<u>Essential Outcomes: Midterm Test 1 and 2</u>

1. Principle underlying evolution by natural selection: origin of variation, heritability, differential reproduction, change in genotype of the population over time:

A certain population starts out with variations in genetics (variation). Those with favored genes survive and reproduce more. Over time those with unfavoured genes die off and are replaced by offspring with favoured genes, gradually changing the overall phenotype of the entire population.

Through genetic variation a variant is produced. If their mutation is beneficial to their survival and increases their fitness they reproduce more. Offspring coming from the variant individual will inherit the mutation and will continue to pass on the mutation to their future offspring. Over time the population continues to reproduce until the genotype of the population has changed to reflect the variant who has the highest fitness.

Heritability is an estimate of how much of the diversity regarding a certain trait is due to diversity in the population's gene pool, is the ability of a favoured trait to be passed on.

Differential reproduction arises due to the limited resources in an environment and thus the struggle to survive with increased competition levels and environmental selective pressures. Essentially, the organisms with the adaptive traits will be more fit to survive than the organisms with the non-adaptive traits, hence having a higher relative fitness, resulting in their survival to adulthood and reproduction over certain organisms.

2. Evidence from the fossil record. historical biogeography, comparative morphology and molecular biology that supports the idea of descent with modification from a common ancestor.

Fossil record: Darwin proposed that all species that have ever lived are genetically related. It documents such continuity in morphological characteristics providing clear evidence of ongoing changes in biological lineages (evolutionary sequences of ancestral organisms and their descendents)

Historical biogeography: The study of the geographical distributions of plants and animals in relation to their evolutionary history. Interprets the products of natural selection as evolutionary adaptations. Example: Species on oceanic islands often closely resemble species on the nearest mainland suggesting that the island and mainland species have a common ancestry.

Comparative morphology: Analyses of the structure of living and extinct organisms are based on the comparison of homologous traits (characteristics that are similar in two species), because they inherited the genetic basis of the trait from their common ancestor. Vestigial structures were also studied, they represent degenerated structures which were once functional in ancestors of an organism but have become degenerated over evolutionary time.

Molecular biology: Through comparing embryos they found that early embryos of related species are similar with morphological differences becoming apparent later in development. This provides evidence that they evolved from a common ancestor as differences only appear in later development.

3. Characteristics of a scientific theory and the importance of falsifiability

Scientific theories represent a coherent set of testable hypotheses that attempt to explain facts about the natural world. Theories are tested by being falsified thus no theory can be accepted if it is not falsifiable because there is no way to conclusively say that it is not true. Theories become factual when they cannot be proven false.

4. Changes in amount of DNA throughout the cell cycle

During G1 of G2 there is no change in the amount of DNA. During S phase chromosomes are replicated thus the amount of DNA doubles. During Anaphase the sister chromatids separate and half the replicated chromosomes go to either side of the cell thus the amount of DNA is divided by 2 and returns to the original amount of DNA. During Telophase each daughter nuclei has the original amount of DNA.

5. Main features of each stage of mitosis with respect to cytoskeleton and chromatin

The cytoskeleton is made up of Tubulin which makes up the microtubles, Keratin which makes up the intermediate filaments and Actin which make up the microfilaments.

Prophase: Chromosomes begin to condense and compact, appear to be thing threads under a microscope. Nucleolus disappears (shutdown of RNA synthesis). Mitochondric spindle begins to form between the two centromeres.

Prometaphase: Spindle microfibers(microtubules) grow from centrosomes at opposing spindle poles toward the centre of the cell. A kinetochore form on each chromatid at the centromeres (kinetochore microtubules bind to these). These connections determines the outcome of mitosis

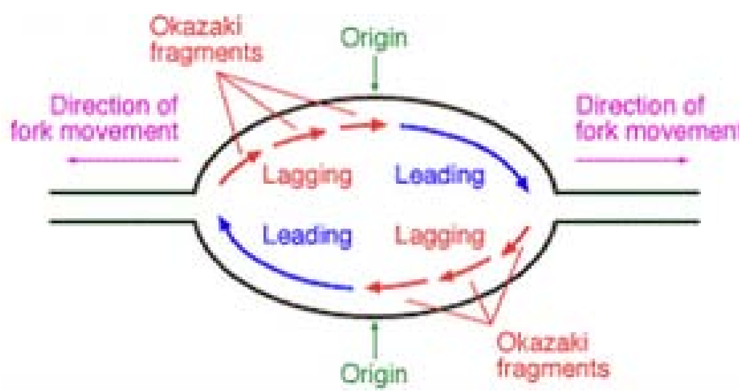
Metaphase: Spindle microtubles move the chromosome to align at the spindle midpoint (metaphase plate). Chromosomes complete their condensation and their size id dependant on location. When all chromosomes are at midpoint, metaphase can give way to separation of chromatids.

Anaphase: Sister chromatids separate and move to opposite poles (movement powered by motor proteins on kinetochore). Movement continues until the daughter chromosomes move to opposite poles.

Telophase: The spindle disassembles, chromosomes decondense, nucleolus reappears, and new nuclear envelope forms at each pole, producing the two daughter nuclei.

6. Structure of a replication bubble

Two replication forks meeting forming a replication bubble but each fork moves away from replication origin and 2 strands are replicated in opposite directions. Due to antiparallel direction both still replicate in 5'-3' direction. Eventually the 2 replication forks will reach each other thus forming the replication bubble. Lagging and leading strand are on opposite sides of either fork, moving away from each other. Leading strand are formed when they are facing in the direction of the unwinding replication fork. Multiple replication bubbles can exist on a given DNA strand.



7. Relationship between DNA replication and metaphase chromosome structure

At metaphase, the homologous chromosomes line up at the metaphase plate. At this point the amount of DNA is double what is in a normal cell, these homologous pairs are attached to the microtubules connecting them to spindles at opposite poles of the cell.

When DNA is replicated during S phase the common 2 chromatid (1 chromosome) structure are formed and metaphase is when you can visibly see those structures. If the replication did not happen there would only be one chromatid(unreplicated) in the metaphase plate and mitosis wouldn't be able to proceed because the microtubules from opposite poles only has one kinetochore to attach to.

8. Difference between DNA damage and mutation

DNA mutation is a double stranded change in the sequence of DNA. What its consequences are is irrelevant, it doesn't have to do anything bad or anything at all, if it's a double stranded change in the sequence that is a mutation. DNA damage is an alteration in the chemical structure of DNA, such as a break in a strand of DNA, a base missing from the backbone of DNA, etc. DNA damage is a physical abnormality that can be recognized by enzymes and therefore repaired (but not all damage is repaired by enzymes and some can lead to mutations).

Damage can be repaired sometimes but mutations can't be reversed. Mutations in reproductive cells are heritable where as damage in reproductive cells are not because damaged DNA sequence is not replicated. It can't be replicated until damage is removed or damage becomes a mutation. If not recognized by repair mechanism, DNA will be replicated and an incorrect base or additional base may be added or neglected.

9. Origin of various types of genomic variation

75% variant bases are single nucleotide polymorphisms and 25% variants are copy number variations, inversions. Many genetic variations arise from mutations or transposable elements. Insertion sequences which serve as a recognition site for enzyme transponase. An insertion element carries only a single DNA sequence, which codes for its transposition. If two insertion sequences are close together, then when transposed they carry the DNA sequence between them along with them forming a transposon. A special type of transposon called a retro transposon also exists whereby the DNA sequence is transcribed into RNA by reverse transcriptase and then back into a DNA strand which is inserted into target DNA strand. Tautomeric shifts occur when the wrong base is added to a sequence. If not recognized, the replicated DNA will have a transition mutation of a single base pair. In/del mutations occur when there is a slippage in DNA strand during replication. This causes the DNA strand to loop resulting in one strand with an extra DNA base pair and the other strand having one less base pair. Substitution mutations occur when single base pair is incorrectly added in place of another one.

10. Main differences between meiosis and mitosis

Meiosis	**Mitosis**
There are 4 genetically different daughter cells are produced, all of which are also unique from the parent cell. The daughter cells have different number of chromosome than the parent cells, the daughter cells are haploid while the parent cells are diploid. There are 2 divisions; first division is	Two identical daughter cells are produced, both of which are genetically identical to the parent cell. The daughter cells have the same number of chromosomes as the parent cell. The daughter cells are diploid. There is only 1 division in mitosis. The number of chromosomes remains the same throughout

reductional (reduced the chromosome number) and the second is equatorial (reduces the chromosome number). Meiosis is used for sexual recombination and sexual reproduction.	the process. Mitosis is used or the growth and repair of cell. Mitosis is used in asexual reproduction.

11. Products of meiosis in animals vs. plants, fungi and algae

In animal life cycles, the zygote divided by mitosis and the product of meiosis in animals is a gamate.

In plants the zygote divides by mitosis to make a diploid body but the products of meiosis in a plant are spores. Those spores divide by mitosis to give this multicellular haploid body called a gameotophyte, the gametophyte then makes gamates by mitosis. Plants alternates between diploid and haploid. Zygote divides by mitosis to make a diploid body (sporophytes). Some sporophyte cells undergo meiosis to make spores (reproductive cells - n). These spores then divide through mitosis(n) to make gametophytes which makes gametes through mitosis.

In some fungi/algae the haploid phase the gametophyte is making gametes by mitosis and its zygote goes through meiosis immediately. The zygote does not divide by mitosis, there is no multicellular diploid phase. The spores undergo mitosis to create gametophyte first, which then undergoes another round of mitosis to create gametes. Zygote dose not undergo recombination because the offspring's are identical to the parents.

12. Characteristics of homologous chromosomes

Homologous chromosomes carry the same genes but have different alleles. In each pair of chromosomes one is maternal and the other is paternal. Although two homologous chromosomes carry the same genes arranged in the same order, different versions of these genes(alleles) may be present on either chromosome. Chromosomes have a consistant shape and bonding pattern and have the same centromere (region of DNA found near the middle of the chromosome) position. They have corresponding loci(location of a particular allele on a chromosome) but are likely to have different distribution of mobile element insertions.

13. Mechanism by which recombination creates new combination of alleles

During crossing over 2 homologous chromosomes will line up on top of each other forming a tetrad held together by synaptonemal complex. While the two chromosomes may carry the same genes in the same order, they likely contain different alleles. During crossing over the ends of homologous chromosomes are exchanged, producing new combination of alleles on each chromosome. Crossing over occurs randomly and at different points on the chromosome, creating numerous possibilities for new combinations.

14. Various mechanisms by which meiosis generates variation

Crossing over(recombination). Alignment during mitosis; the homologous chromosomes line up randomly at the metaphase plate and are randomly assorted. Random assortment; homologous chromosomes assort randomly into each daughter cell. The assortment of each homologous chromosome is independent of the other, meaning that there are multiple combinations in which the chromosomes can assort themselves. Random fertilization; gametes pair themselves randomly creating random combination of alleles.

15. Segregation of various alleles during meiosis in monohybrid, dihybrid and sex-linked situations.

Law of segregation; alleles maintain their individuality and segregate independently of other alleles. There are different forms of a given gene called alleles. In a given pair of different alleles, one may be dominant while the another is recessive. The dominant allele is characterised as controlling the phenotype of the organism. Regardless of their dominance, the two alleles of an individual segregate evenly into the gametes of the organism. In case of dihybrid cross, the two different genes have no effect of the other segregation. Monohybrid cross follows ratio;1:2:1 and dihybrid cross follows ratio;9:3:3:1. In sex-linked situations the alleles again segregate independently but a recessive allele carried on the x-chromosome will be automatically expressed in a male(only 1 x-chromosome) while a female would merely be a carrier of the allele.

16. Conditions under which allele frequencies change or not in a population over time

Any type of selection will change allele frequencies; mutation, natural selection, non-random mating, gene flow(migration between populations) and genetic drift (finite population size), thus if no selection is present, allele frequencies will not change. Allele frequencies change during gene flow, and due to mutations (but there must be a very large amount of random mutations).

17. Populations that are, or are not, at genetic equilibrium, given observed genotype frequencies

Allele frequencies of a population in genetic equilibrium exist in a particular ratio: Hardy Weinberg Principle ($p^2+2pq+q^2$). When a population reaches genetic equilibrium, the genotype frequencies remain constant. Selection can continue to take place but when a population reaches genetic equilibrium, it indicates that evolution is not taking place.

18. Calculate relative fitness from absolute fitness

Absolute fitness (W): the number of surviving offspring produced over an individual's lifetime.

Relative fitness(w): calculated by standardizing a genotype's absolute fitness; fitness of an individual is compared to fitness of an individual within the same species (divided by highest fitness). The relative fitness ranges from 0 to 1. The individual with the greatest fitness has a fitness of 1. To calculate relative fitness use $w=W/W_{max}$ (where Wmax if the absolute fitness of the most successful genotype).

19. How dominance status of alleles affects the response to selection

When selection favours the recessive allele (will reach fixation)or there's a heterozygous disadvantage, the dominant allele(or whichever has the lowest frequency) will eventually be eliminated from the population and reach zero. When selection favours the dominant allele (will keep increasing but never reach fixation), the recessive allele will never reach zero, and was harmful but selection was never able to get rid of the allele. The harmful recessive allele is shield from elimination because it is hidden in heterozygote. This allows harmful recessive alleles to persist in populations at low frequencies. When these harmful alleles are rare, most of the copies will be found in heterozygote with normal fitness. Selection can usually weed out all harmful dominant alleles with genetic disorders (less common)but not recessive alleles.

20. Relationship between selection and evolution

Selection can be occurring without evolution occurring. Alleles exist in an initial frequency. Selection favours certain traits and selects against others causing these allele frequencies to change. The change in allele frequency is the basis of evolution; however, at a certain point the allele frequencies reach equilibrium, meaning they are no longer changing. At this point, we can say that the population is not evolving yet selection is still acting on the population because the selective pressures still exist.

21. Processes that reduce, remove, or maintain heritable variation in populations

Reduce Variation: Genetic drift (bottleneck and founder effect) Changes in allele frequencies due to chance events. Genetic drift is constantly occurring. It causes the reduction of heritable variation. Smaller populations are more easily affected because the number of alleles that make up the populations allele frequencies is smaller, thus small changes are more drastically seen. If a chance event wipes out a large portion of a population, remaining individuals must repopulate. These individuals represent only a fraction of the population's original genetic diversity; thus new population has less genetic diversity. Natural selection (depends what if selects for) maintains genetic diversity. Advantageous traits are favoured and allele frequency increases while disadvantageous traits are unflavoured and are removed from the population. Balancing selection also exists (negative frequency dependent selection) where frequent alleles are unflavoured. This maintains both dependent selection) where frequent alleles are unflavoured. This maintains both.Increases Variation: Gene flow, Mutations. Maintain Variation: Non-random mating (changes the phenotype frequency but not the allele frequency)a mate based on genotype or phenotype decreases the genetic variation in a population. It increases the amount of homozygous individuals in a population while decreasing the amount of heterozygous individuals, diversity is not conserved. Natural selection (depends what is selects for)

22. Which assumptions of Hardy-Weinberg equilibrium have likely been violated, given an observed set of genotype or phenotype frequencies

Large population (no genetic drift), little mutations (negligible), no selection pressure (genotypes have equal fitness), randomly mating, no immigration/emigration. If the observed genotype does not match the expected genotype that was calculated using the formula (p^2+2pq+q^2) then the Heardy-Weinberg equilibrium was violated and external factors cause this discrepancy, such as a small population, or selection pressures.

23. Examples and predictions of size-advantage model of sex change

Prodandry: organisms that begin as males and become females when they reach a particular size. Example; In clownfish, being small provides the most advantages to males and is a disadvantage to females. When clownfish reaches a particular size (when they are largest in school) they become a female because it is more advantageous for a female to be large.

Protogyny: organisms start as females and once they reach a particular size, they become males. Some males have more to gain from being large than females do. In general, by analyzing the relationship between size and fitness, we can determine which sex will be adopted by a species when they are of a specific size.

24. Examples and predictions of adaptive sex ratio manipulation

In deer populations some daughters benefit from having mothers with high ranking in the herd. Mother's of high ranking tend to produce more female offspring. In the population as a whole, the ration of males to females balances at 1:1 ratio. The living conditions can affect the gender of the offspring as mother's will produce offspring of a gender that will most benefit.

25. Costs and benefits of reproducing sexually as opposed to asexually

Costs of Sexual reproduction: Mating calls and dances can attract predators, competition for a mate can be dangerous, when mate is found only half of the genome is passed on to offspring and reproduction is dependent on female population because males can only reproduce as long as there is a viable female around. Benefits of sexual reproduction: Harmful mutations can be removed from the genome through sexual recombination, increases the genetic variation of a population thus increasing resistance of population to a disease, caters to a changing environment (with different genotypes, at least one of the offspring is more likely to survive in the case of new environmental conditions.) and it allows population to evolve faster (helpful variations are spread faster and beneficial alleles come together faster in offspring genome).

26. Calculate degree of relatedness between two individuals, given the type of relationship (parent-offspring, cousins, etc.)

Identical twin= 1, Siblings= 0.5, Half-siblings= 0.25, First cousins= 0.125, Parent= 0.5, Uncle/Aunt= 0.25, Grandparent= 0.25 and Great-grandparent=0.125.

Multiply relatedness and add if they have multiple relatives.