Adv H Biology Learning Outcome checklist Unit 2 Organisms and Evolution

2.1 Field Techniques

Subsection	I can state or explain the following
(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.
	standard rules for fieldwork safety, such as 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.
(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.
	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.
	quadrats, of suitable size and shape, or **transects** are used for sampling 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.
(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.

	taxonomy involves the identification and naming of organisms and their classification into groups based on shared characteristics. Classic taxonomy classification is based on morphology.
	phylogenetics is the study of the evolutionary history and relationships among individuals or groups of organism. 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.
	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 model organisms can be applied to other species that are more difficult to study directly.
(d) Monitoring populations	
	presence, absence or abundance of **indicator species** can give information of environmental qualities, such as presence of a pollutant. 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.
	The procedure for the **mark and recapture technique** is a method for estimating population size using the formula **N= 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= MC/R.
	Mark and recapture 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.
	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.
(e) Measuring and recording animal behaviour	
	I can state that 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.
	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.
	I can describe the importance of avoiding **anthropomorphism** when analysing behaviour
	Anthropomorphism can lead to invalid conclusions.

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2.2 Evolution

	I can state or explain the following
2 a) Drift and Selection	
	define **evolution** as 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 and that 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.
	as organisms produce more offspring than the environment can support, those individuals with variations that best fit 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.
	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.
	explain that 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 underrepresented 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.
	Selection pressures can be **biotic**: competition, predation, disease, parasitism; or **abiotic**: changes in temperature, light, humidity, pH, salinity.
	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).

	the HW principle can be used to determine whether a change in allele frequency is occurring in a population over time, as changes suggest evolution is occurring.
	use the HW principle to calculate allele, genotype and phenotype frequencies in populations: $$\mathbf{p^2+2pq+q^2=1}$$ where p = frequency of dominant allele; q = frequency of recessive allele; p^2 = frequency of homozygous dominant genotype; 2pq = frequency of heterozygous genotype and q^2 = frequency of homozygous recessive genotype.

2 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 number of individuals of a particular genotype after selection, to those 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.
	calculate absolute and relative fitness: Absolute fitness = frequency of a particular genotype after selection/frequency of a particular genotype before selection Relative fitness = number of surviving offspring per individual of a particular genotype/number of surviving offspring per individual of the most successful genotype

2 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.
	symbiosis as a co-evolved intimate relationships between members of two different species.
	the impacts of these relationships can be positive (+), negative (-) or neutral (0) for the individuals involved.
	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 (+/-).
	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

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2.3 Variation and Sexual Reproduction

	I can state or explain the following
(a) Costs and benefits of sexual and asexual reproduction	
	state the 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.
	use the **Red Queen hypothesis** to explain the persistence of sexual reproduction, as co-evolutionary interactions between parasites and hosts may select for sexually reproducing.
	if hosts reproduce sexually, the genetic variability in their offspring reduces the chances that all will be susceptible to infection by parasites.
	Hosts better able to resist and tolerate parasitism have greater fitness.
	Parasites better able to feed, reproduce and find new hosts have greater fitness.
	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.
	in asexual reproduction, just one parent can produce daughter cells and establish a colony of virtually unlimited size over time, because offspring can be reproduced more often and in larger numbers with asexual reproduction.
	vegetative cloning in plants and parthenogenesis in lower plants and animals that lack fertilisation are examples of asexual reproduction in eukaryotes.
	Parthenogenesis is reproduction from a female gamete without fertilisation
	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.
	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.
(b) Meiosis	
	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. **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. The chromosomes of each homologous pair are separated and move towards opposite poles **Cytokinesis** occurs and two daughter cells form.
	crossing over of DNA is random and produces genetically different recombinant chromosomes.
	linked genes are those on the same chromosome. Crossing over can result in new combinations of the alleles of these genes.
	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**.
	I can describe 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.
(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 is a process by which most of one X chromosome is inactivated and explain that X chromosome inactivation prevents a double dose of gene products, which could be harmful to cells.
	carriers are less likely to be affected by any deleterious mutations on these X chromosomes, because 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 hermaphrodite 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. For example, environmental sex determination in reptiles is controlled by environmental temperature of egg incubation.
	sex can change within individuals of some species as a result of size, competition, parasitic infection, or temperature.
	in some species the sex ratio of offspring can be adjusted in response to resource availability.

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2.4 Sex and Behaviour

	I can state or explain the following
(a) Parental Investment	
	compare sperm and egg production in relation to number and energy store, and explain that there is greater investment by females.
	female investment is 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
	classify **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.
	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.
	compare 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.
(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**.
	successful courtship behaviour in birds and fish can be a result of species-specific sign stimuli and fixed action pattern responses.
	sexual selection selects for characteristics that have little survival benefit for the individual, but increase their chances of mating.
	many species exhibit **sexual dimorphism** as a product of sexual selection. For example, 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.
	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.

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2.5 Parasitism

	I can state or explain the following
(a) i) Niche	
	An **ecological niche** is a multidimensional 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
	competitive exclusion is 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 resourcing partitioning
a) ii) the parasite niche	
	a parasite is a **symbiont** that 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.
	an ecological niche is a multidimensional summary of tolerances and requirements of a species.
	parasites tend to have a narrow 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 the host.
(b) Parasite life cycles	
	some parasites require only one host to complete their life cycle but many parasites require more than one host to complete their life cycle.
	the organism on or in which the parasite reaches sexual maturity is the **definitive host**.
	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.
	a species has a **fundamental niche** that it occupies in the absence of any interspecific competing influences.
	a species has a **realised niche** that it occupies 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.
	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.
	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 have a phospholipid membrane surround 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.
	Viral life 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. This virus gene forms new viral particles when transcribed.
(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 or by consumption of intermediate hosts
	endoparasites of the body tissues are often transmitted by vectors
	Factors that increase transmission rates: the overcrowding of hosts at high density; mechanisms that allow the parasite to spread even when infected hosts are incapacitated, such as vectors and waterborne dispersal stages.
	host behaviour is often exploited and modified by parasites to maximise transmission; through the alteration of host foraging, movement, sexual behaviour, habitat choice or anti-predator behaviour,
	the host behaviour becomes part of the extended phenotype of the parasite.
	parasites also often suppress the host immune system and modify host size and reproductive rate in ways that benefit the parasite growth, reproduction or transmission.
(d) Defence against parasitic attack	
	the immune response in mammals has both non-specific and specific aspects.
	non-specific defences of mammals: physical barriers, chemical secretions, inflammatory response, phagocytes and natural killer cells destroying cells infected with viruses.
	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.
	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. 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.
(e) Immune evasion	
	parasites have evolved ways of evading the immune system.
	endoparasites mimic host antigens to evade detection by the immune system, 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, or allow re-infection of a 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.
	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.
	the vaccines contain antigens that will elicit an immune response.
	rapid antigen change has to be reflected in the design of vaccines.
	the similarities between host and parasite metabolism makes it difficult to find drug compounds that only target the parasite.
	some parasites are difficult to culture in the laboratory making it difficult to design vaccines.
	civil engineering projects to improve sanitation combined with coordinated vector control may often be the only practical control strategies
	parasites spread most rapidly in those conditions where coordinated treatment and control programs are most difficult to achieve.
	challenges arise where parasites spread most rapidly as a result of overcrowding or tropical climates.
	overcrowding can occur in, eg refugee camps that result from war or natural disaster or rapidly growing cities in LEDCs.
	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.