UNIT 8 | EVOLUTIONARY THEORIES

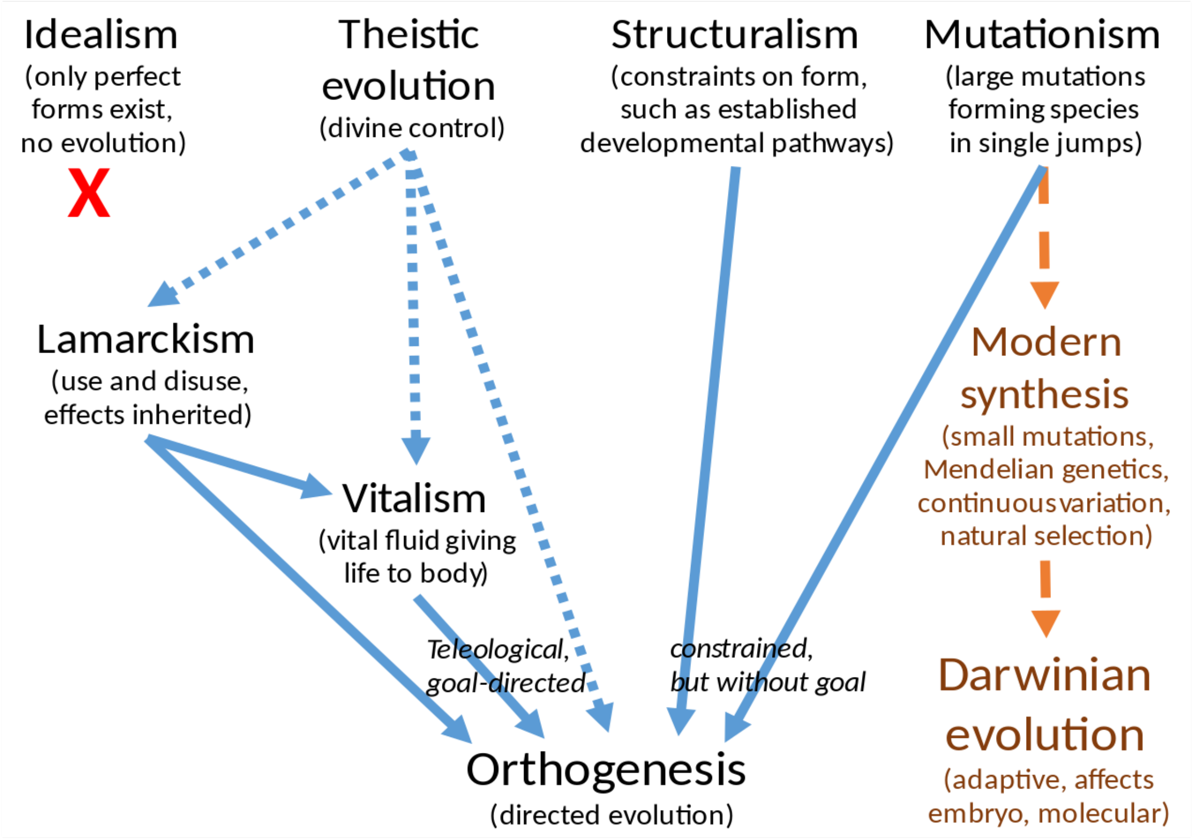
Source: https://www.bbvaopenmind.com/

Rafael Navajas-Pérez
www.rafaelnavajas.eu

UNIVERSIDAD DE GRANADA

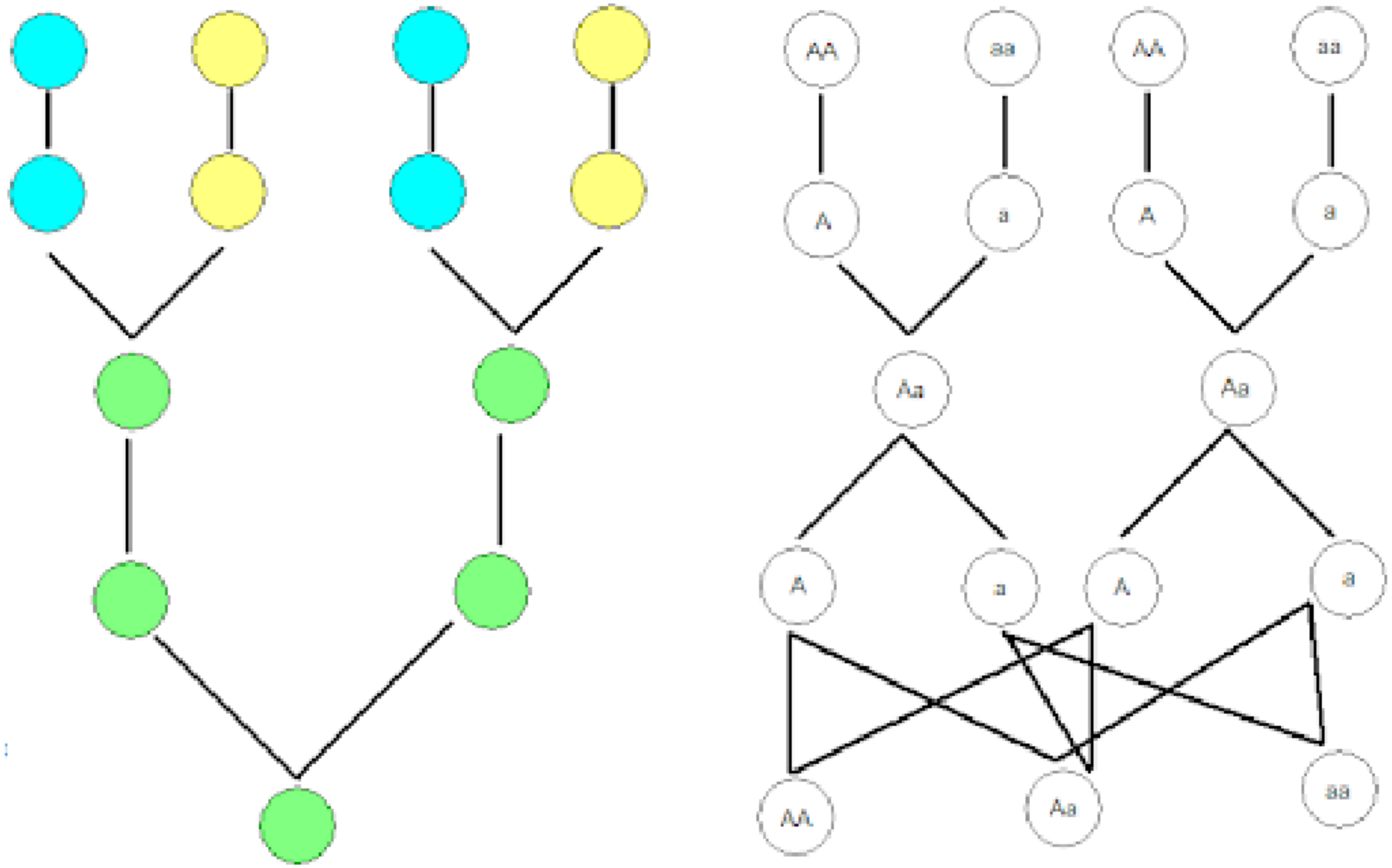
THEORIES OF EVOLUTION

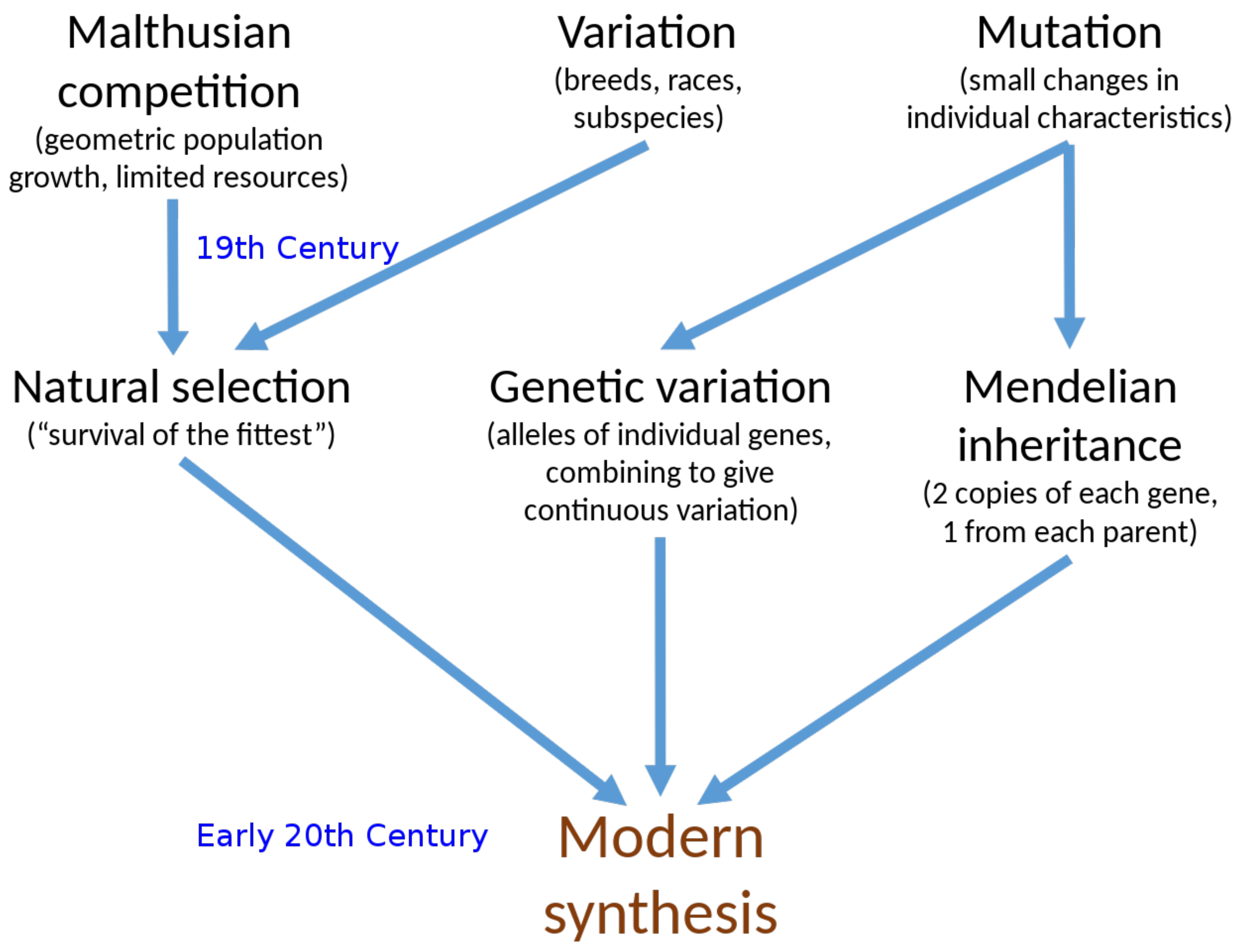
Theory	Date	Notable proponent	Species can change?
Scala naturae[6]	c. 350 BC	Aristotle	No
Great chain of being[1]	1305	Llull, Ramon; scholastics	No
Vitalism[21]	1759	Wolff, Caspar Friedrich	Yes
Theistic evolution	1871–6	Gray, Asa Mivart, St George J.	Yes
Orthogenesis[24]	1859	Baer, Karl von	Yes
Orthogenesis[25] inc. emergent evolution	1959	Teilhard de Chardin, Pierre	Yes
Lamarckism[26]	1809	Lamarck, Jean-Baptiste	Yes
Catastrophism[27]	1812	Cuvier, Georges	No
Structuralism[28]	1917	Thompson, D'Arcy	Yes
Saltationism[29][30] or Mutationism	1831	Geoffroy Saint-Hilaire, Étienne	Yes
Neutral theory of molecular evolution[31]	1968	Kimura, Motoo	Yes
Darwinian evolution[32]	1859	Darwin, Charles	Yes



Source: By Ian Alexander - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=62298929 and Wikipedia

BLENDING VS PARTICULATE INHERITANCE




Malthusian competition
(geometric population growth, limited resources)
Variation
(breeds, races, subspecies)
Mutation
(small changes in individual characteristics)
19th Century
Natural selection
("survival of the fittest")
Genetic variation
(alleles of individual genes, combining to give continuous variation)
Mendelian inheritance
(2 copies of each gene, 1 from each parent)
Early 20th Century
Modern synthesis

CHROMOSOMAL THEORY OF EVOLUTION

-**Nägeli** and **Beneden** observe for the first time plant and animal chromosomes, respectively (1842).

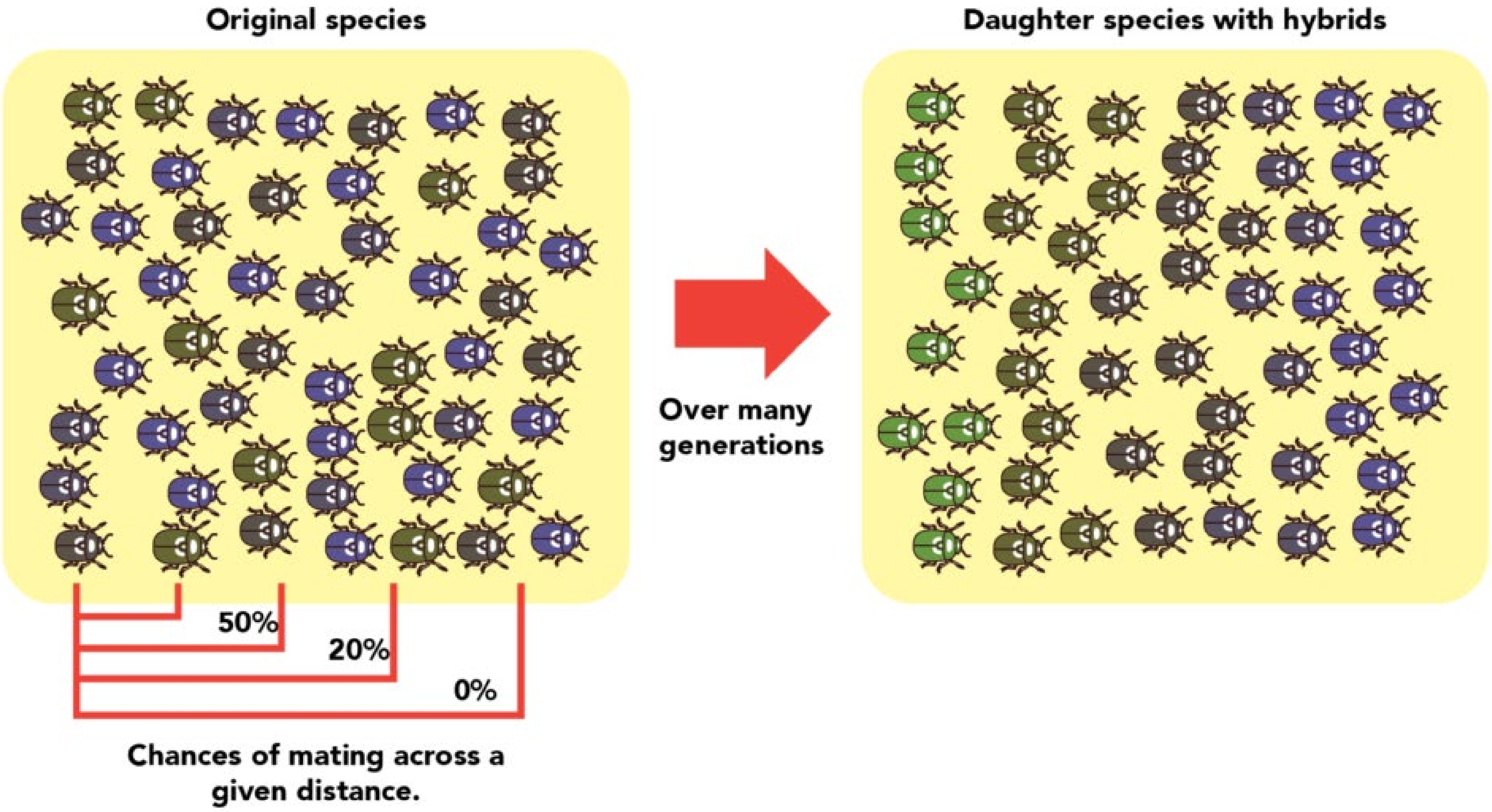
-**Wilhelm** coins the term *chromosome*(1888).

-**Sutton**, **Boveri** and **Morgan** chromosomal theory of evolution.

First human karyotype (1956)

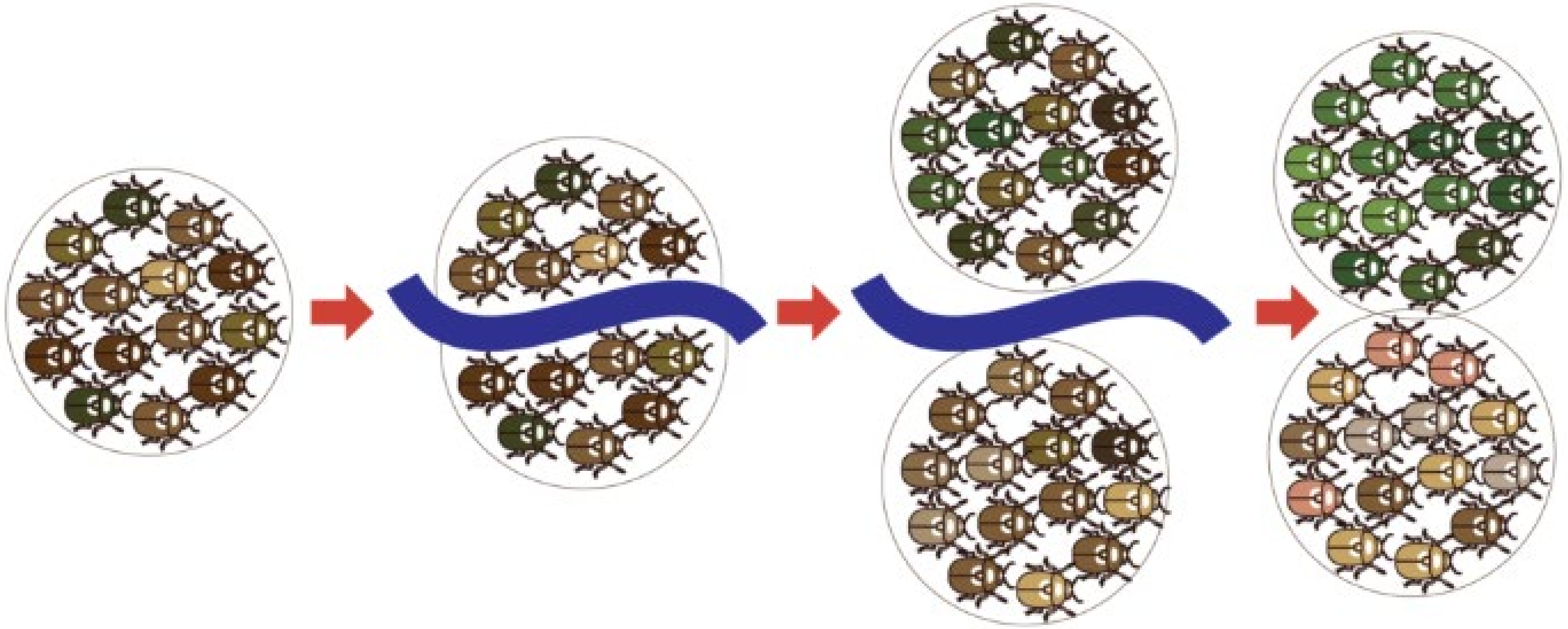
Fuente: Tjio, JH, Levan, A, The chromosome number of man, Hereditas: Genetitiskt Arkiv, Band 42 (1956), 1-2: pp. 1-6.

SPECIATION: Gene Flow



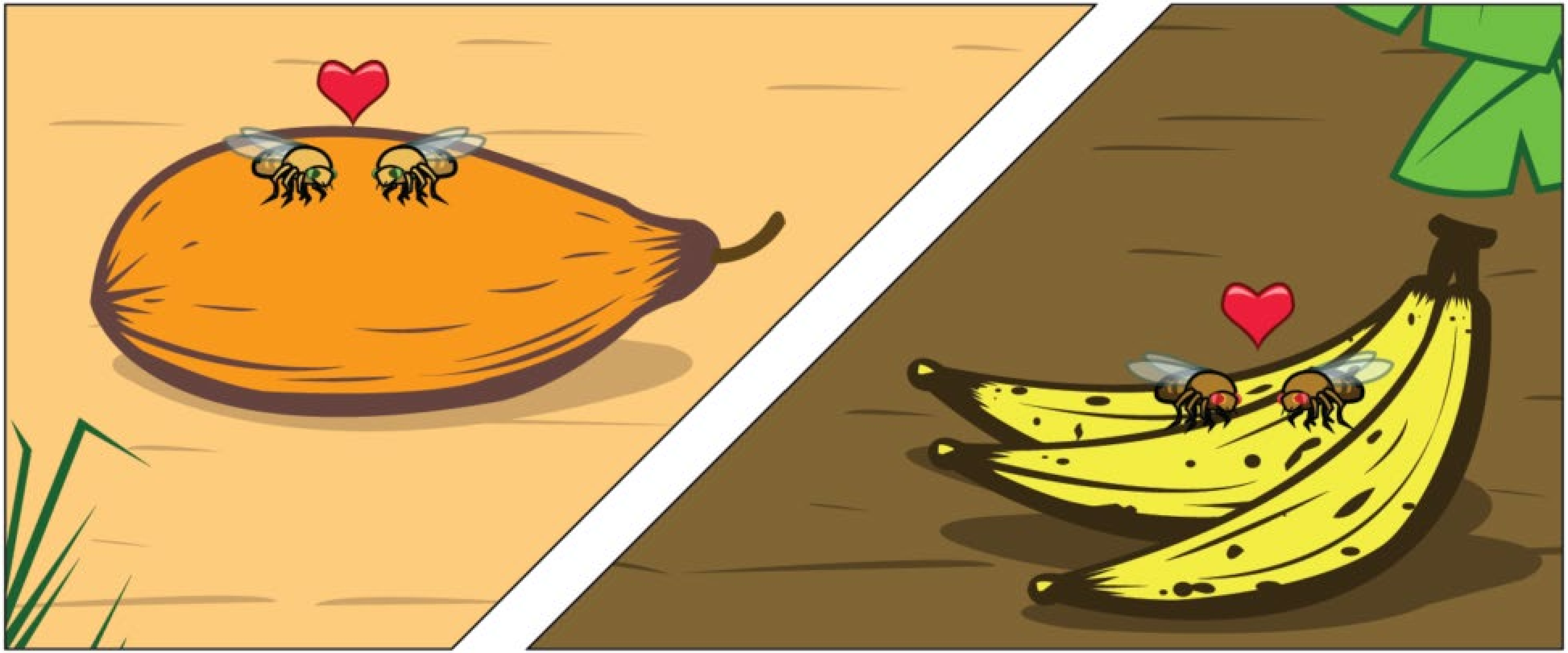
Source: https://evolution.berkeley.edu/

Allopatric speciation: speciation by geographic isolation. Something extrinsic to the organisms prevents two or more groups from mating with each other regularly, eventually causing that lineage to speciate. Isolation might occur because of great distance or a physical barrier, such as a desert or river.



Source: https://evolution.berkeley.edu/

Sympatric speciation: this speciation does not require large-scale geographic distance to reduce gene flow between parts of a population. It could be caused by the exploitation of a new niche, for example. This may automatically reduce gene flow with individuals exploiting the other niche.



Source: https://evolution.berkeley.edu/

EVIDENCE FOR EVOLUTION

- **Anatomy and Embryology.** Species may share similar physical features because the feature was present in a common ancestor.

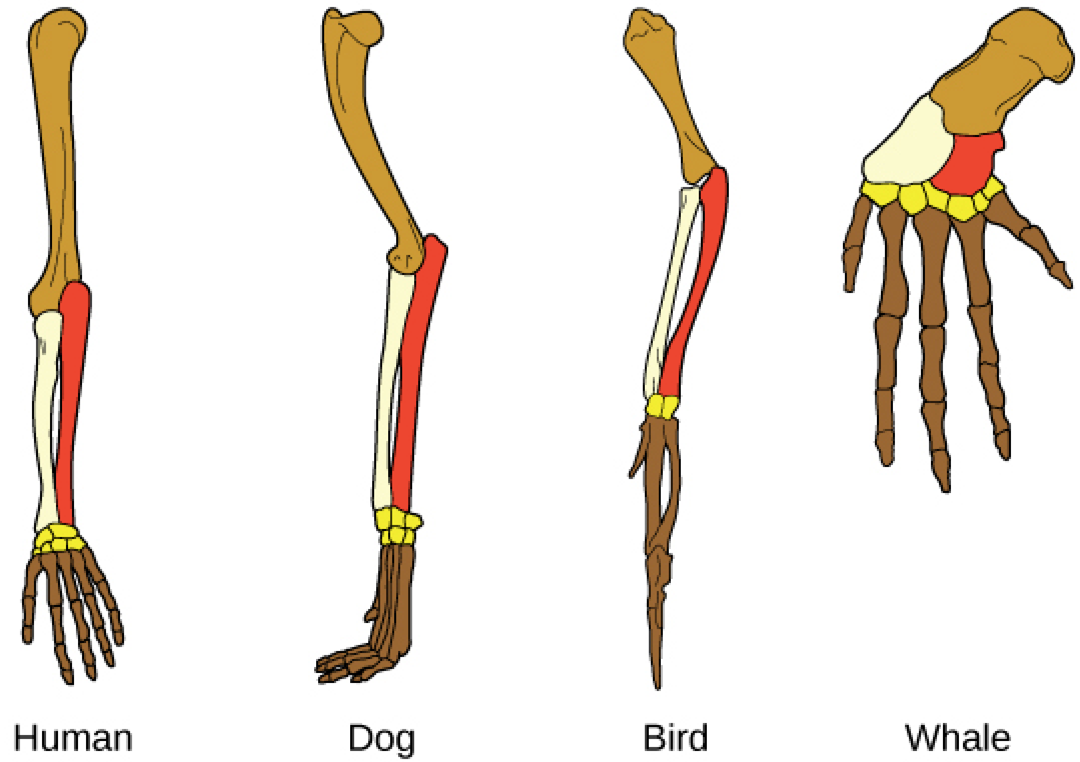
- **Biogeography.** The global distribution of organisms and the unique features of island species reflect evolution and geological change.

- **Fossils.** Fossils document the existence of now-extinct past species that are related to present-day species.

- **Molecular biology.** DNA and the genetic code reflect the shared ancestry of life. DNA comparisons can show how related species are.

Source: Khan Academy

EVIDENCE FOR EVOLUTION

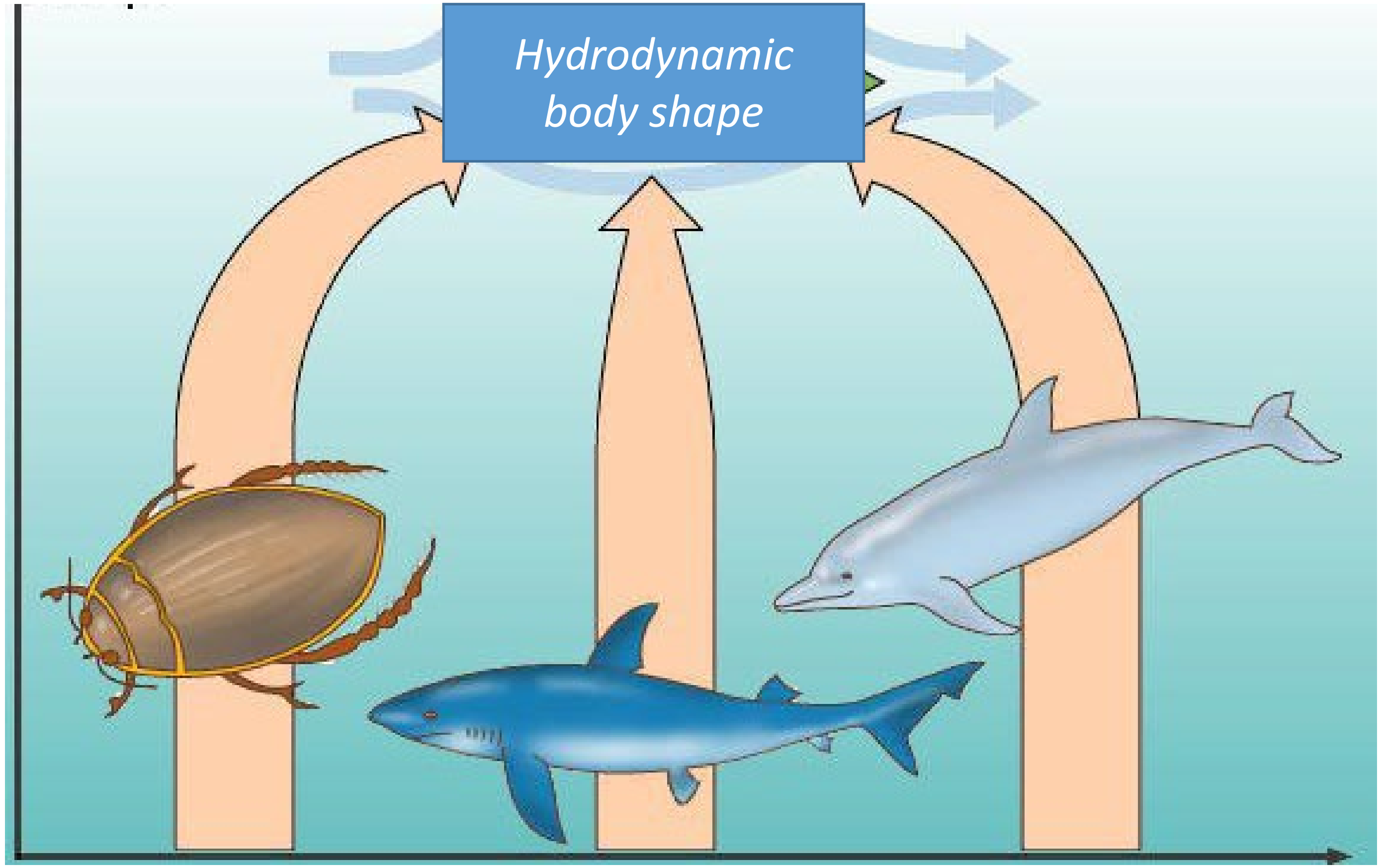


Physical features shared due to evolutionary history (a common ancestor) are said to be **homologous**. This can be caused by This process is called **divergent evolution**.

"Different function, same origin"

Source: Khan Academy

EVIDENCE FOR EVOLUTION

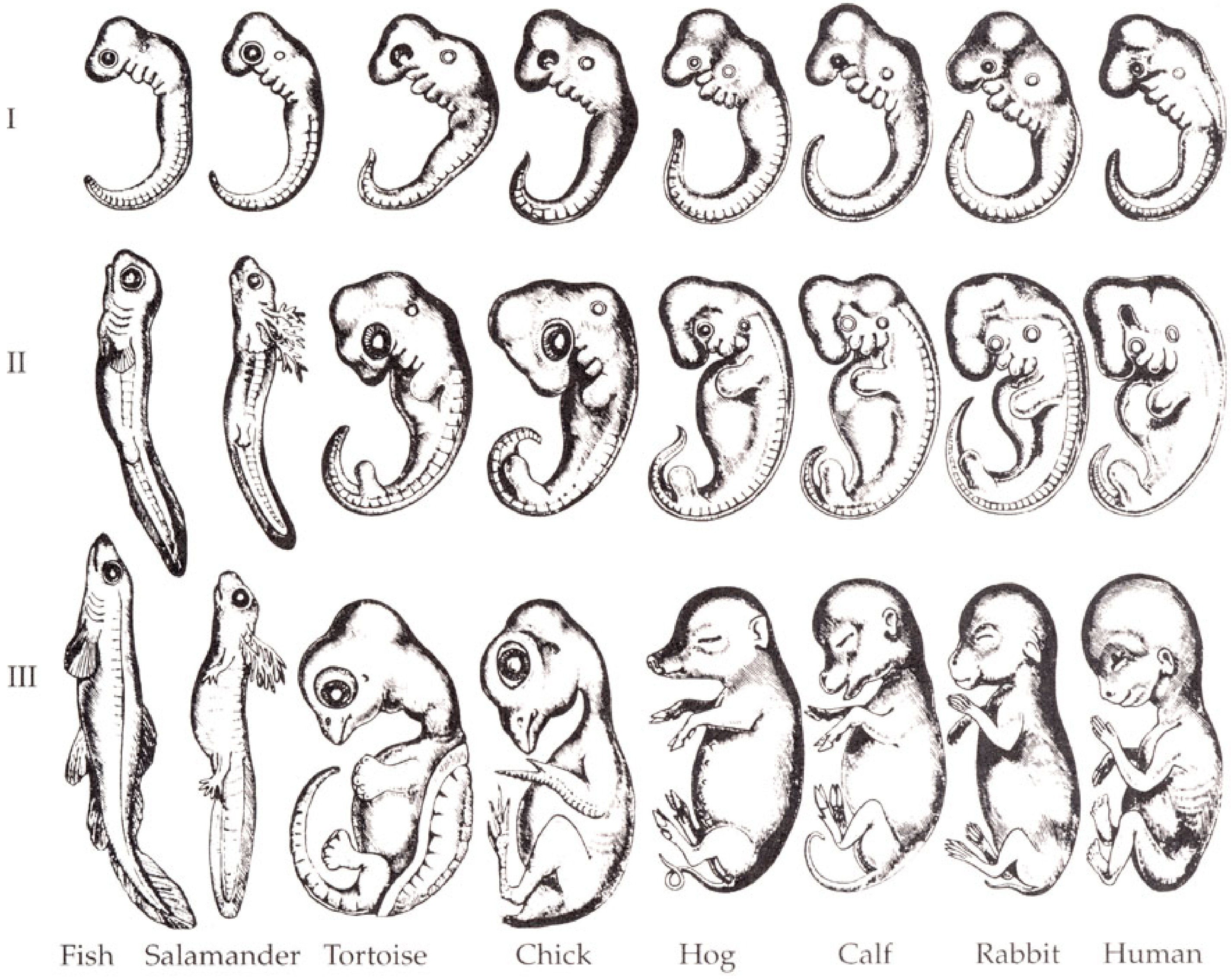


Instead, some physical similarities are **analogous**: they evolved independently in different organisms because the organisms lived in similar environments or experienced similar selective pressures. This process is called **convergent evolution**.

Source: Khan Academy & Proyecto Biosfera

EVIDENCE FOR EVOLUTION

Recapitulation Theory: "**ontogeny recapitulates phylogeny**"



Source: Wikipedia

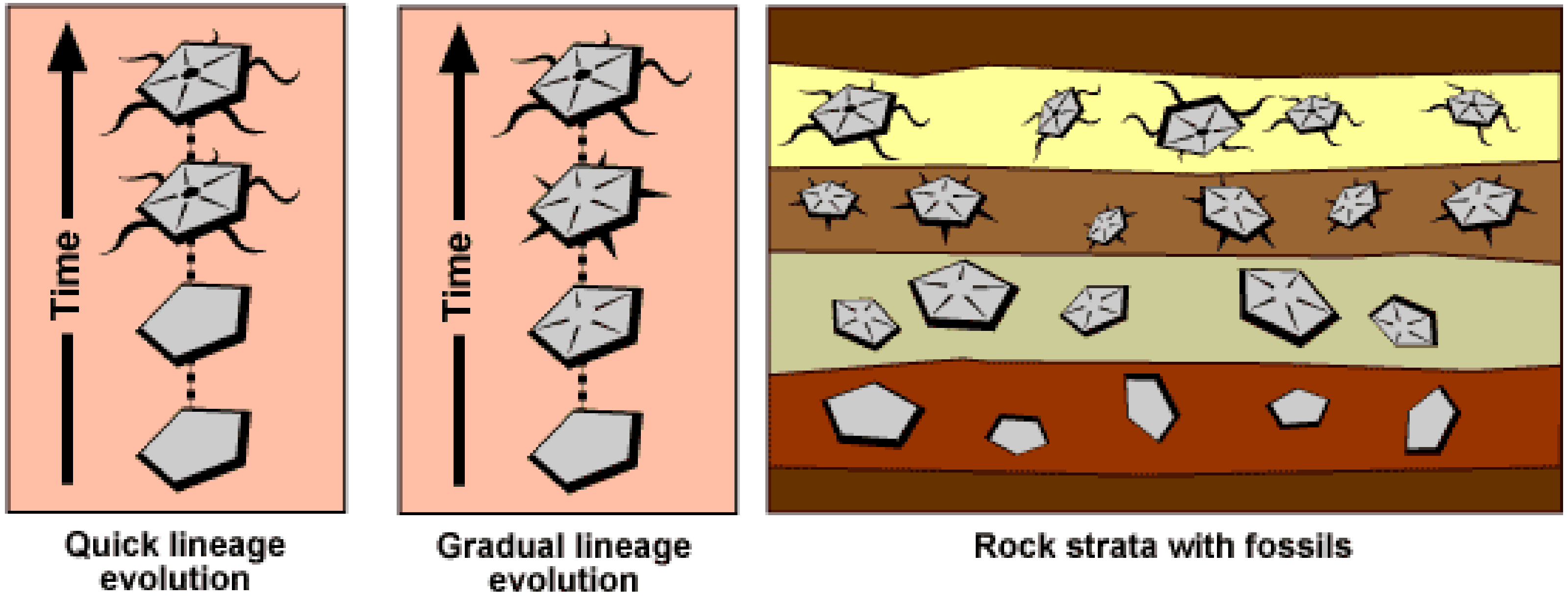
EVIDENCE FOR EVOLUTION

The geographic distribution of organisms on Earth follows patterns that are best explained by evolution, in combination with the movement of tectonic plates over geological time.

For instance, there are unique groups of plants and animals on northern and southern continents that can be traced to the split of Pangaea into two supercontinents (Laurasia in the north, Gondwana in the south).

Source: Khan Academy

THE PACE OF EVOLUTION

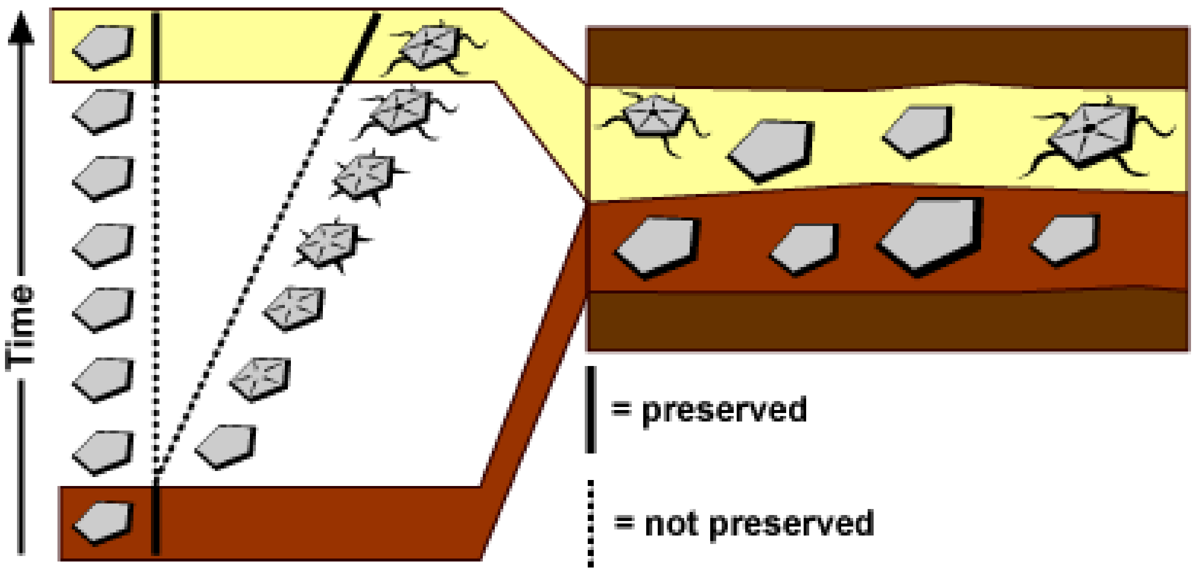


Source: https://evolution.berkeley.edu/

COMPETING HYPOTHESIS

Phyletic gradualism — slow steady divergence of lineages

The "burst" of evolution is a geological illusion. It only looks like a burst because a lot of time — say, 5 million years — passed between the times when the two rock layers were laid down. In this period of time, species 3 gradually diverged from ancestor 1 through a series of transitional forms, but these transitional forms were not preserved.

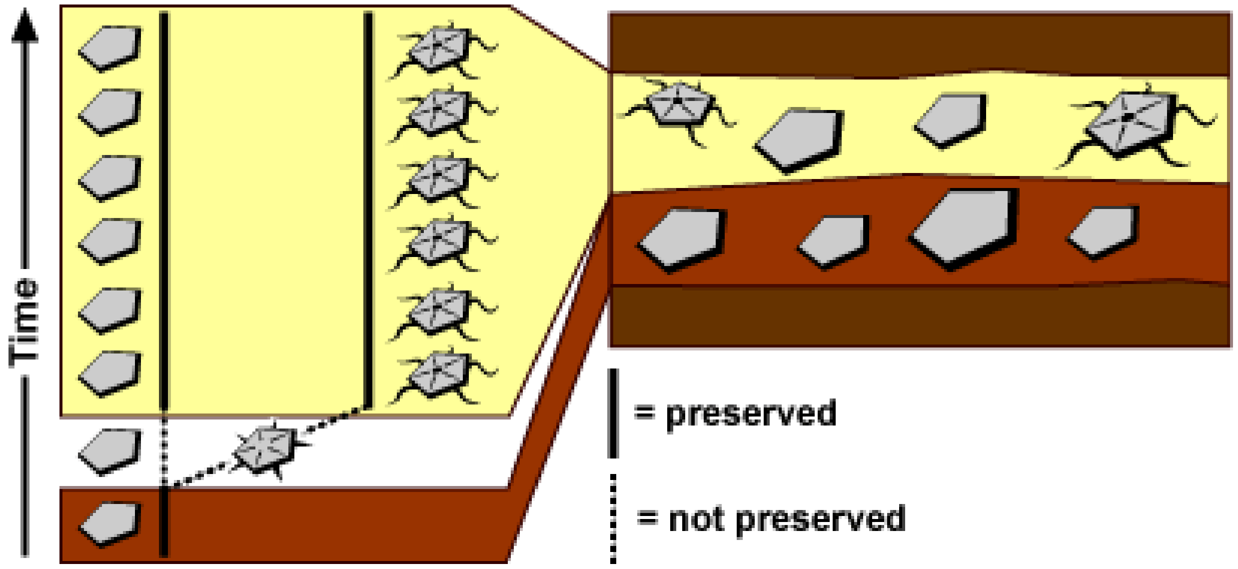


Source: https://evolution.berkeley.edu/

COMPETING HYPOTHESIS

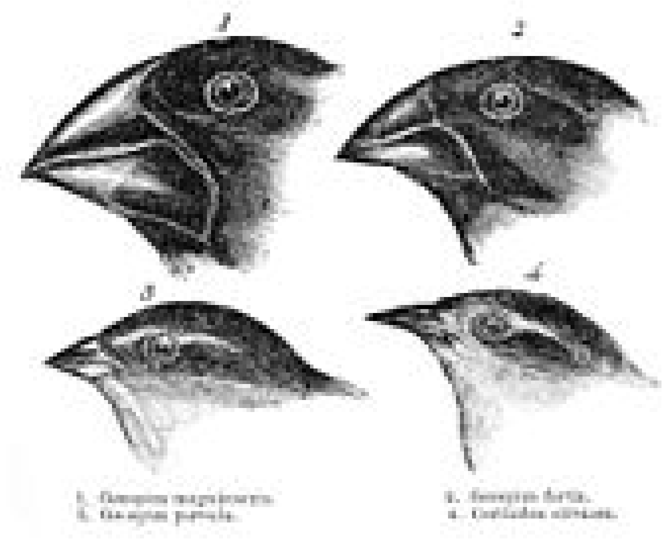
Punctuated equilibrium — a large amount of change in a short time tied to a speciation event

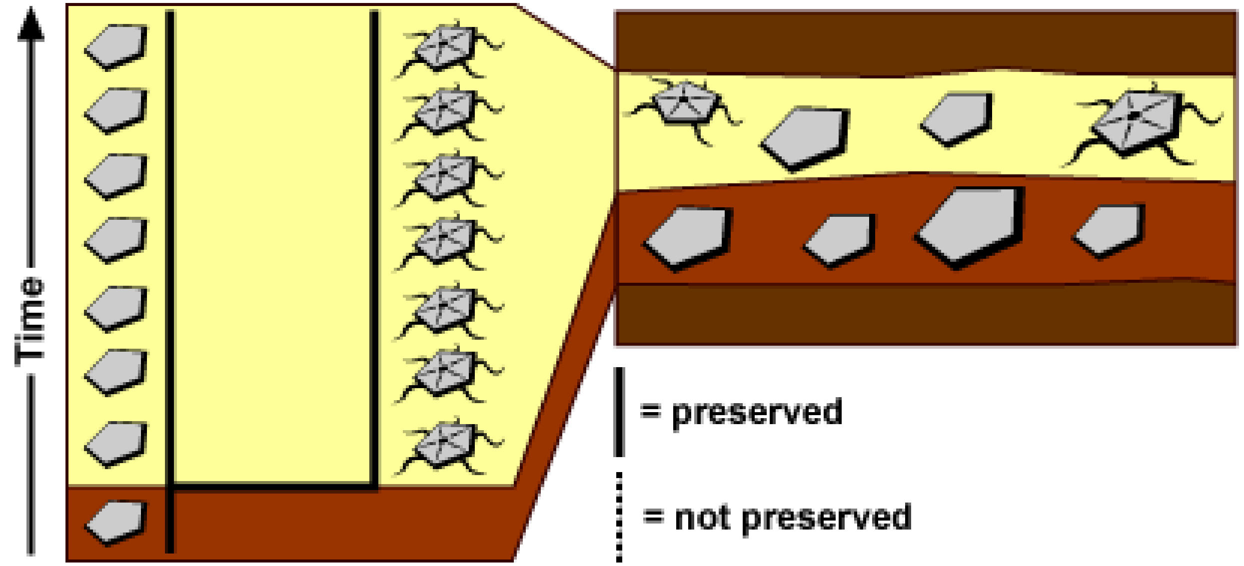
Species 2 and 3 are only 100,000 years younger than ancestor 1, and all the evolutionary change connecting them took place in this short time. The “burst” of evolution is really a burst. Transitional forms between ancestor 1 and species 3 did exist, but for such a short amount of time that they were not preserved in the fossil record.



Source: https://evolution.berkeley.edu/

COMPETING HYPOTHESIS





The "hopeful monster"

Consistent with fossil record

Macromutation (saltation) — a big mutation produces sudden evolutionary change skipping over transitional forms

The "burst" of evolution is really a burst — there was a lot of evolutionary change in a very short amount of time. Species 3 was produced by a mutation that radically changed the offspring of ancestor 1 in many ways.

Source: https://evolution.berkeley.edu/ & Wikipedia

The neutral-selectionist dilemma

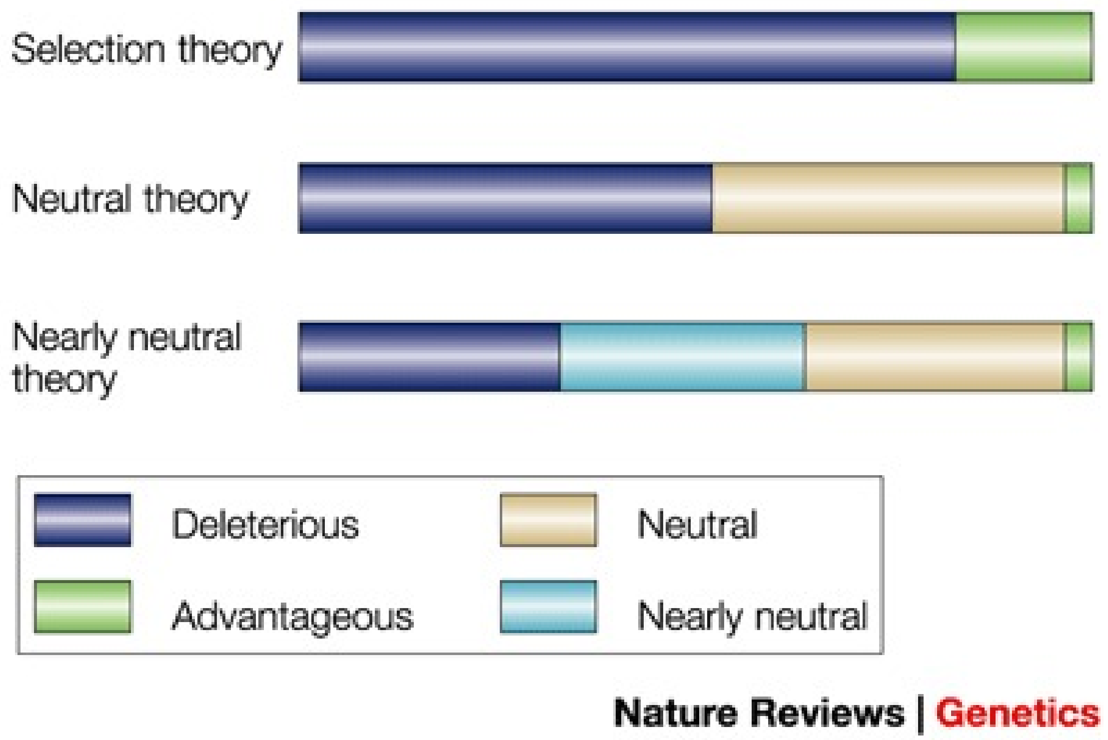
The neutral theory of molecular evolution (1968): most evolutionary changes occur at the molecular level, and most of the variation within and between species are due to random **genetic drift** of mutant alleles that are **selectively neutral**.

Motoo Kimura & Tomoko Ohta

Source: Wikipedia & https://www.investigacionyciencia.es/

The neutral-selectionist dilemma

The selectionist theory of molecular evolution: early neo-Darwinian theories assumed that all mutations would affect fitness and, therefore, would be advantageous or deleterious, but not neutral.



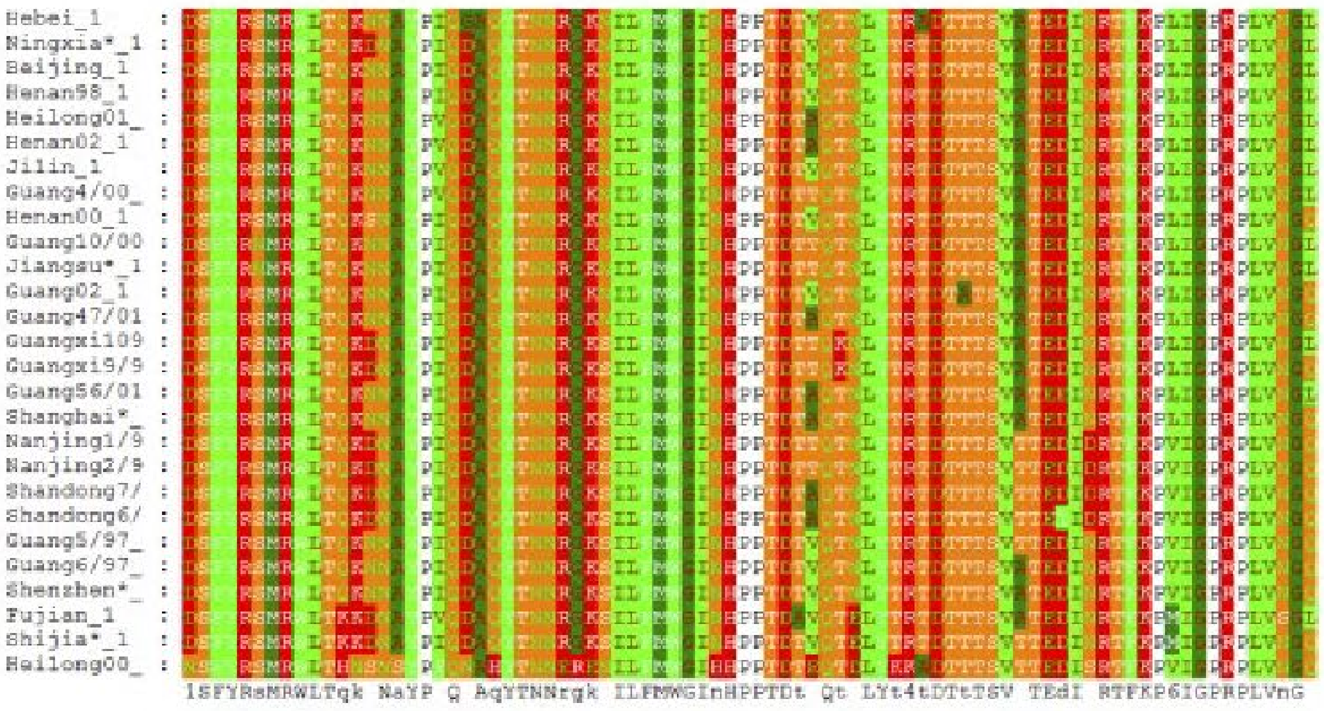
EVIDENCE FOR EVOLUTION

Most organisms share…

- The same genetic material (DNA)
- The same, or highly similar, genetic codes
- The same basic process of gene expression (transcription and translation)
- The same molecular building blocks, such as amino acids

Source: Khan Academy

CONSTRUCTING MOLECULAR PHYLOGENIES



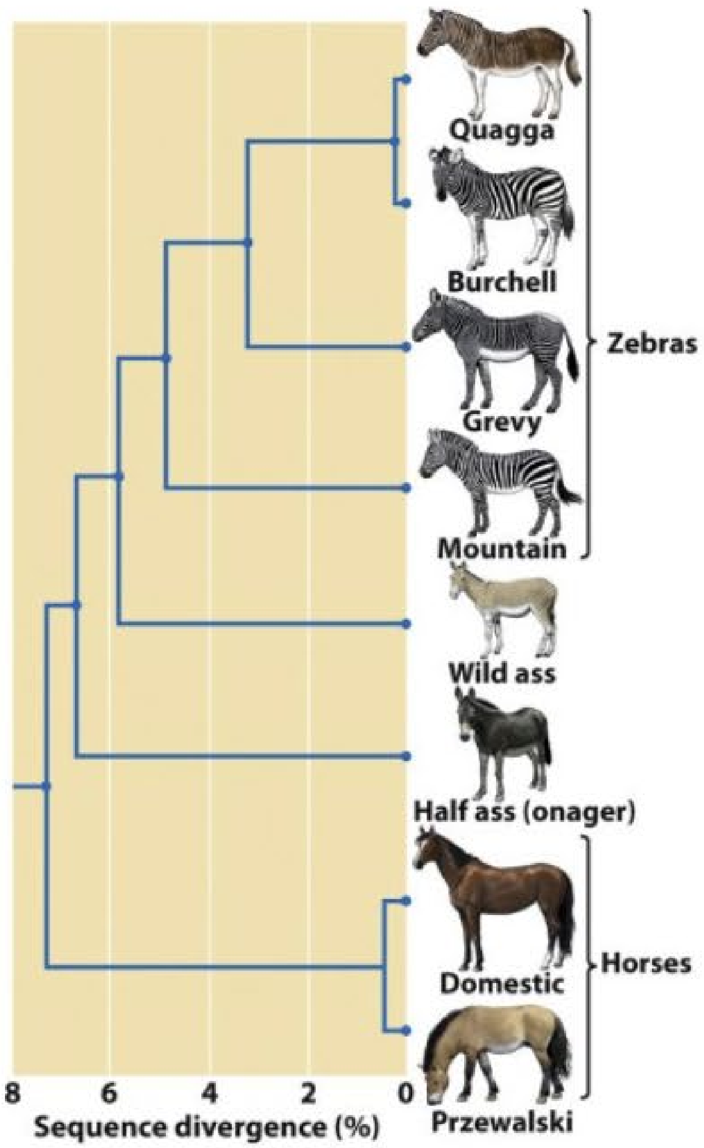
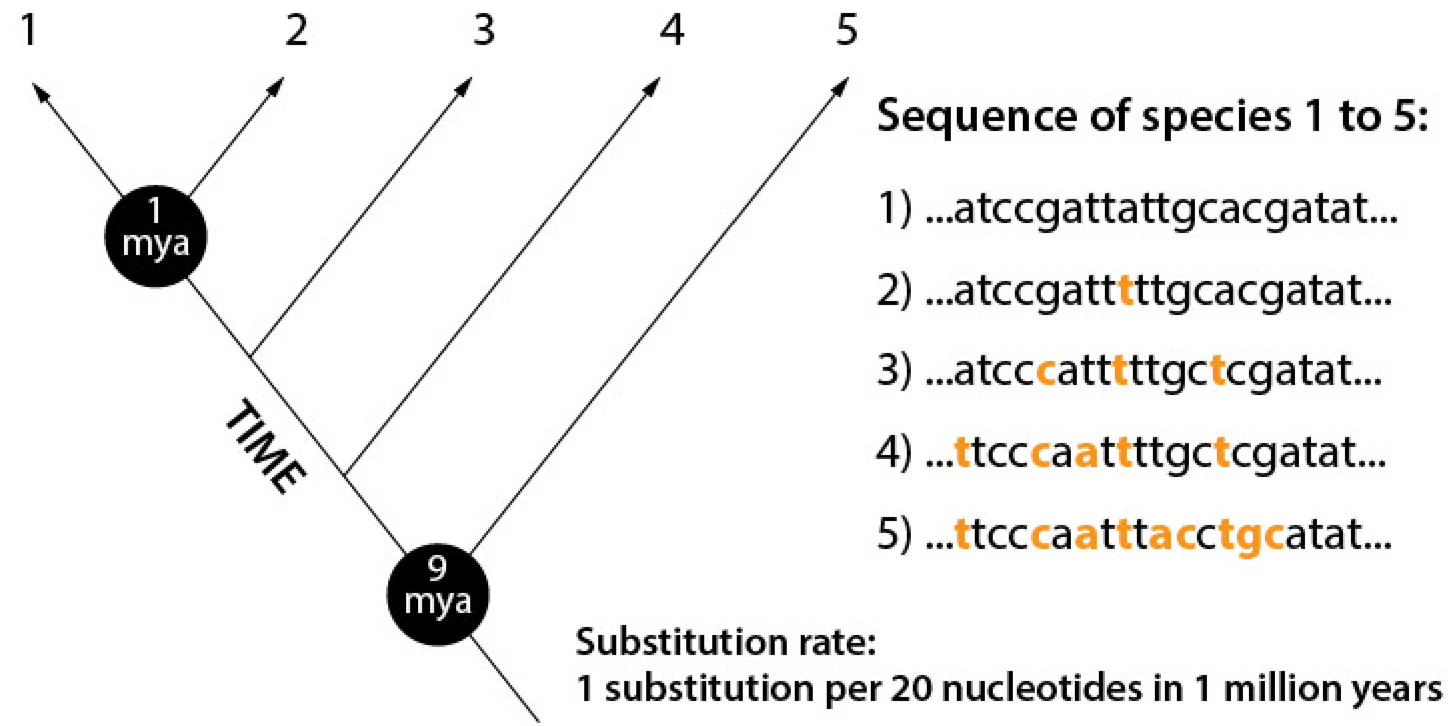


Figure 26-13
Genetics: A Conceptual Approach, Third Edition

MOLECULAR CLOCK



Source: https://tanguay.info/

EVIDENCE FOR EVOLUTION

Macroevolution, which refers to large-scale changes that occur over extended time periods, such as the formation of new species and groups.

Microevolution, which refers to small-scale changes that affect just one or a few genes and happen in populations over shorter timescales.

Microevolution and macroevolution aren't really two different processes. They're the same process – evolution – occurring on different timescales. Microevolutionary processes occurring over thousands or millions of years can add up to large-scale changes that define new species or groups

Source: Khan Academy

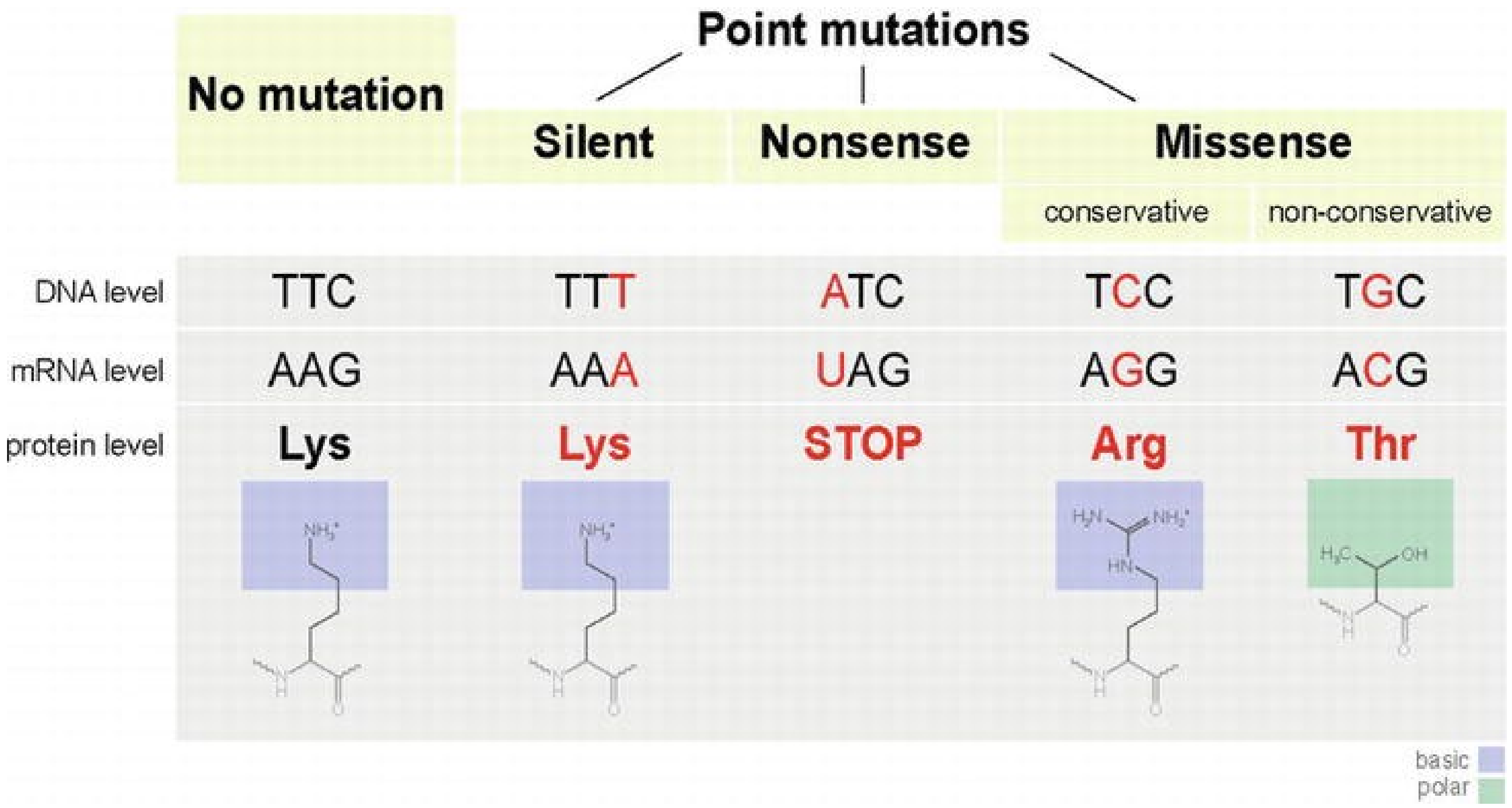
Sources of genetic variability:

- Mutation
- Genetic shuffling (sex)
- Gene flow (migration)
- Horizontal gen transfer

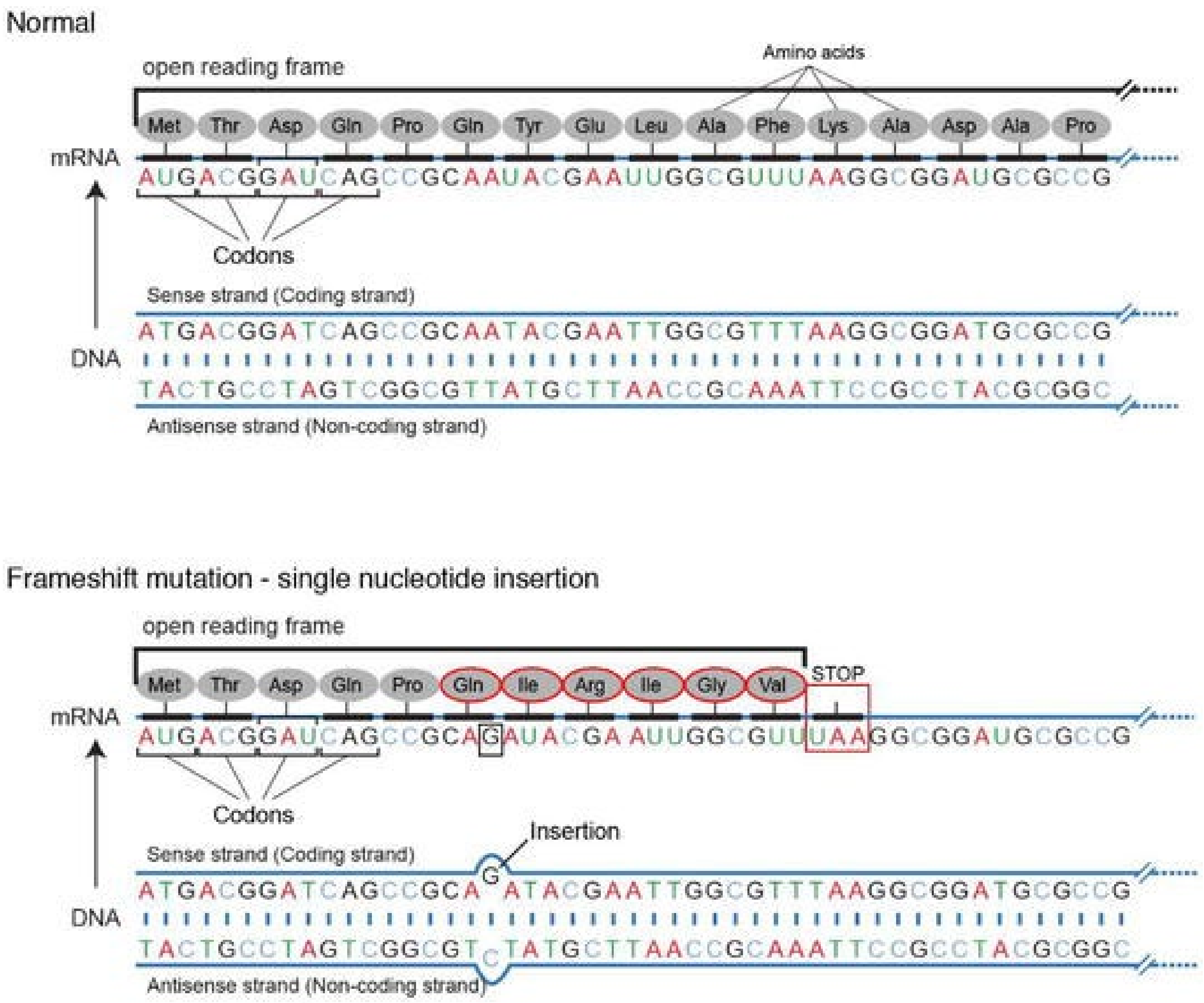
Evolutionary processes:

- Natural selection
- Genetic drift

MUTATION

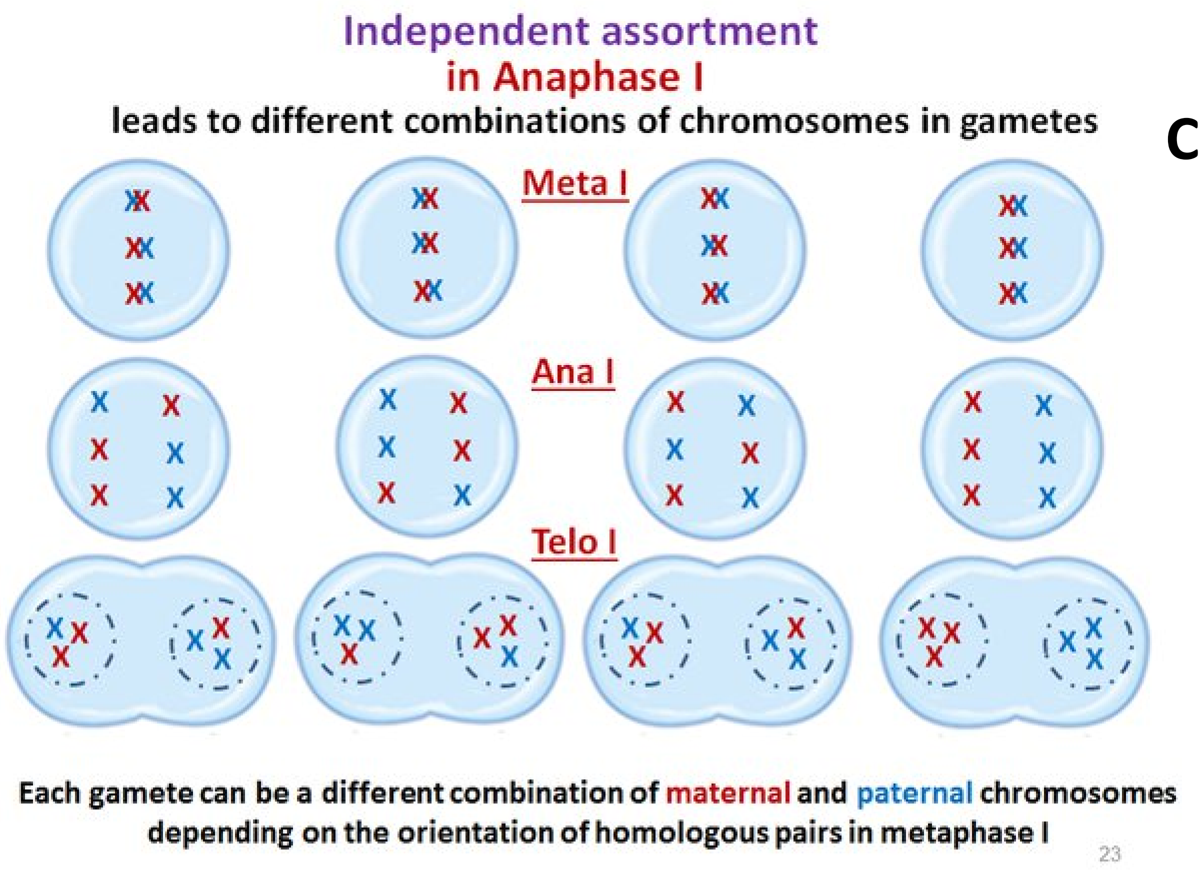

Point mutations
No mutation
Silent
Nonsense
Missense
conservative
non-conservative
DNA level
TTC
TTT
ATC
TCC
TGC
mRNA level
AAG
AAA
UAG
AGG
ACG
protein level
Lys
Lys
STOP
Arg
Thr
basic
polar

MUTATION

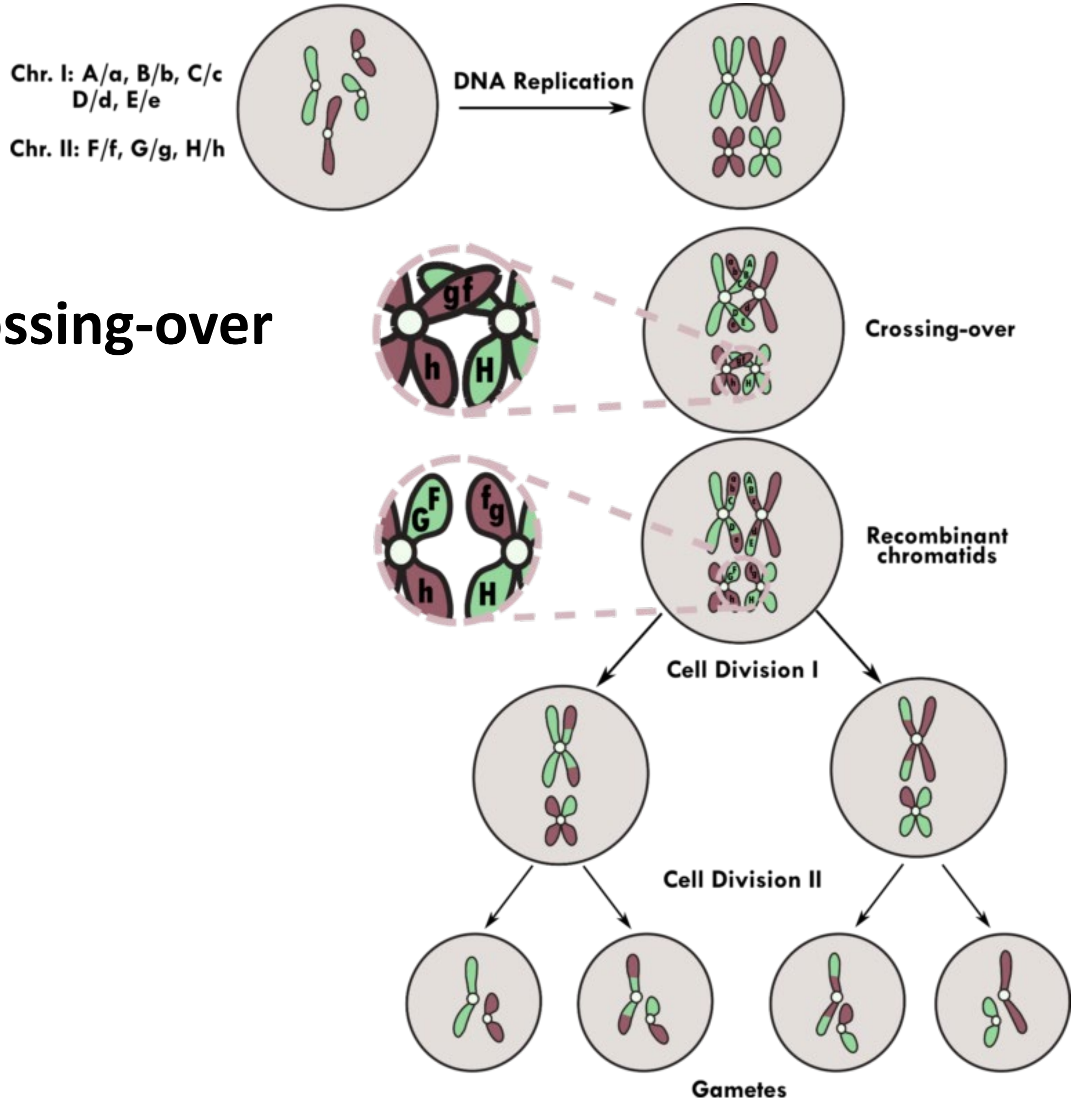

Normal
open reading frame
Amino acids
Met Thr Asp Gln Pro Gln Tyr Glu Leu Ala Phe Lys Ala Asp Ala Pro
mRNA
AUGACGGAUCAGCCGCAAUACGAAUUGGCGUUUAAGGCGGAUGCGCCG
Codons
Sense strand (Coding strand)
ATGACGGATCAGCCGCAATACGAATTGGCGTTTAAGGCGGATGCGCCG
DNA
TACTGCCTAGTCGGCGTTATGCTTAACCGCAAATTCCGCCTACGCGGC
Antisense strand (Non-coding strand)
Frameshift mutation - single nucleotide insertion
open reading frame
Met Thr Asp Gln Pro Gln Ile Arg Ile Gly Val
STOP
mRNA
AUGACGGAUCAGCCGCAGAUACGAAUUGGCGUUUAAGGCGGAUGCGCCG
Codons
Insertion
Sense strand (Coding strand)
ATGACGGATCAGCCGCAGATACGAATTGGCGTTTAAGGCGGATGCGCCG
DNA
TACTGCCTAGTCGGCGTCTATGCTTAACCGCAAATTCCGCCTACGCGGC
Antisense strand (Non-coding strand)

GENETIC SHUFFLING

Independent Assortment

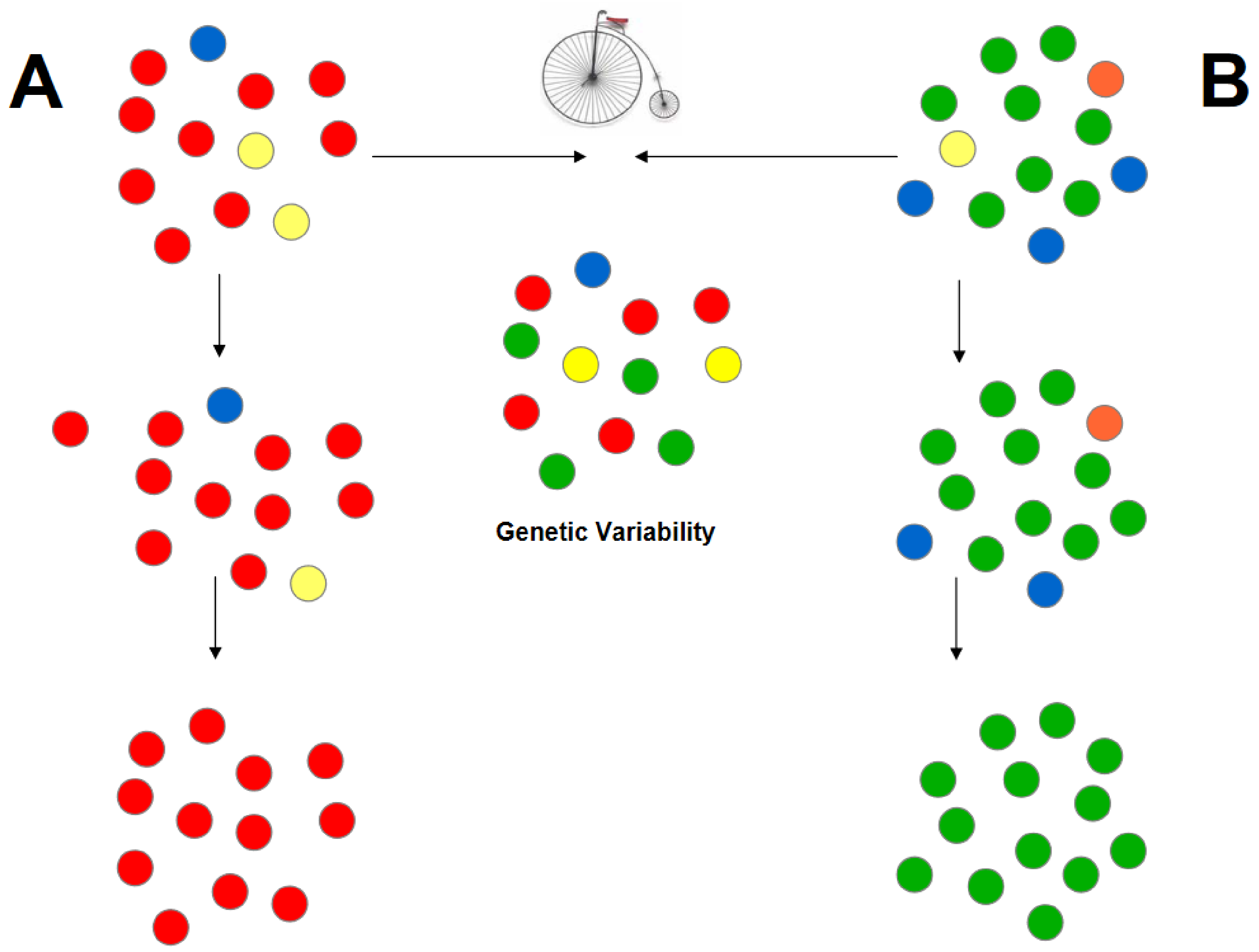


Crossing-over



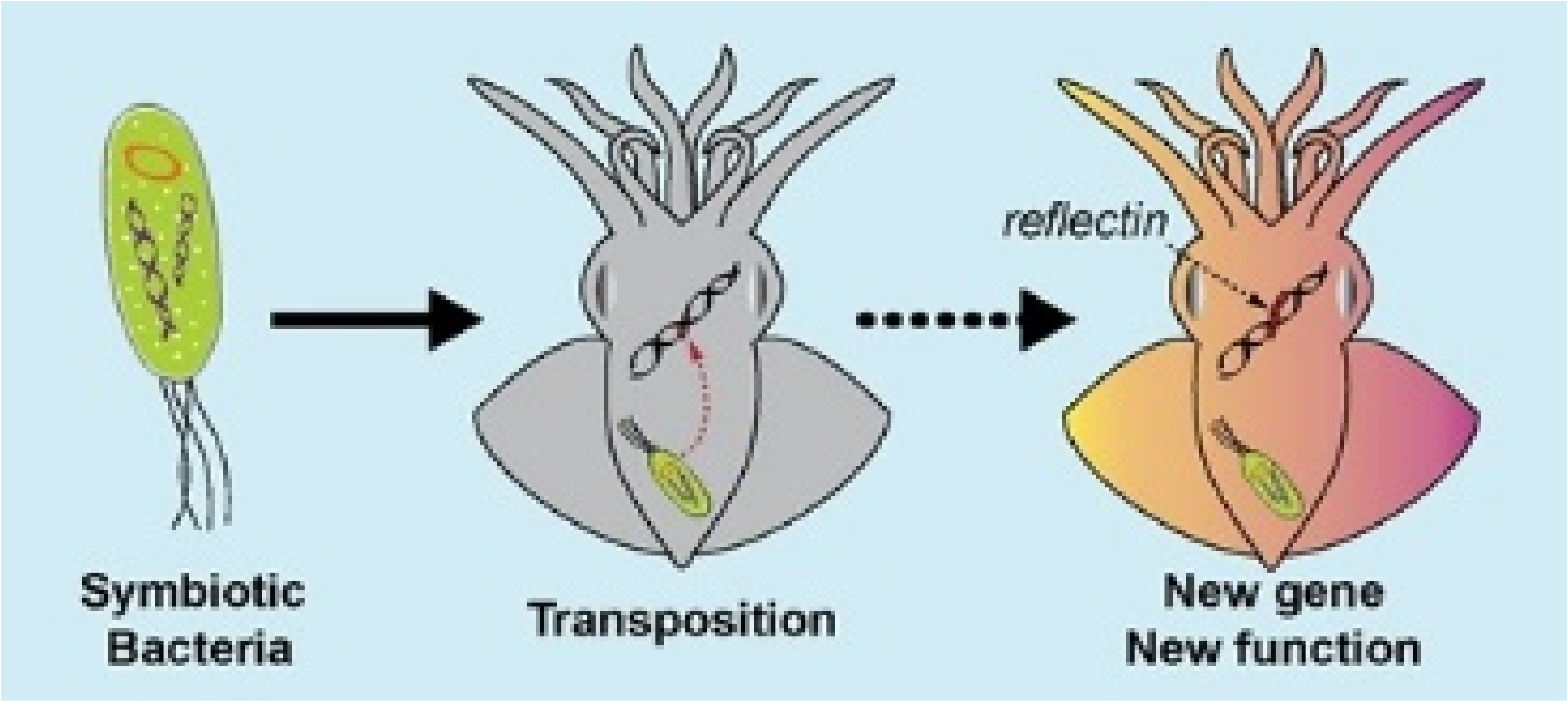
Source: https://www.quora.com/ & https://conductscience.com/

GENE FLOW



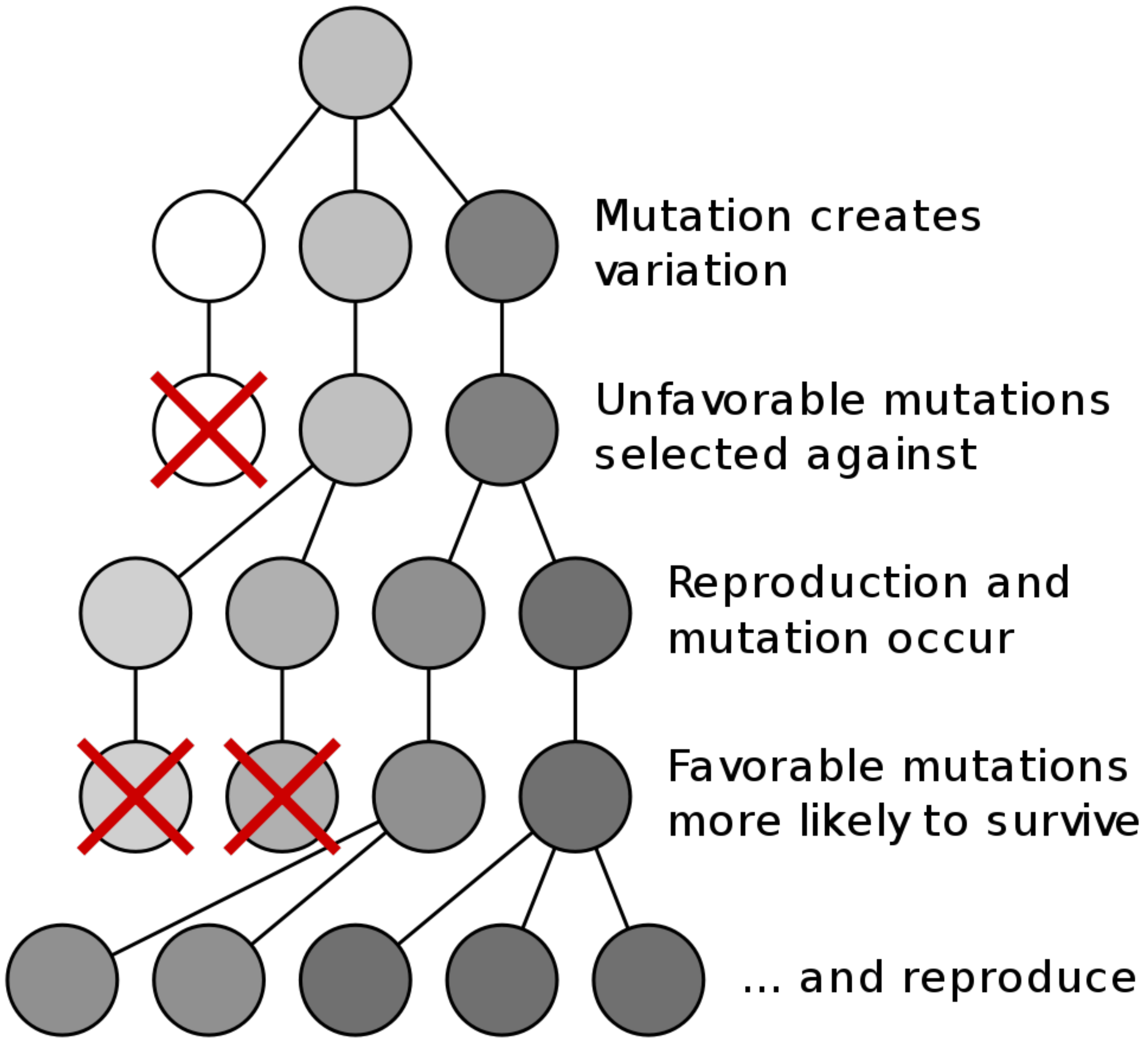
HORIZONTAL TRANSFER

"You are what you eat, what you live on, what lives on you, and what lives in you…"

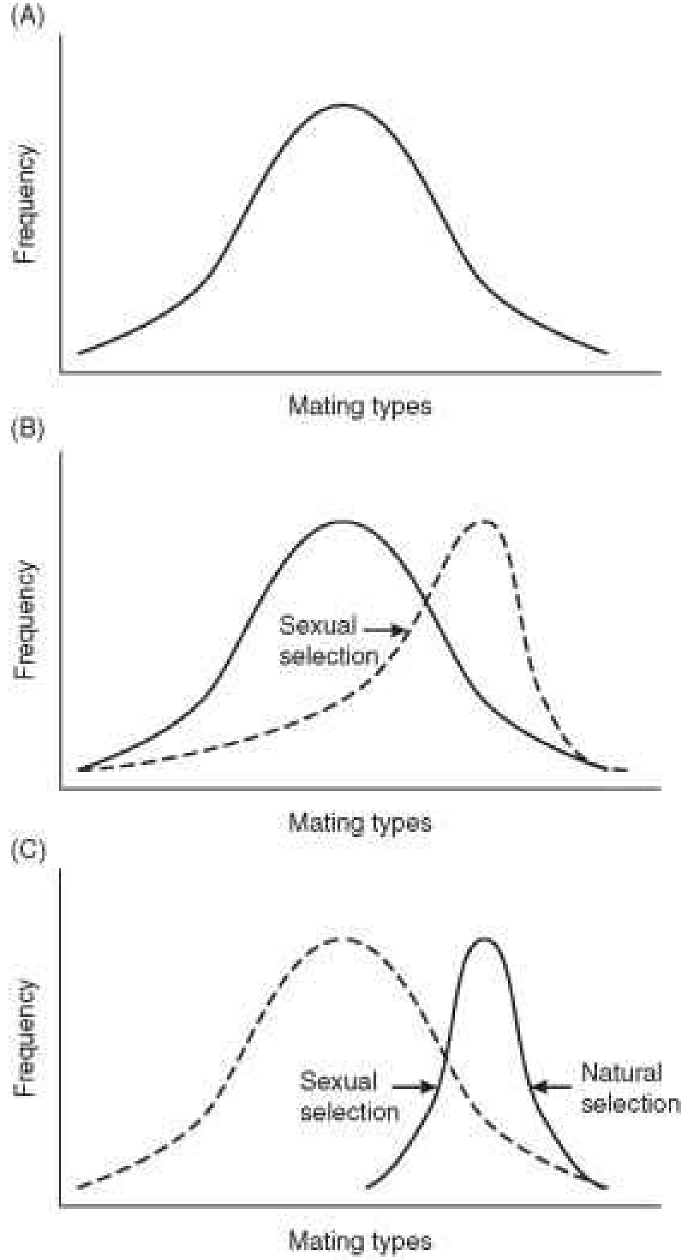


Source: https://www.panspermia.org/

SELECTION

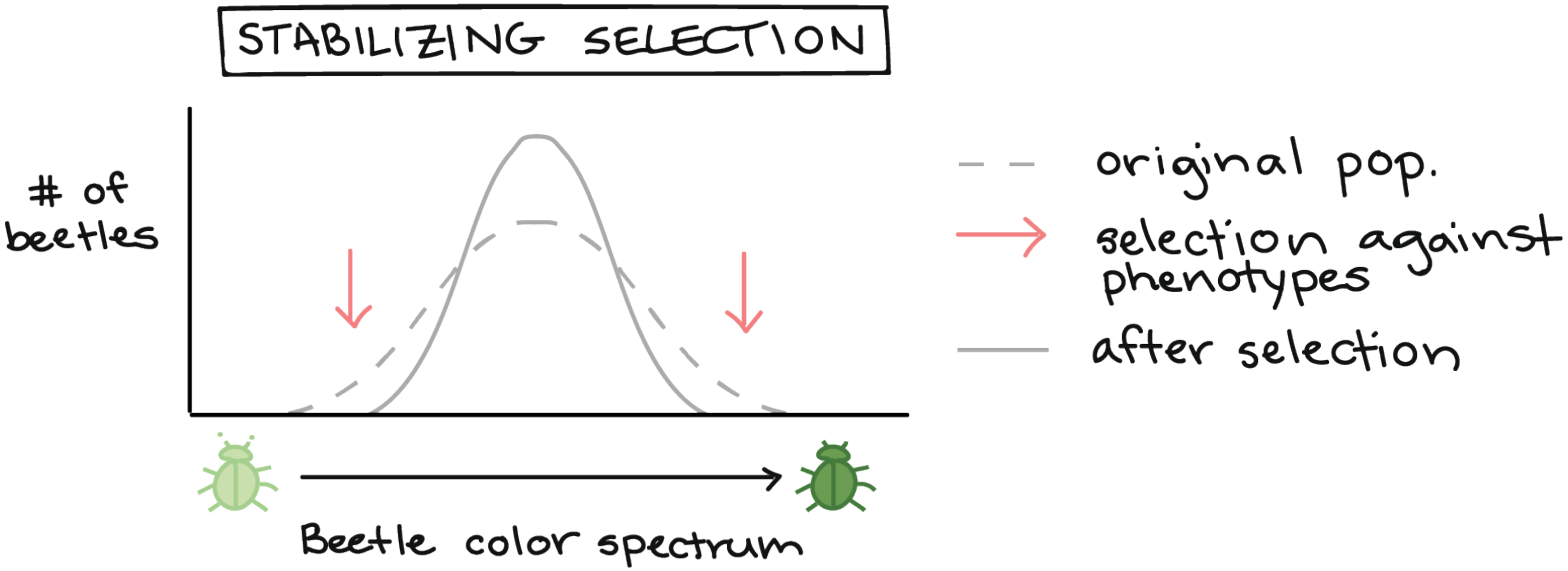

Mutation creates variation
Unfavorable mutations selected against
Reproduction and mutation occur
Favorable mutations more likely to survive
... and reproduce

SEXUAL SELECTION



Source: https://what-when-how.com/ & https://biogeekery.wordpress.com

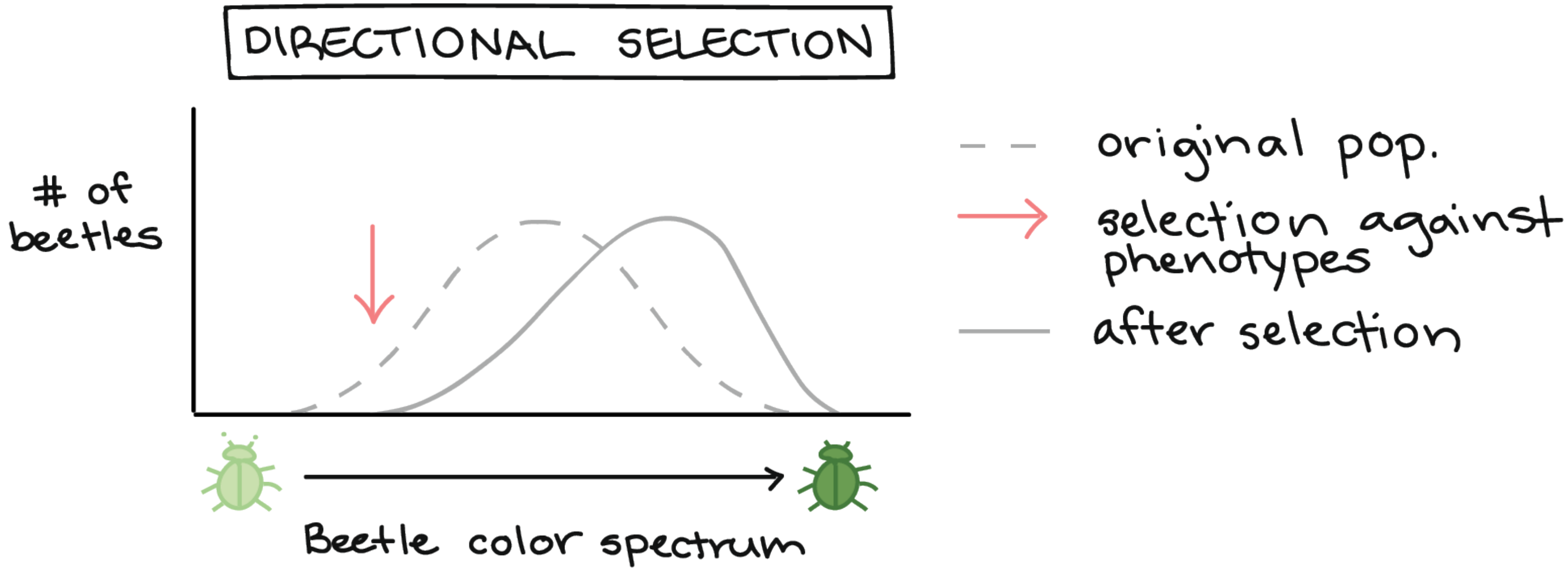
SELECTION



•**Stabilizing selection:** Intermediate phenotypes have the highest fitness, and the bell curve tends to narrow.

Source: Khan Academy

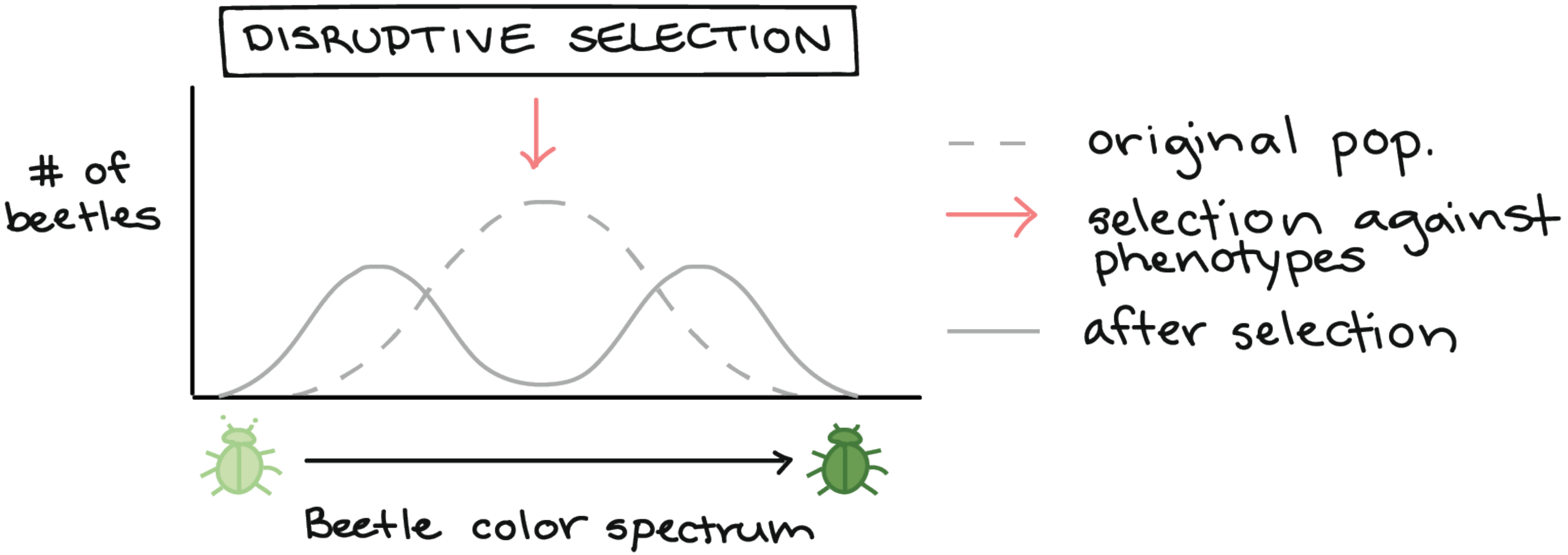
SELECTION



•**Directional selection:** One of the extreme phenotypes has the highest fitness. The bell curve shifts towards the more fit phenotype.

Source: Khan Academy

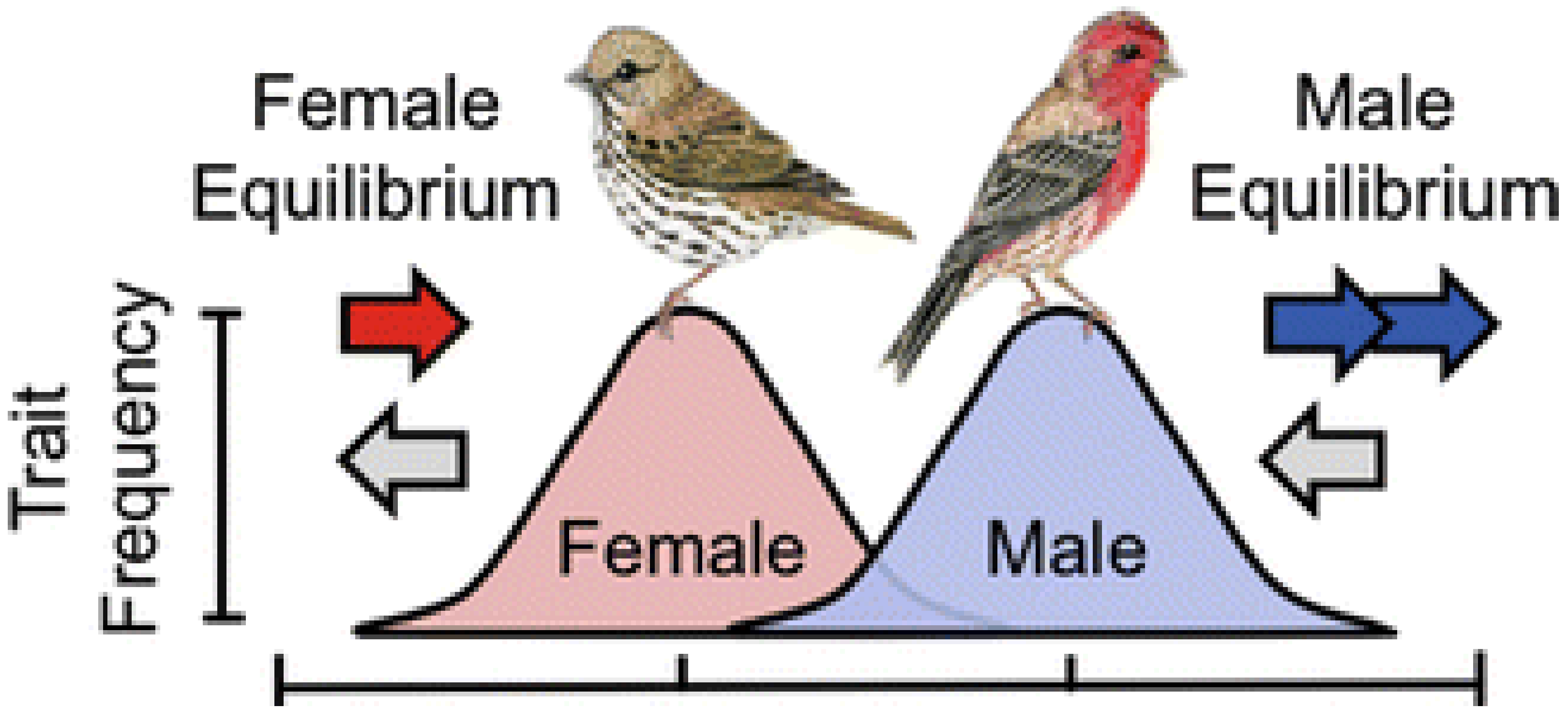
SELECTION



•**Disruptive selection:** Both extreme phenotypes have a higher fitness than intermediate phenotypes. The bell curve develops two peaks.

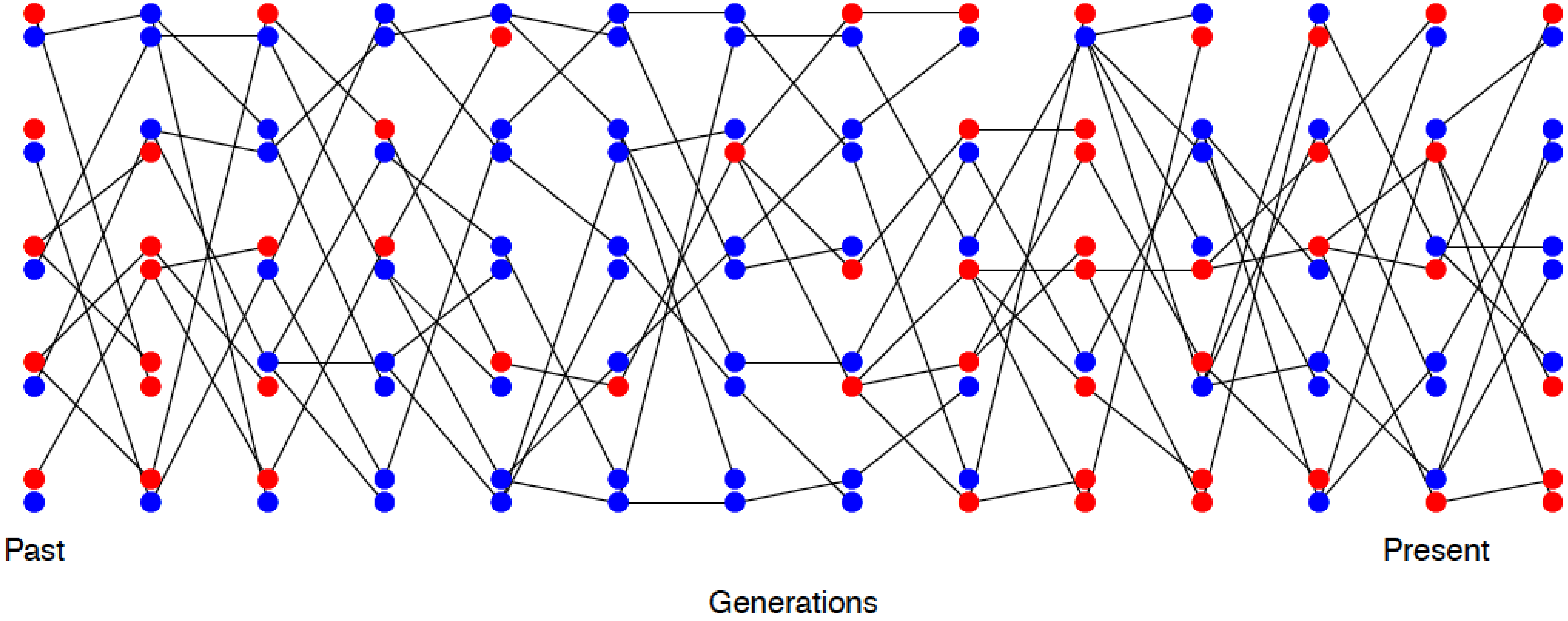
Source: Khan Academy

SEXUAL SELECTION



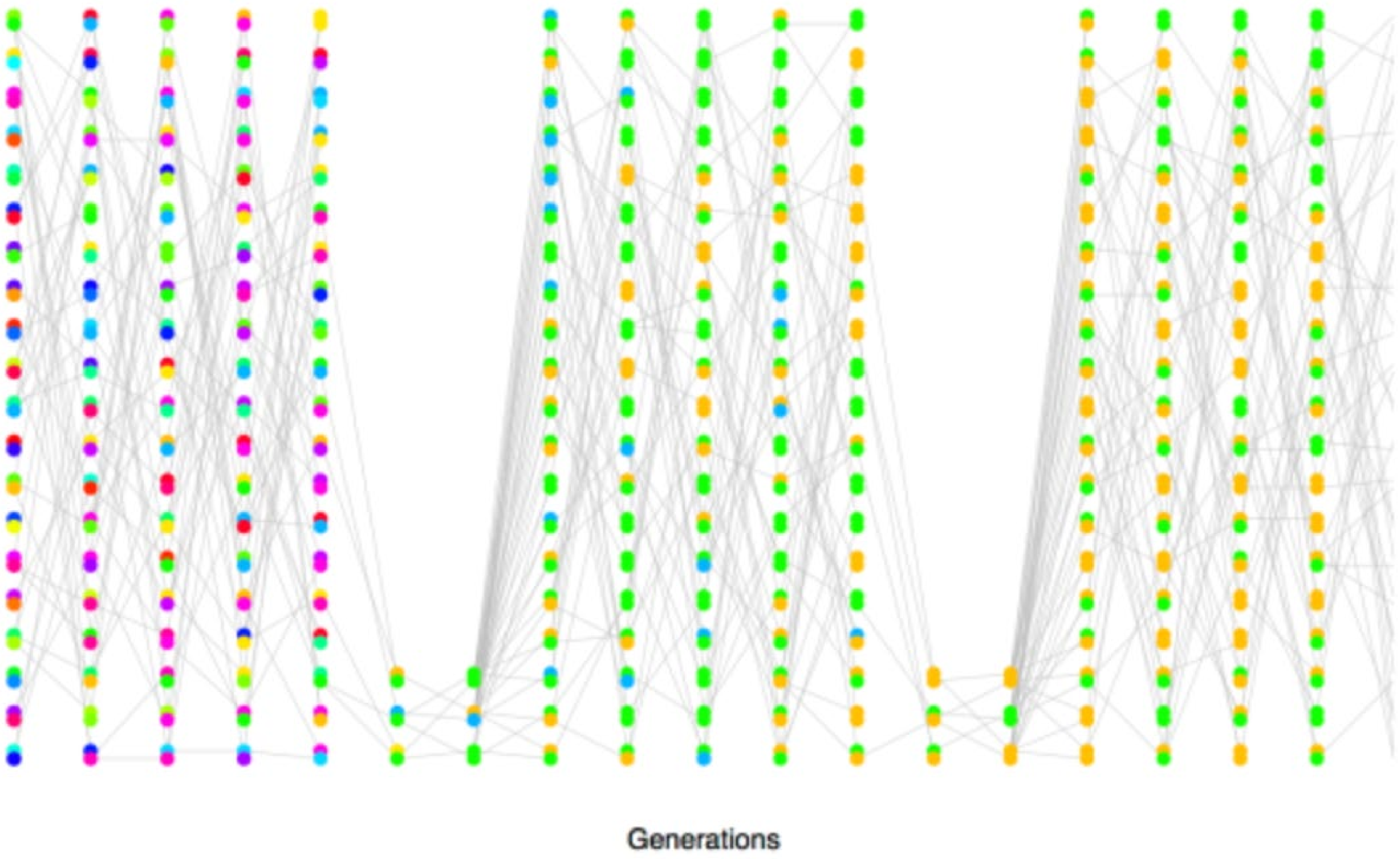
Evolutionary Psychological Science. Springer, Cham. https://doi.org/10.1007/978-3-319-16999-6_1678-1

GENETIC DRIFT

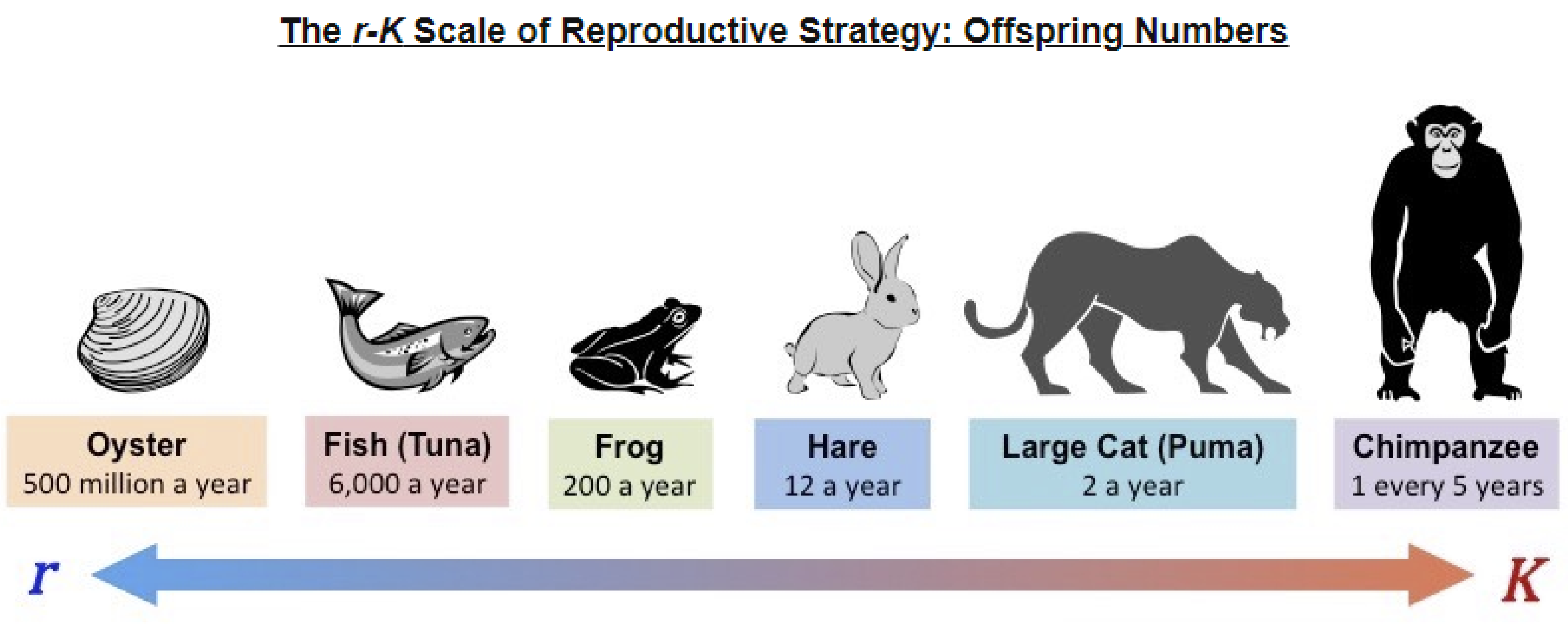


Source: https://gcbias.org/

GENETIC DRIFT



Source: https://gcbias.org/



Source: https://ib.bioninja.com.au/