BACK TO SCHOOL: **EVOLUTION**

Evolution and the Natural World

Lecture 3

22/09/2021

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NATURAL SELECTION

From an organism’s perspective

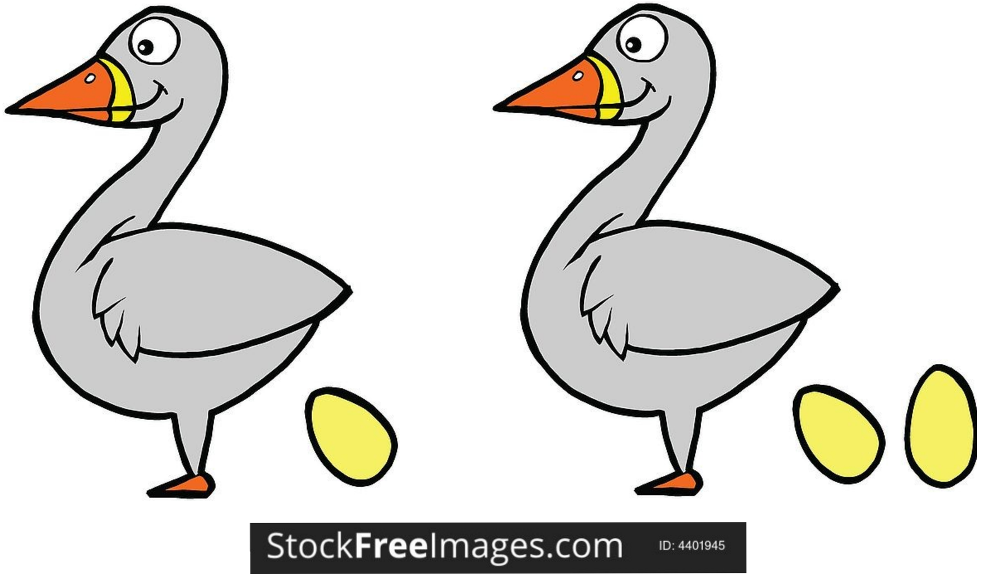
Evolution vs Natural Selection

Evolution vs Natural Selection

- Evolution is the process of change over generations

- Natural selection is (one of) the mechanism of evolution – differential survival and reproduction

Requirements for NS



- Organisms of the same species differ
- Those differences result in differantial reproduction
- Those differences are heritable

Adaptations increase fitness

https://adlayasanimals.wordpress.com/2013/11/17/fiddler-crab-genus-uca/

Things are a bit more complicated

- No simple correspondence between genotype and phenotype
- Genes (alleles) are transmitted across generations, not traits (phenotype)
- Better phenotypes have higher chances of reproducing but still can fail due to random reasons
- Any adaptation is a match to the environment – so it is relative

EVOLUTION

The genetic perspective

What are the sources of diversity?

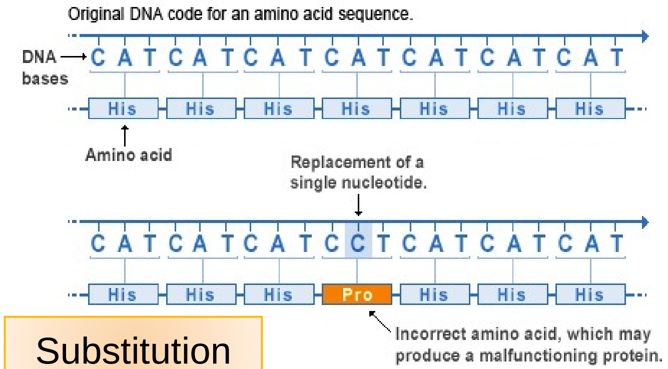
https://www.bandt.com.au/marketing/dont-just-talk-talk-actively-foster-diversity-inclusion-top

- Interaction with environment – often not heritable
- **Genetic differences**
  - Mutations – source of new alleles
  - Different combinations of alleles from the parents

Mutations: types

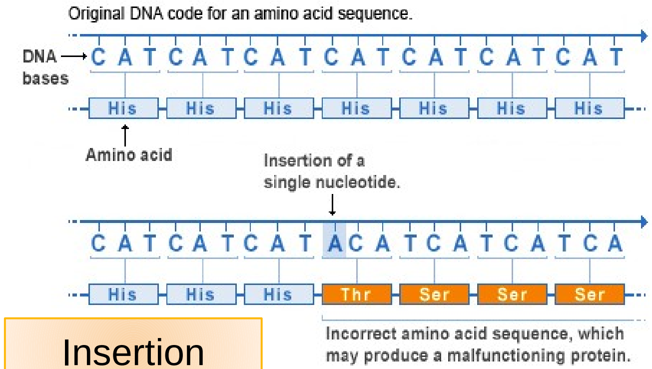
- Mutations in the coding sequence of the gene
- Mutations in the regulatory sequences (promoters, enhancers and others)
- Mutations in non-functional sequences

Mutations: types



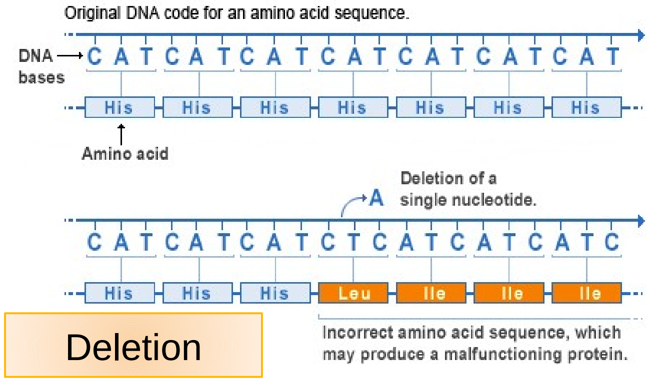
Substitution

U.S. National Library of Medicine



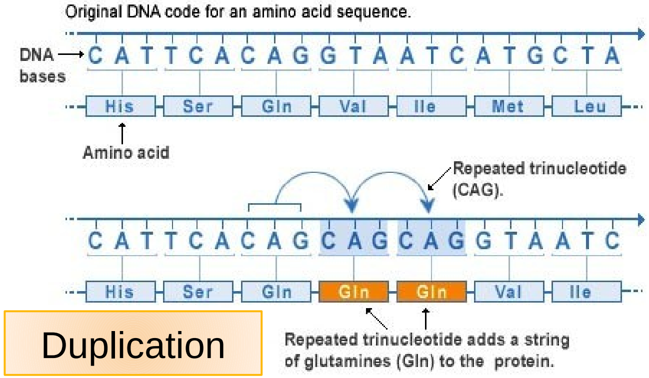
Insertion

U.S. National Library of Medicine



Deletion

U.S. National Library of Medicine



Duplication

U.S. National Library of Medicine

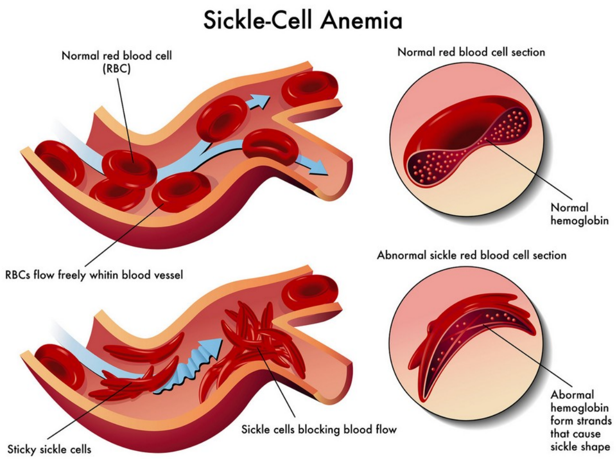
Mutations: effects

- Neutral – no or little effect on the phenotype
  - Redundancy of the genetic code (several codons for 1 AA)
  - Non-functional DNA (junk DNA)
  - Redundancy of biological systems (several genes/pathways for the same function)
  - Affect the phenotype but it doesn`t matter
- Harmful
- Beneficial

Depends on the environment

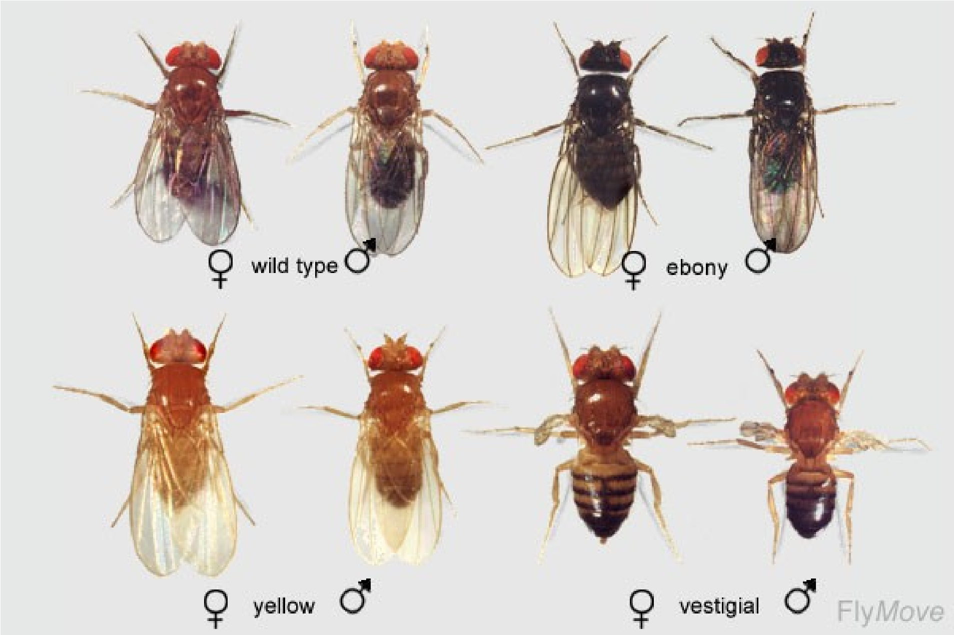
Mutations: examples

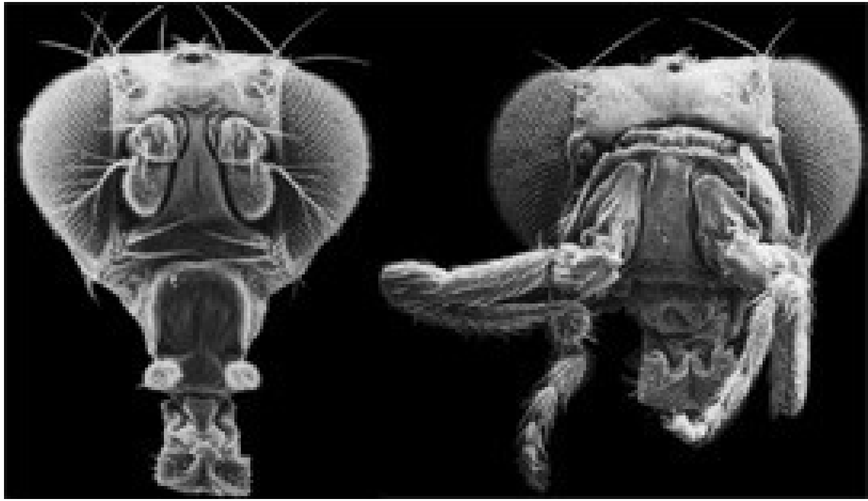
- Humans:
  - Haemophilia, cystic fibrosis, phenylketonuria
  - Skin colour, lactase persistence, HIV resistance
  - Sickle cell anemia
- Bacteria
  - Antibiotic resistance



Mutations: examples

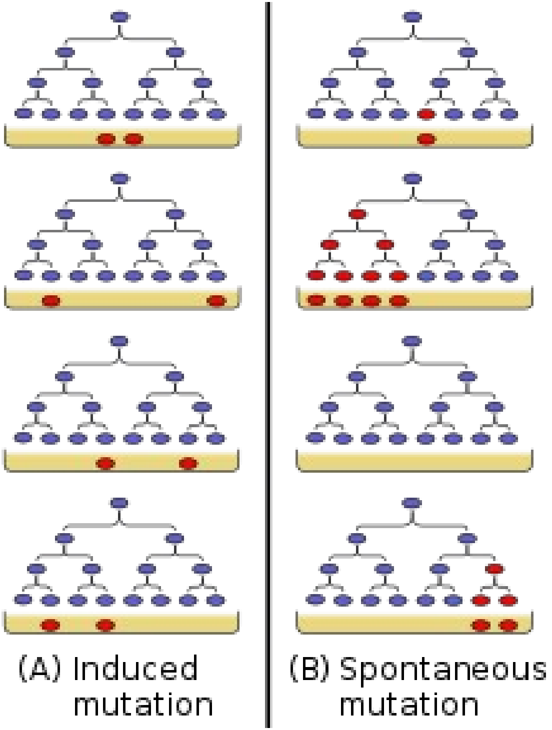
- Drosophila



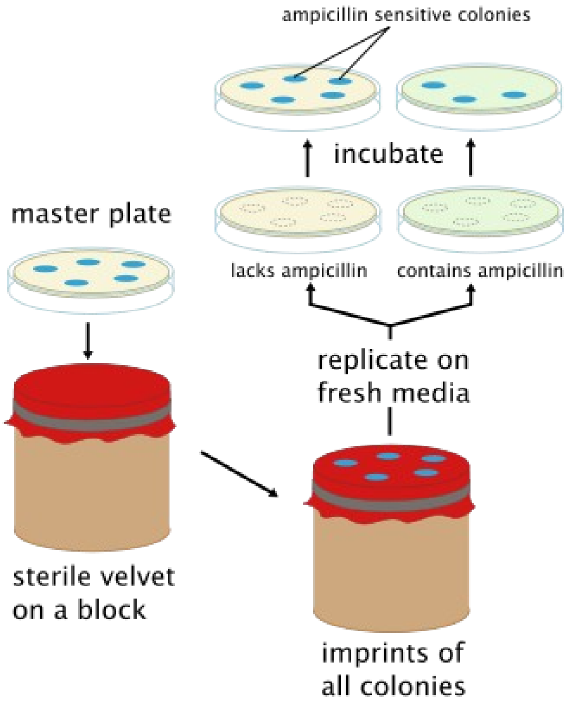


http://flymove.uni-muenster.de/Media/FindMediaOutput.php?thema=Genetics
https://thebrain.mcgill.ca/flash/capsules/outil_rouge05.html

Mutations: random or induced

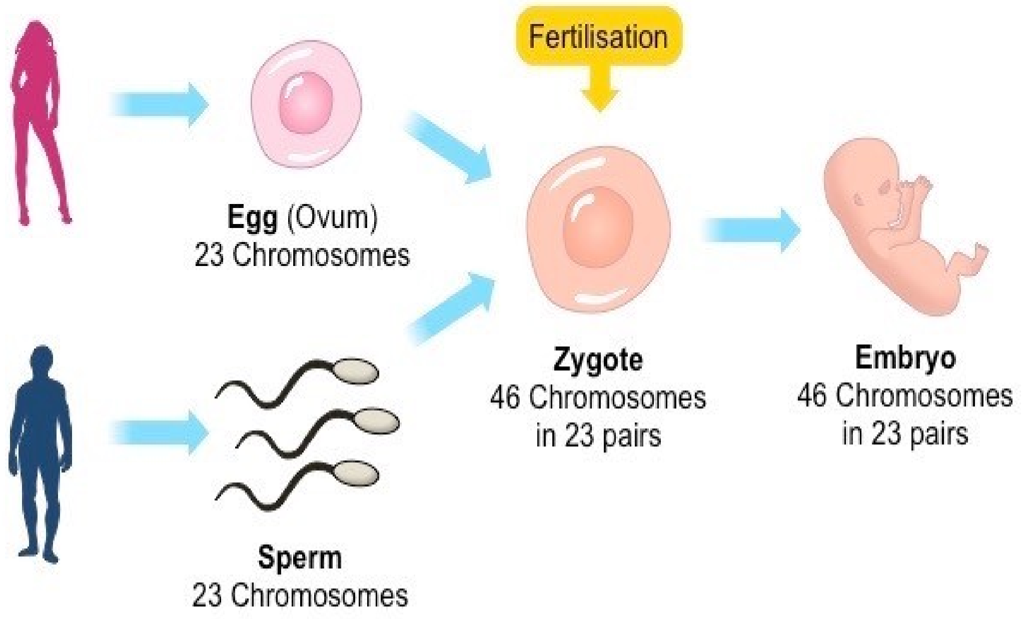


Luria and Delbruck experiment



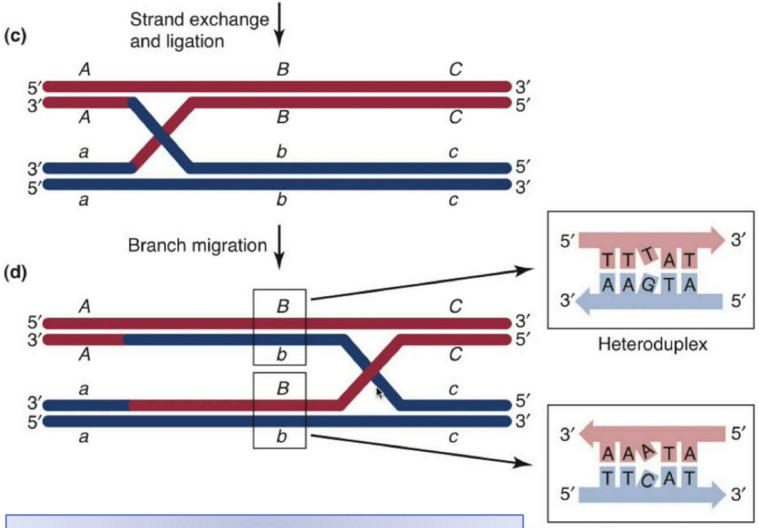
Newcombe experiment

Sexual reproduction



https://ib.bioninja.com.au/standard-level/topic-6-human-physiology/66-hormones-homeostasis-and/sexual-reproduction.html

- Aa x Aa > AA, Aa, aa
- AAbb x aaBB > AaBb

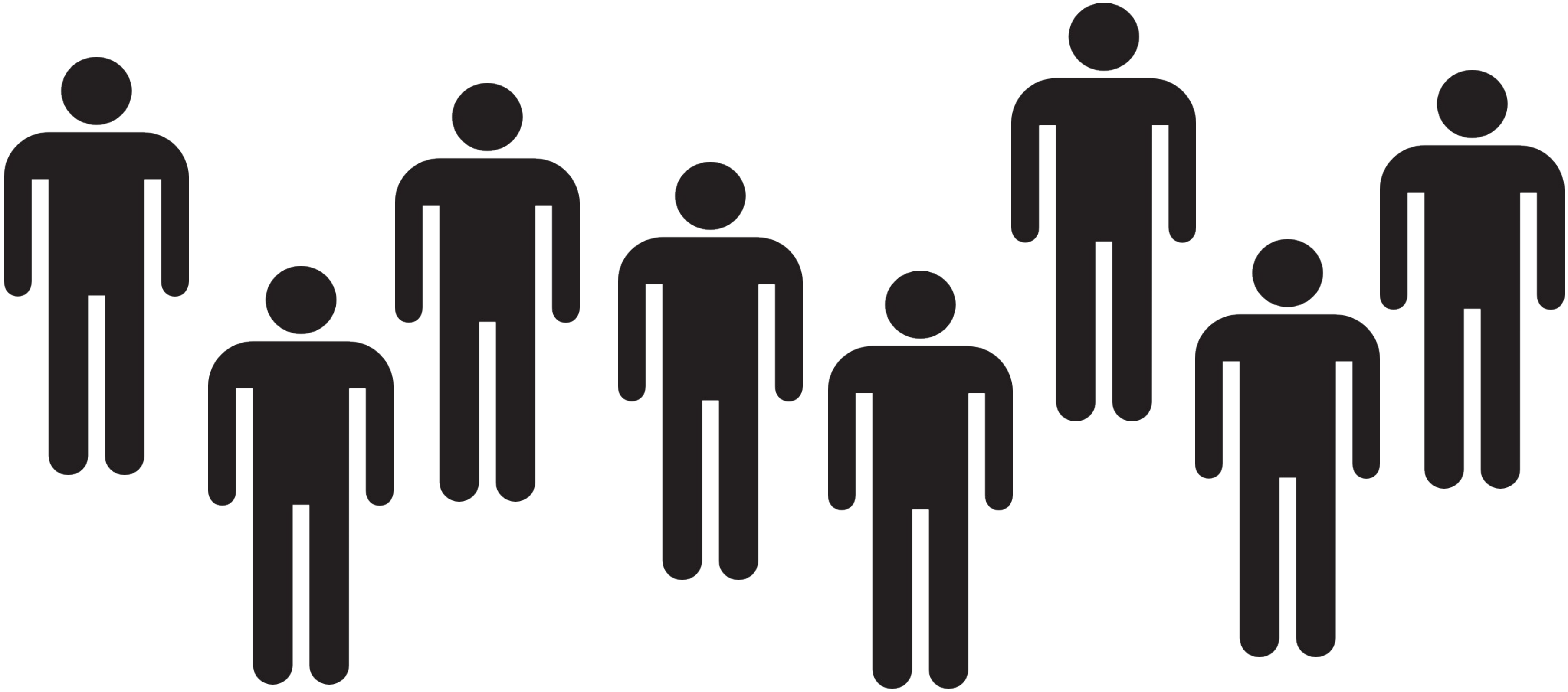


Genetic recombination

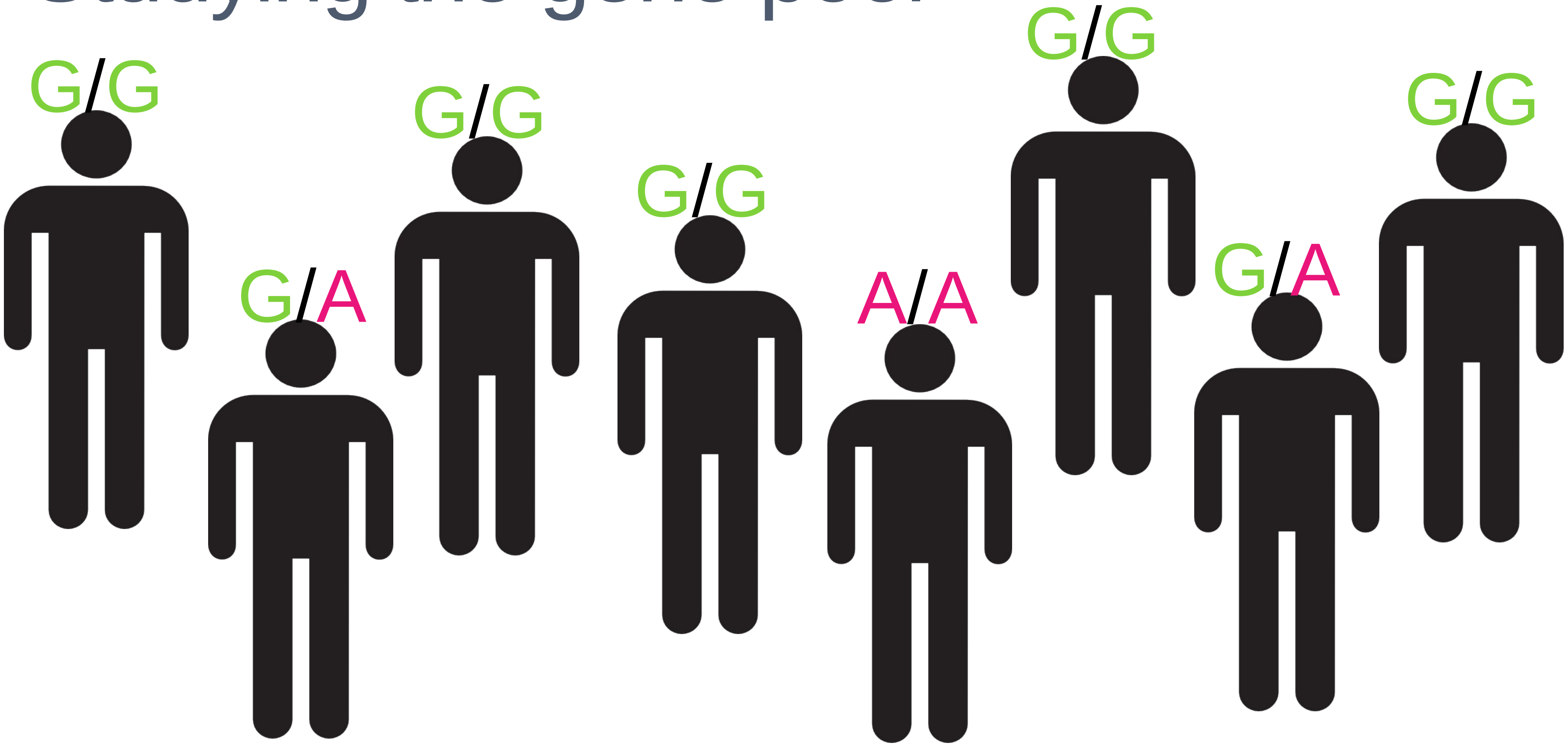
Population is what evolves

- Evolution is about "good" phenotypes becoming more frequent in a population over generations
- This is due to changes in allele frequencies

Population genetics



Studying the gene pool



Studying the gene pool

G/G

G/G

G/G

G/G

G/G

G/A

A/A

G/A

Studying the gene pool

G/G

G/G

G/G

G/G

G/G

G/A

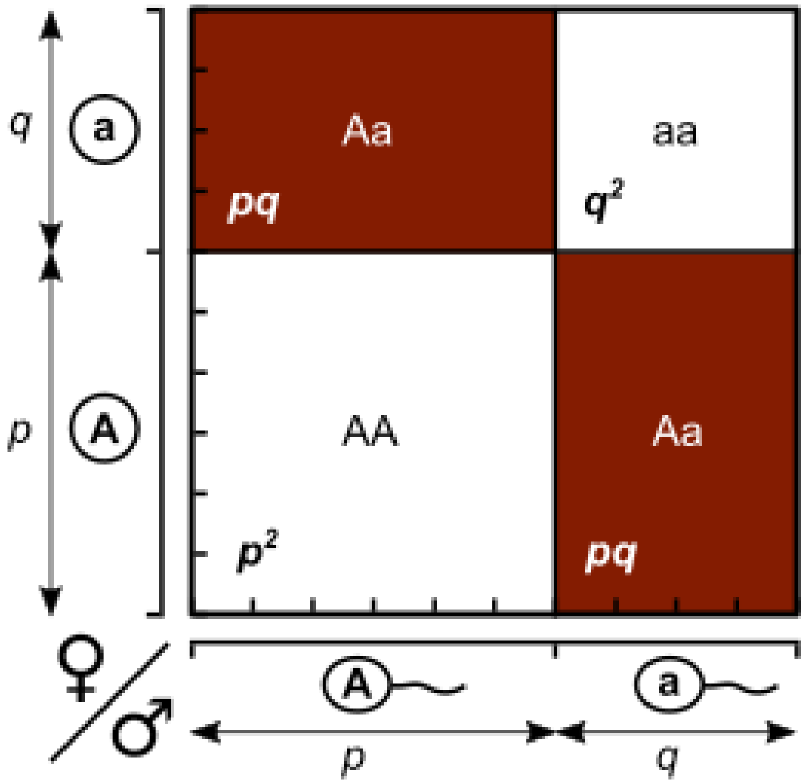
A/A

G/A

Genotype	Count	Frequency
G/G	5	62.5%
G/A	2	25%
A/A	1	12.5%

Allele	Count	Frequency
G	12	75%
A	4	25%

Hardy-Weinberg Principle



- If you know **genotypes** frequencies – you can **calculate alleles** frequencies
- If you know **allele** frequencies, you can **expect** certain **genotypes** frequencies based on some assumptions

HW Principle: Assumptions

- Mendelian inheritance
- All genotypes equally likely to survive and reproduce (= no natural selection)
- Panmixia
- No random effects

In many cases deviations from these assumptions are subtle, so the principle generally holds

Strong deviations from HW may indicate that something interesting is going on

Is the population at HW?

PRNP protein amino acid residue # 129			
	Met/Met	Met/Val	Val/Val
Observed	16	86	23
Expected			

Is the population at HW?

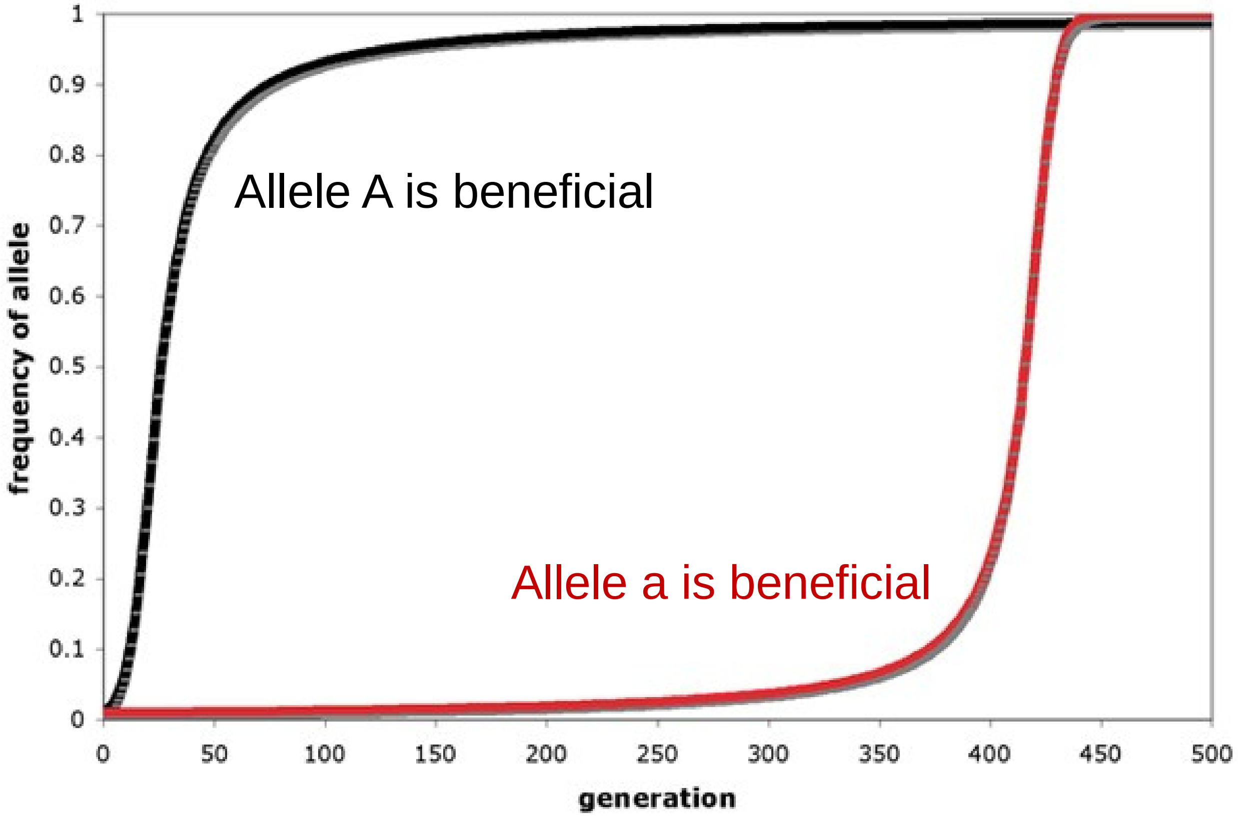
PRNP protein amino acid residue # 129			
	Met/Met	Met/Val	Val/Val
Observed	16	86	23
Expected	28	62	35

Processes shaping the gene pool

- Mutations
- Recombination
- Natural selection
- Gene flow
- Genetic drift

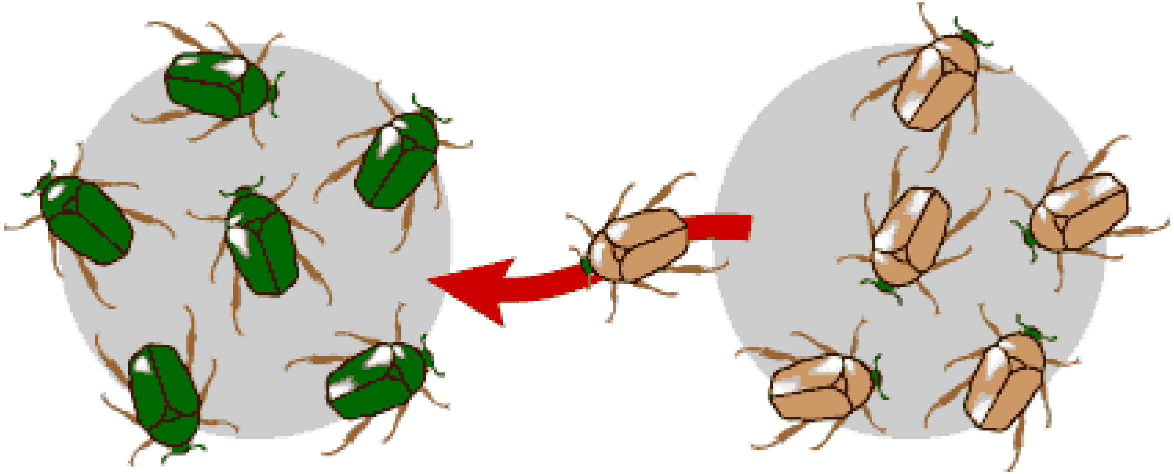
Randomly create new alleles and combinations thereof

Natural selection



- Leads to an increase in frequency of beneficial alleles and reduction in frequency of harmful alleles

Gene flow



- Changes the gene pool by bringing alleles and genes from other populations
- Additional source of diversity

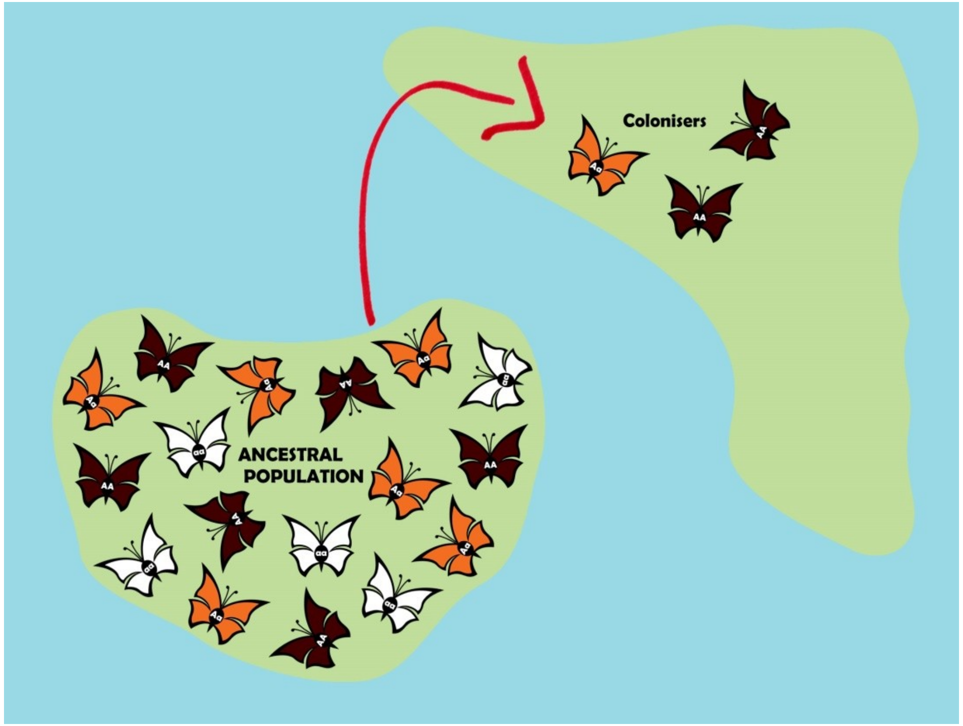
https://evolution.berkeley.edu/evolibrary/article/evo_21

Genetic drift

https://evolution.berkeley.edu/evolibrary/article/evo_24

- One example: same phenotype but different genotypes
- Leads to random changes in alleles frequencies, irrespective of their effect on fitness

Genetic drift: population size matters



https://www.pathwayz.org/Tree/Plain/FOUNDER+EFFECT

- The smaller the number of individuals, the stronger the effect of random processes
- Bottleneck and founder effects
- Small populations may have rather high frequencies of harmful alleles

Genetic drift: population size matters

- Genetic drift is important for human genetics

Population genetics: key points

- All genes and their alleles comprise a gene pool of a population
- Mutations create new alleles and genes
- Sexual reproduction creates new combination thereof
- Gene flow results in genetic exchange between populations; genetic exchange between species is also possible

Population genetics: key points

- Allele frequencies change over time due to random processes (genetic drift) and because some alleles have phenotypic effects that increase the chances of that allele being passed over to the next generation (natural selection)
- All those process together result in a change of the gene pool and population-average phenotype over time