Selection & Evolution

CHP 17

VARIATION

- Caused by:
  - independent assortment
  - crossing over
  - random mating
  - random fertilisation
  - } reshuffle existing alleles - produce phenotypic variation
  - mutation } produce completely new alleles
- mutation
  - new allele often recessive
  - somatic mutations cannot be passed to offspring
- variation also caused by environment
  - ↳ not passed to offspring
- variation within pop. ⇒ some individuals have advantage
  - ↳ genetic variation provides the raw material on which natural selection can act.
- Variation ⇒ any diff between cells, individual organisms by genetic effect / environmental factors.

CONTINUOUS & DISCONTINUOUS VARIATION

Quantitative | Qualitative

- Similarities:
  - both differences in phenotype may be inherited
  - both may involve several genes.
- Differences:

DISCONTINUOUS	CONTINUOUS
Diff alleles @ single gene locus have ↑ effect on phenotype	Diff alleles @ single gene locus hv small effects on phenotype (2×)
Diff genes hv diff effect on phenotype	Diff genes hv same (often additive) effect on phenotype. (2× + 2× = 4×)
	↑ number of genes may hv combined effect ⇒ polygenes

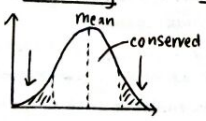
ENVIRONMENTAL EFFECTS ON PHENOTYPE

- Environmental effects may allow full genetic potential (height) to be reached / stunt it
  - ↳ eg. ↓ nutrition, ↓ light intensity
- t- test used to compare variation of 2 different populations
- ∴ in selective breeding – must know how much of the phenotypic variation is genetic & environmental.

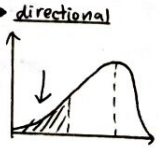
EVOLUTION

- theory ⇒ organisms have changed over time.
- Natural selection keeps things the way they are ⇒ **stabilising selection**
- if new environmental factor / new allele appears, allele frequency changes ⇒ **directional selection**
- Conditions favour both extremes of a population ⇒ **disruptive selection**

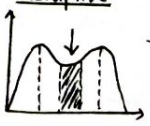
- stabilising



- directional



- disruptive



NATURAL SELECTION

⇒ Effects of selection pressures on the frequency of alleles.

- As pop ↑, environmental factors ↓ numbers
  - ↳ biotic (Eg predation, competition)
  - ↳ abiotic (Eg H_2O supply, nutrient level)
  - ↳ Eg, Rabbit↑, grass ↓ + fox↑, rabbit ↓ + disease↑
- if pressure of environmental factor large, pop ↓.
  - ↳ when fallen considerably ⇒ rise
  - ↳ ∴ pop oscillate about mean level
- Variation within population ⇒ some will hv features which give them an advantage in the 'struggle for existence'.
  - ↳ Eg. Alleles for agouti coat have selective advantage over alleles for white.
    - → white rabbit preyed on ∴ cannot mature & reproduce.
- fitness ⇒ capacity of an organism to survive & transmit its genotype to its offspring
- Natural selection raises the frequency of alleles conferring an advantage & reduce frequency of alleles conferring disadvantage.

NEW ALLELE

- mutations may be useful
- evolution occurs because natural selection gives some alleles better chances of survival than others
- changes in allele frequency in a pop are basis of evolution.
- Eg: antibiotic resistance, sickle cell anaemia.

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Selection & Evolution

natural selection

ALLELE FREQUENCY
- natural selection (non-random)
- genetic drift (random)

ANTIBIOTIC RESISTANCE

- When penicillin taken, bacteria sensitive to penicillin die.
- May be one or more individual bacteria with an allele giving resistance to penicillin.
- Bacteria have one single loop of DNA ∴ only 1 copy of each gene
  - ↳ mutant allele have immediate effect on phenotype.
- have selective advantage ∴ survive & reproduce.
- By using antibiotics, we change the environmental factors which exert selection pressure on bacteria.
  - ↳ antibiotic ↑, selection pressure ↑
- Alleles for antibiotic resistance often occur on plasmids
  - ↳ ∴ frequently transferred.

INDUSTRIAL - MELANISM

- changing environmental factors may produce changes in allele frequency.
- C - speckled (common in non-industrial)
  C - black (common in industrial)
- selection pressure causing change of allele frequency in industrial areas → predation by birds.
- ↑ pollutants, lichens do not grow ∴ trees have darker bark ∴ dark moths better camouflaged.
- Speckled (C) eaten before they could reproduce.
- Changes in environmental factors only affect likelihood of an allele surviving in a population [NOT] likelihood of allele arising from mutation.

SICKLE CELL ANAEMIA

- sickle cell allele most common = where malaria is found.
- 2 strong selection pressures acting on Hb^S, Hb^A
  - Selection against Hb^SHb^S = strong
    - ↳ become seriously anaemic
  - Selection against Hb^AHb^A = strong
    - ↳ more likely to die from malaria.
- ∴ Hb^AHb^S have strong selective advantage
  - ↳ x anaemia, x malaria.
- non-random process on allele frequency.

GENETIC DRIFT

↳ change in allele frequency that occurs by chance.

- Small no. of individuals are separated from rest of large population.
- only small sample ∴ unlikely to have same allele frequencies as large pop.
- further genetic drift occurs
  - ↳ evolution of this pop. take diff direction from larger parent pop.
  - → founder effect.

HARDY - WEINBERG PRINCIPLE

- calculate proportions of genotypes in a large randomly mating pop.
- conditions:
  - large pop.
  - no mutation
  - random mating
  - no selection pressure
  - no migration
- p - frequency of dominant allele
  q - frequency of recessive allele
- $p + q = 1$
  $p^2 + 2pq + q^2 = 1$
  - $2pq$ ∵ either A/a or a/A (paternal / maternal)
- can determine diff genotypes in pop, & predict ratios in next generation. Compare w/ observed results using χ^2
- sig. diff & no migration & random mating, then directional selection occuring.

ARTIFICIAL SELECTION

- when humans purposefully apply selection pressures.
- to improve features.
- individuals w/ desirable features chosen to interbreed → selective breeding
- some desirable alleles passed to offspring
- offspring w/ most desirable features chosen to interbreed, repeat over many generations
- frequency of advantageous alleles ↑
  frequency of disadvantageous alleles ↓
- For dairy cows, docility, ↑ growth rate, ↑ milk yields.
- Bulls cannot be assessed for milk production ∴ → progeny testing
  - ↳ bull's female offspring used to see if bull suitable for further crosses.

Selection & Evolution

(ARTIFICIAL SELECTION)

- breeders have to consider whole genotype ∵ within each organisms genotype are all the alleles of genes that adapt it to its environment
  - ↳ background genes.
    - ↳ alleles of genes that help an organism adapt to its environment
- Problems → animal large & long time to mature
  - → gestation period long & no. of offspring is small
  - → background genes.

CROP IMPROVEMENT

- selective breeding produces new varieties of crop plants.
- farmers pick out best plants & allow them to breed & reproduce for next year
  - ↳ great changes in cultivated varieties of crop plants compared to ancestors.
- Purpose → diff varieties (eg high in gluten)
  - → resistance against diseases
  - → ↑ yields.
- For wheat, seed collections screened for disease resistance, climate resilience, efficient use of nitrogen fertilisers.
  - ↳ plants w/ suitable trait grown in large numbers & passed to commercial breeders.
- Dwarfed wheat → ↑ yeild, easier to harvest, less susceptible to being knocked flat by rain, produce less straw.
- wheat carry mutant alleles of reduced height (Rht) genes.

INBREEDING & HYBRIDISATION IN MAIZE

- If maize plants are inbred (crossed w/ genotypes like their own, plants in each generation become progressively smaller & weaker.
  - ↳ inbreeding depression.
- ∵ homozygous plants less vigorous than heterozygous ones.
- if outbreeding done @ random, maize variation ↑ ∴ difficult to harvest
- farmers buy hybrid seeds. (heterozygous)
  - ↳ large variety of hybrids for diff purposes.

- these genes code for DELLA proteins, which reduce effect of gibberellins on growth.
- ∵ more active transcription inhibitors produced.
- plant cells also do not have receptors for gibberellins due to mutant allele 'Tom Thumb'
- For rice, selective breeding used to produce varieties of rice that show some resistance to many diseases.

THE DARWIN - WALLACE THEORY OF EVOLUTION BY NATURAL SELECTION

- O_1 → organisms produce more offspring than are needed to replace the parents.
- O_2 → Natural populations remain stable in size over long periods.
- D_1 → There is competition for survival (Struggle for existence)
- O_3 → There is variation among the individuals of given species.
- D_2 → The best adapted variants will be selected for by the natural conditions operating at the time
  - ↳ survival of fittest.
- Today's → natural selection = selecting particular alleles / group of alleles

SPECIES & SPECIATION

- Species ⇒ group of organisms with similar morphological, physiological, biochemical & behavioral features which can interbreed to produce fertile offspring and are reproductively isolated from other species.
- Process of forming new species → speciation.
- Problems of testing by interbreedings.
  - → organisms are dead
  - → same sex
  - → no time / facilities
  - → organisms will not breed in captivity.
  - → asexual reproduction
  - → immature.
- To produce, new species, 2 groups of same species must undergo reproductive isolation.

Selection & Evolution

REPRODUCTIVE ISOLATION

- Prezygotic
  - → individuals not recognising one another as potential mates or not responding to mating behaviour.
  - → Animals being physically unable to mate
  - → incompatibility of pollen and stigma in plants
  - → inability of male gamete to fuse w/ female gamete
- Postzygotic
  - → failure of cell division in zygote
  - → non-viable offspring (offspring soon die)
  - → viable but sterile offspring

ALLOPATRIC SPECIATION

- Due to geographical isolation.
- Population of species ⊖ different areas, cannot mix.
- selection pressure different ∴ diff alleles selected for.
- overtime, morphological, physiological & behavioral features diff ∴ 2 populations could no longer interbreed.
- new species evolved.

SYMPATRIC SPECIATION

- through polyploidy → more than 2 complete sets of chromosomes in its cells.
- sterile hybrids undergo chromosome doubling → becomes fertile.
- allopolyploid contains 2 sets of chromosomes from 2 closely related species.
  - ↳ can be fertile.

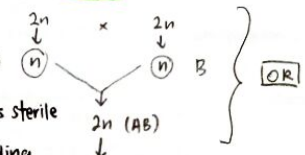
COMPARING AMINO ACID SEQUENCE

- small change in amino acid sequences do not change overall structure.
  - ↳ Eg. Active site of enzyme remains same but other parts diff.
- differences in sequence ↑, less closely related → share more recent ancestor.

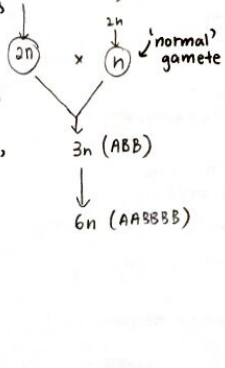
COMPARING NUCLEOTIDE SEQUENCE OF MITOCHONDRIAL DNA (mtDNA)

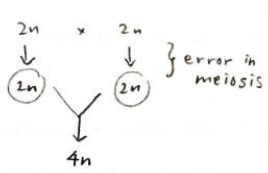
- Used to study Homo sapiens.
- mtDNA inherited through the female line ∵
- zygote contains the mitochondria of the ovum.
- mtDNA circular ∴ can't undergo crossing over, changes only due to mutation
- 'molecular clock' hypothesis
  - → constant rate of mutation over time
  - → greater number of differences in nucleotide sequence, longer ago shared common ancestor.
  - → calibrated using fossil evidence.

- cross between 2 species



- hybrid offspring is sterile
- chromosome doubling occurs because of failure of separation of chromosomes during meiosis
- tetraploid formed is fertile (occasionally)
- tetraploid crosses w/ diploid
- hybrid offspring is sterile, triploid formed
- chromosome doubling ∴ hexaploid formed





EXTINCTIONS

- due to → climate change
  - → increased competition from better adapted species
  - → human causes.
- mass extinctions → sudden change in environment
  - → asteroid
- reasons for conservation failure
  - → lack of political support
  - → ↑ demand for animals/plants
  - → criminal groups.