antigens that will elicit an immune response The similarities between host and parasite metabolism makes it difficult to find drug compounds that only target the parasite Antigenic variation has to be reflected in the design of vaccines		
Some parasites are difficult to culture in the laboratory making it difficult to design vaccines		Research the problems associated with the development of successful vaccines for HIV and malaria.

Key area	Depth of knowledge required	Suggested learning activities
Challenges arise where parasites spread most rapidly as a result of overcrowding or tropical climates These conditions make co-ordinated treatment and control programs difficult to achieve Civil engineering projects to improve sanitation combined with co-ordinated vector control may often be the only practical control strategies Improvements in parasite control reduce child mortality and result in population-wide improvements in child development and intelligence, as individuals have more resources for growth and development	Overcrowding can occur in refugee camps that result from war or natural disaster or rapidly growing cities in LEDCs.	Research the decline of effectiveness of chemical treatments over time. Research parasitism and childhood. Research the impact of parasitism on child mortality rates in different parts of the world. Consider the benefits of intervention programmes in terms of childhood development and intelligence.

Administrative information

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History of changes to National Unit Specification

Version	Description of change	Authorised by	Date

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