

Chapter 7: Geographic Variation and speciation

7.3 Adaptive Value of Geographical Variation

→ Evolution of the Loss of Fur and Skin Colour in Humans

- 6-7 million years ago, the hominins (all human species) shared a common ancestor with the chimpanzee (pale skin covered by a dark fur)
- Fur is vestigial structure in humans
- A. Afarensis: an extinct hominin that lived between 3.9 and 2.9 million years ago in Africa. Lived in tropical forests, it was bipedal and arboreal. Diet consists of fruits, tubers and leaves. Had a sedentary way of life.
- As of 3 MYR: important cooling, droughts in east africa, formation of the savannas, impact on hominin species
- H. erectus (1-2 myr); less fruit was available so meat was added to the diet
- They had to walk longer distances for prey + water → they had a more active lifestyle (hunter-gatherer)
- Natural selection acts on the shape of the body (ability to run)
- Abundance of sweat glands + less fur to caused them to have a more efficient thermoregulation
- Furry animal glands → especially sebaceous and apocrine; oily sweat; perspiration is difficult
- Human glands → especially eccrine; watery sweat; easy perspiration (up to 10L/day) add pic
 - Ex: sweating horse: sweating is difficult b/c of few eccrine sweat glands (protein of eccrine+apocrine sweat glands=latherine)
- Carnivore thermoregulation: panting and eccrine sweat glands found only on the pads of paws
- Human perspiration: up to 10L/day. A lot of eccrine sweat glands (loss of fur to facilitate sweat evaporation)
- Selection in favour of darker skin (1-2 Ma) happened at the same time as fur loss
- Natural selection favoured the individuals having thicker, darker and more acidic skin (more melanosomes = more melanins)
- Protection against = uv rays, drought, bacterial attacks, and vitamin deficiencies
 - Ex: cat? Human? chimp?
- For over 1 Myr (between 1-2 myr to 100 000 years): the skin of all hominins species including homo sapiens was dark
- Routes of human migration

→ Hypothesis to explain evolution of skin colour

- Note: we need to find an inherited trait that gives those who had it a positive survival and reproduction differential (adaptation) from generation to generation compared to other members of the population
- Folic acid + darker skin: folic acid (vitamin B9) is destroyed in skin by excessive UV rays.

- **B9 deficiency:** serious and possibly lethal developmental malformations (spina bifida), poor wound healing, disrupted immune system, sperm malformation.
- A vitamin deficiency at a young age, and, particularly, in pregnant women would have a direct impact on the survival and reproductive success of the individual.
- Thus, we can say that dark skin offers a protection against the UV rays that offers a survival and reproductive advantage (that's an adaptation)
- **Vitamin D3 and Pale skin:** vitamin D3 is synthesized in the skin by UV rays. It helps the absorption of calcium in the gut. (Deficiency → rickets aka bowed legs, etc)
- A deficiency in vit D3 would have a direct impact on the reproductive success of affected individuals
- Pale skin in low uv radiation would maximize the absorption of UV rays and the survival of the human population in areas of uv deficiency (adaptation)
- Links between the quantity of UV rays reaching the earth and human skin colour
- The great human migration that started 100k years ago has seen humans invade increasingly northern habitats more recently (especially in the last 40k years) and evolve paler skin to maximize UV absorption in areas where UV radiation is weak for adequate synthesis of vitamin D3 by the skin.
- In areas w/ an important annual deficit UV rays, colonization by humans (10k to 15k years ago) was made possible b/c humans compensated for deficiency in vit D3 through diet (hunting, fishing, and domestication)
- Conclusion →
 - The loss of fur in hominins is linked to lifestyle changes due to climate change, more than 1-2 myr ago
 - The skin color became dark quickly after the loss of fur. The skin remained dark for more than 1 myr
 - The evolution of pale skin in some human populations is linked to the colonization of habitats further north during 100k years. This paler skin is an adaptation to maximize the absorption of UV rays in zones where radiation is low; this allowed healthy synthesis of vit D3.
 - A selective advantage of darker skin in regions of high UV intensity is to minimize the degradation of folic acid by UV rays.
 - Note: individuals w/ darken skin in regions of high UV intensity synthesize vit D3 at a much slower rate than individuals with pale skin
- The colour of skin is
 1. A variable of polygenic traits which explains the variability of pigment intensity
 2. An adaptation to UV radiation
 3. Only and indicator of the environment in which populations have lived

7.5 Origin of Species

→ Phyletic Speciation (anagenesis): gradual evolution or “linear” succession of species in a way that the changing species shows different phenotypes through time

→ Multiplication of Species (cladogenesis): creation of species by establishing a reproductive barrier between them.

- Cladogenesis: only mechanism responsible for the creation of the biodiversity Ex: evolution of primates
 - From a genetic standpoint, a premise for the multiplication of species interruption of migration or gene flow between populations, allowing populations to evolve independently
- Allopatric Speciation: a population with continuous distribution divided in two or multiple populations by a geographical barrier: Steps:
 1. Passive isolation of populations in space (while they are isolated, slightly different environmental pressure in each habitat) ⇒ no more gene flow
 2. A genetic modification, under the combined effect of isolation and selective pressures, replaces a co-adaptive system the genes by another, more suitable to different ecological conditions
 3. Acquisition of reproductive isolation before the subsequent overlapping areas
- *Complete speciation*: no viable hybrids in the contact zone (sympatric area) between areas
- The dispersal capabilities of individual is important in defining the probability of speciation in some groups when compared to other groups
- The isthmus of Panama (completed approx. 3myr ago) has created a barrier between populations of ancestral species and created a new species

Ex: Eastern Meadowlark (*Sturnella Magna*) and Western Meadowlark (*Sturnella neglecta*) Minimal phenotypic differences (distinct song and behaviour); Evolved different songs while isolated- no hybrids observed in contact zones in field since females can identify song differences; In lab settings hybrids will occur, this doesn't count as speciation; (reproductive barrier still present) Reproductive barrier:

1. Acquired when species in isolation
2. When area of sympatry re-occurs, they are unable

→ Sympatric Speciation: new species appears within a population (speciation without geographic isolation)

- ex: Polyploidy (30%-40% of plants): multiplying the normal # of chromosomes. Can happen when the chromosomes do not separate during meiosis which produces diploid gametes (instead of haploids) Rare in animals
- ex: Thornapple maggot is native to N. America. Flies deposit eggs inside the apples. Eggs hatch, develop, feed inside fruit.
- Positive assortative mating in flies- same habitat reproduction only

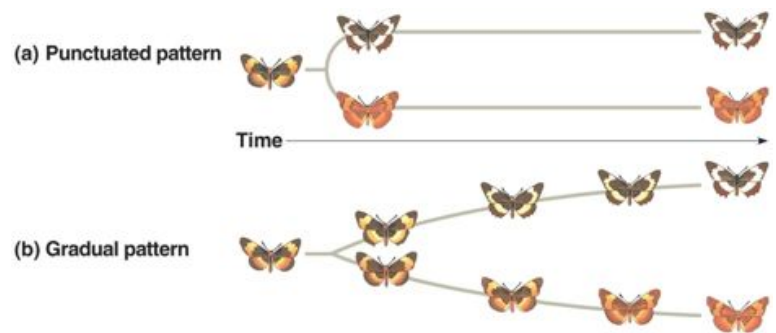
- Two morphs of *Rhagoletis pomonella* in the process of sympatric speciation
- Divergent Selection: selection in terms of habitat use (apple tree vs thornapple)
- Positive Assortative mating: habitats

7.6 Hybrid Zones

- Alleles proper to fire-bellied toad, absent in yellow-bellied toad. Allele goes down very quickly from one end of the hybrid zone to the other.
- No fusion of the species outside hybrid zone
- hybrids have weird morphology, some sterile individuals, developmental issues, associated with a specific intermediate habitat
- Reinforcement of reproductive barriers: fusion of the species
- Ex: polar bear & grizzly bear live in different habitats
 - Grolar bear: rupture of reproductive isolation between grizzly and white bears. Exception: CONsequence of global warming?
 - If polar get used to life on the continent instead of ice, they may get in contact and produce hybrids
 - Common ancestor 400000 years ago
- Character Displacement: the differences between two related species are often greater in sympatric areas (eg 2 species of Galapagos finches)
 - Species separated: allopatric
 - Two species on same island: character displacement
 - Different beak size on the same island: females are then able to identify the males of their own species
 - Females choose males of their own species when the morphology of males is different (sympatric areas)
 - Females make mistakes when the females look the same (allopatric zones)
 - Reproductive barriers between two species
- Turbid water for 20 years: progressive fusion gene pools (hybridization) of the two cichlid species ⇒ lower visibility, females make mistakes in choosing males
 - Sexual dimorphism within the species
 - Female recognize their male based on colour pattern
 - “Turbid water” hybrid offspring from location with dirty water
- If the reproductive isolation is incomplete, there could be the creation of a stable of hybrid zone that contains hybrids. In these narrow geographical zones, there are genes or alleles of a species that pass freely into the gene pool of another species (**gene introgression**)

7.7 Tempo of Speciation

- Process of speciation: 4000 years to 40 million years average:
- 6,500,000 years ⇒ seems very high (avg life of species about the same length)
- rarely less than 500,000 years
- Punctuated pattern (Punctuated EQM): ancestral species submitted to



allopatric/sympatric speciation; mostly morphological change in daughter species will occur at speciation time

- Gradual pattern (phyletic gradualism): when speciation occurs, the act of speciation when barrier is formed, there's very little morphological change that will occur. All morphological change will occur in the lifetime of the individual, AFTER speciation
 - Species are always adapting to their environment
 - Darwinian