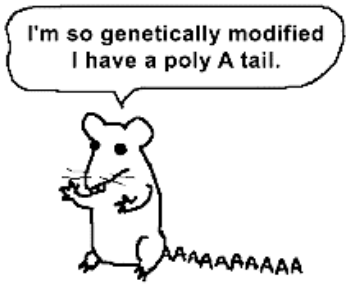
EVOLUTIONARY BIOLOGY OF ANIMALS

History of Evolutionary Thinking

- Evolution is a fact (with lots of evidence to back it up) *and* a theory (repeatably tested by hypotheses). It is not a scientific law (which ahs proof that something happens, but not why) or a hypothesis (a proposed explanation for phenomena) as it is too well tested.
- The evidence for evolution is universally shared features (homology), hierarchical classifications in phylogeny, biological relationships, geological history and geographical distributions
- Darwin's evolution – population change over generations, with gradual change and speciation driven by natural selection.
- Eg. Beak size in Darwin's finches is very heritable. After a drought (when small seed eaters died), the beak size evolved to be larger to enable feeding on larger seeds. It then reduced in subsequent generations
- Hybrid speciation – two species blend to form a unique non-interbreeding species
- Evolution – change in the DNA sequence over many generations, whether by natural selection or genetic drift
- Humans, whether consciously or unconsciously, impact of everything we interact with
- Early hunter gatherers avoided hunting large and dangerous prey – exerting an unconscious selection for large dangerous prey
- Neolithic revolution – the start of agriculture. Selected (purposely?) for non-shattering dispersed corn by only collecting seeds on the stem
- Anaximander 610-546BC – thought nature was ruled by laws and any disturbance to the balance wouldn't persist – bit like ESS
- Empedoccles 492-432BC – had the body parts theory – that random combinations of body parts existed but didn't work, recombining until a working form arose (us)
- Xenophanes 570-475BC – suggested that fossils in sedimentary rocks were once under water
- Lots of thinking about why things didn't exist
- Aristotle 384-322BC – first great zoologist, published books on animal history and such. Began taxonomic classification based upon observation, and used comparative anatomy. Also noticed correlations of morphology in nature. Didn't believe in evolution, and attributed the gradation in nature to the great chain of being
- Great chain of being - hierarchical structure of all matter and lifestarting with God and through to angels, demons, stars, moon, kings, princes, nobles, commoners, wild animals, domesticated animals, trees, other plants, precious stones, precious metals and other minerals

- There can be co-evolution of genomes, eg between host and symbiotic bacteria: luminescent bacteria live in the bobtail squid's light organ – housed in exchange for emitting light, but are limited by the biotic environment



- Pleiotropy – when one gene influences more than one trait (most genes are like this). Eg the melanocortin system (set of genes) determines colour patterns as well as other traits like immunity – darker wild vertebrates are more aggressive, sexually active and resistant to stress than lighter individuals (although may just invest in different life stages)
- Species with a large genome (aka high C-value, the total amount of DNA per cell) develop more slowly than small genome species

- Comparative genomics – when looking at evolutionary changes often have to compare genomes to see changes (eg dolphins have similar changes in brain structure as primates), or to show which genes may be responsible

Summary: Changes in DNA can be small or large. They occur in many ways but are normally deleterious and are removed by natural selection. Understanding what changes persist is useful as it tells us what we might expect to evolve in a particular time frame, and it helps us understand how the evolutionary patterns we see today have come about.

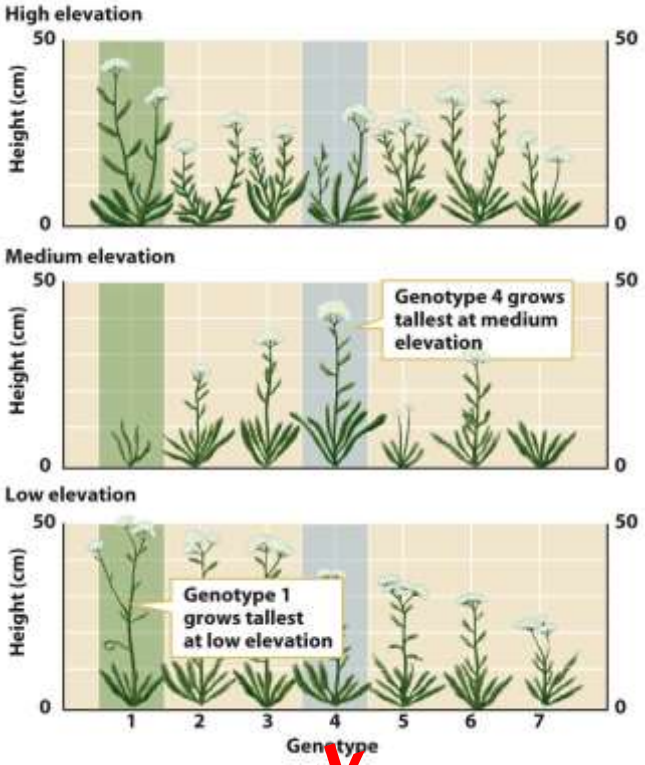
Natural Selection vs Neutral theory

- Darwin had two main insights:

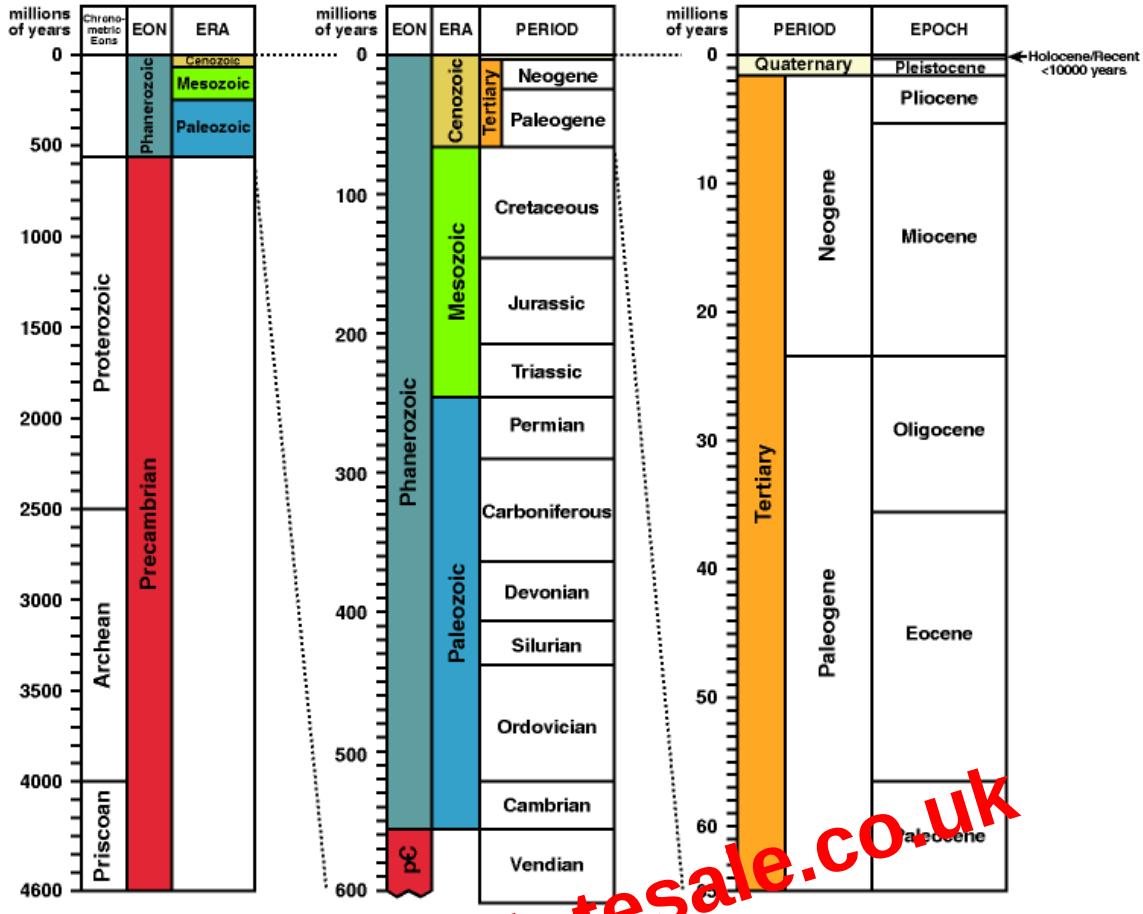
Natural selection – that the environment selects on variation in the traits of organisms, because some variants are more successful than others at surviving and reproducing

Evolution – that all species have descended from one or a few common ancestors

- Mutation is the main source of variation on which natural selection works. It occurs at random, and whilst most mutations are (mostly) harmless and few are deleterious, even fewer are immediately beneficial. Suitable mutations are rare so natural selection works on the standing genetic variation in the population



- Variation which is normally neutral is the most important to act on
- Natural selection only acts on the outward phenotype and interactions caused by the genotype, not the genotype itself
- Not everyone with a gene for blue eyes will have blue eyes – genes code for traits in the context of a particular set of conditions
- Fitness – the ability of an individual (phenotype) to survive and reproduce (not just LRS)
- Viability – probability of survival to reproductive age
- Fertility – average number of offspring per surviving individual
- Absolute fitness – represents the average number of offspring produced by individuals of a particular genotype (normally used)
- Relative fitness – represents the average number of offspring produced by a genotype *relative* to other members of the population (eg +1/-1)
- Natural selection can act over shorter timespans eg, mice coat colour on Florida islands matches habitat colour, but the islands are only 4000-6000 years old
- Coat colour has a genetic basis, with gene McR1 switching between light and dark pathways. This mutation has evolved multiple times (convergent)
- Coat colour *does* have an impact on fitness: darker mice are predated upon more in light habitats and vice versa
- Even small differences in fitness can lead to big change: 1% more offspring in light habitats for light mice would lead to a 100% increase in allele frequency in a population of 10,000 within a few thousand generations – short in an evolutionary timescale sense
- Anything over 5% difference is strong natural selection
- Fitness = 1 – s (selection coefficient) – s=0 is no selection, s=0.02 is a 2% increase in fitness of dark mice against dark habitat
- How long will it take for the dark allele to reach fixation (be the only one)? If two alleles exist (A and a), with frequencies p and q, then with no selection the frequency of each genotype at the next generation will be: $AA = p^2$, $Aa = 2pq$, $aa = q^2$
- With selection the frequency of genotypes is $AA = p^2$, $Aa = 2pq$, $aa = q^2(1-s)$



- Reminder that we are inconsequential (like reallllly) in the scheme of geological time so we should not revise (we are in the Holocene)
- Sediment dwelling organisms were most likely to get fossilised, but fossilisation in general was a very unlikely event meaning we are missing many soft tissue samples, terrestrial organisms and invertebrates
- Soft tissue has more variation than skeletal structure (only a set number of ways to walk), so would give a lot more information
- The oldest fossils identified are bacteria like organisms in south African rocks which are around 3 billion years old (Archean?)
- After the Cambrian explosion we see the first life forms with segmented body plans, shells, exoskeletons, and notochords – increasing body plan complexity
- Fossilised tracks from trilobites walking on the surface show that they walked and searched for prey like a present day species would – behaviour