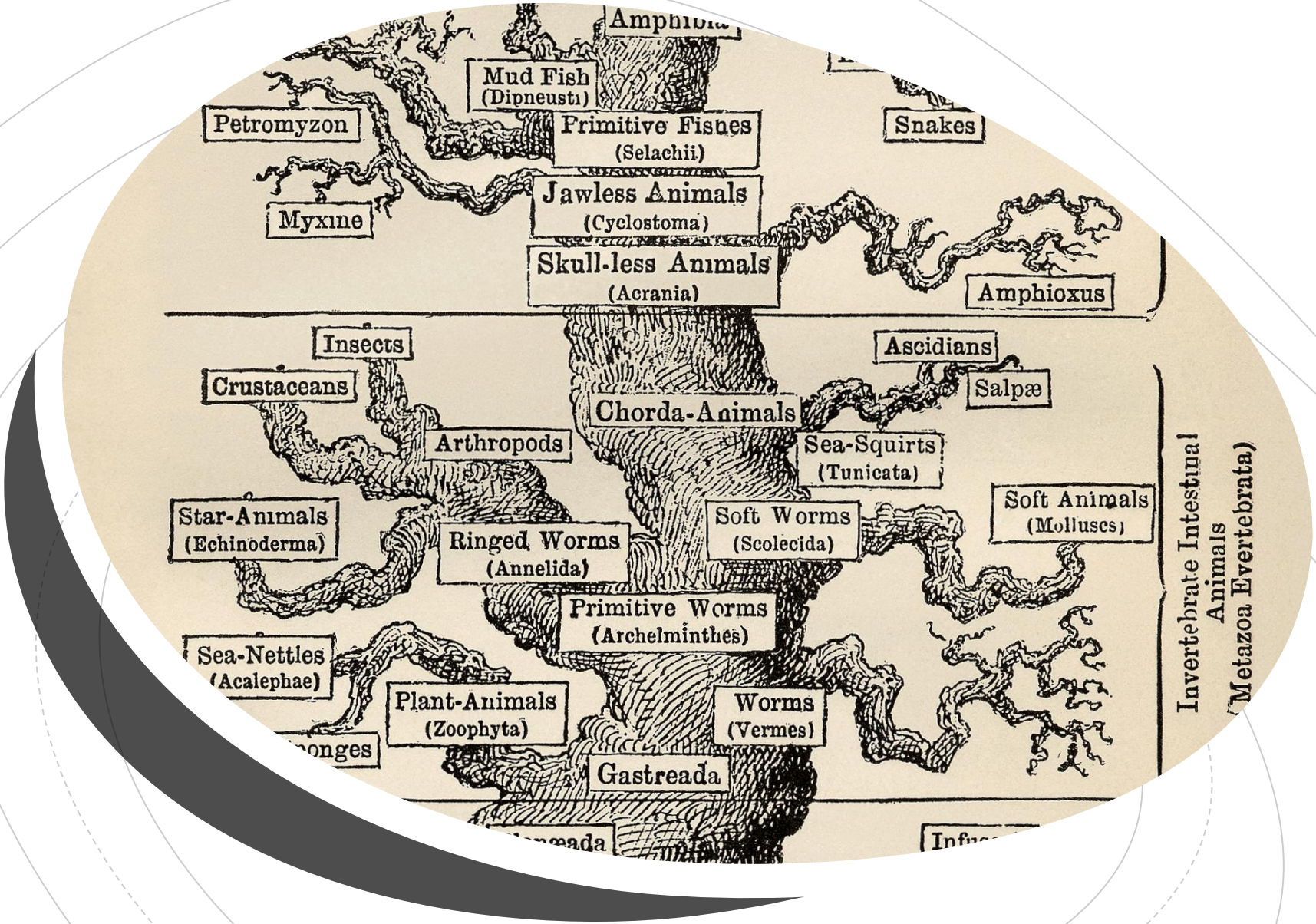
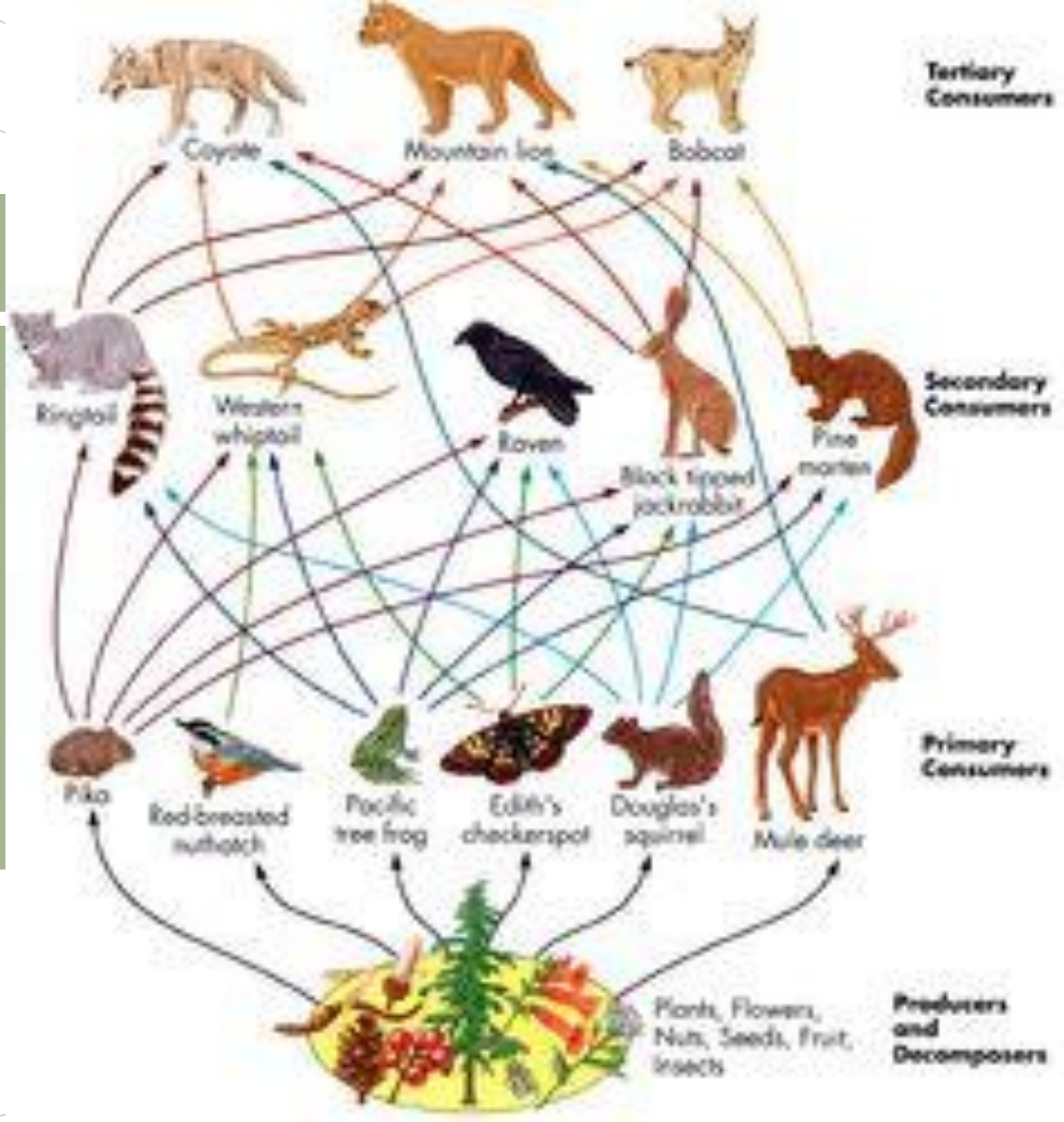


Evolution: Genetics

Class Questions:

-What is Evolution?
- How and why does evolution occur?
-What major evolutionary event sparked multicellular life?
-Which species experience Evolution?

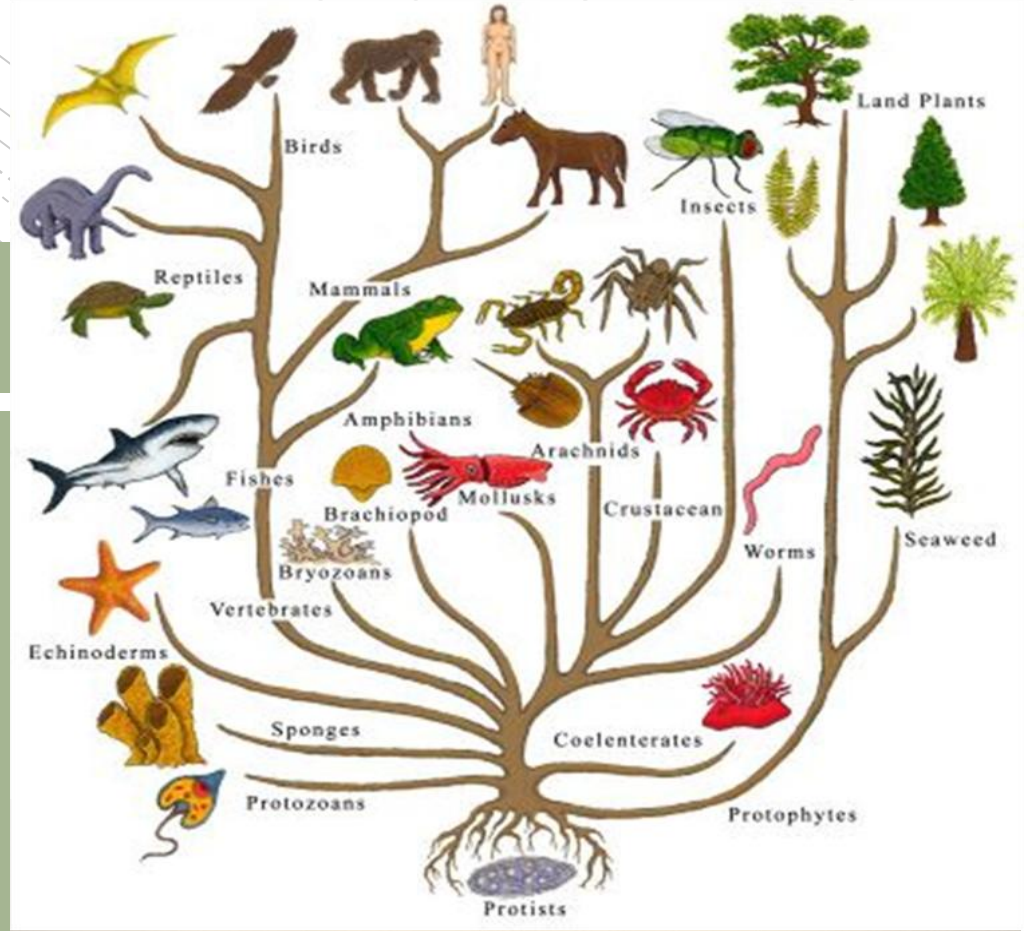


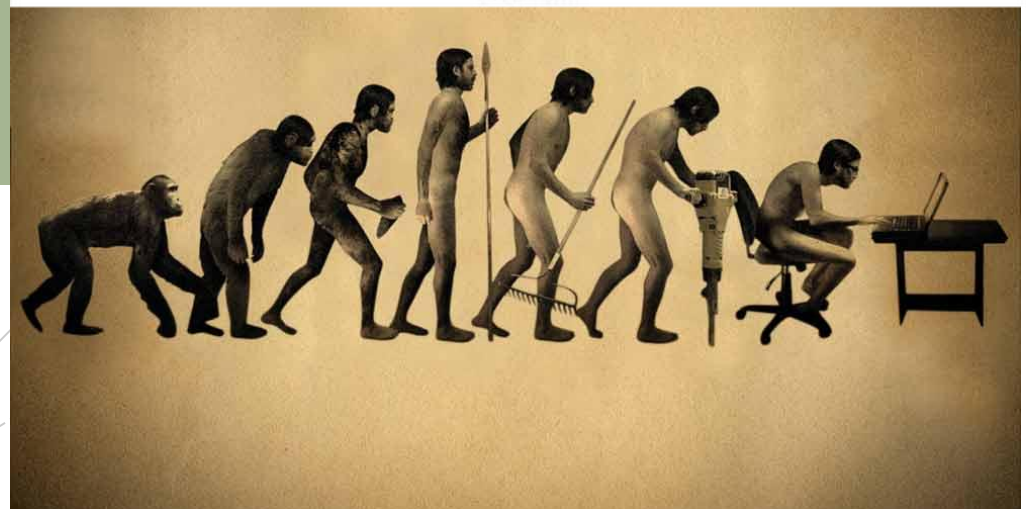
Class Questions:

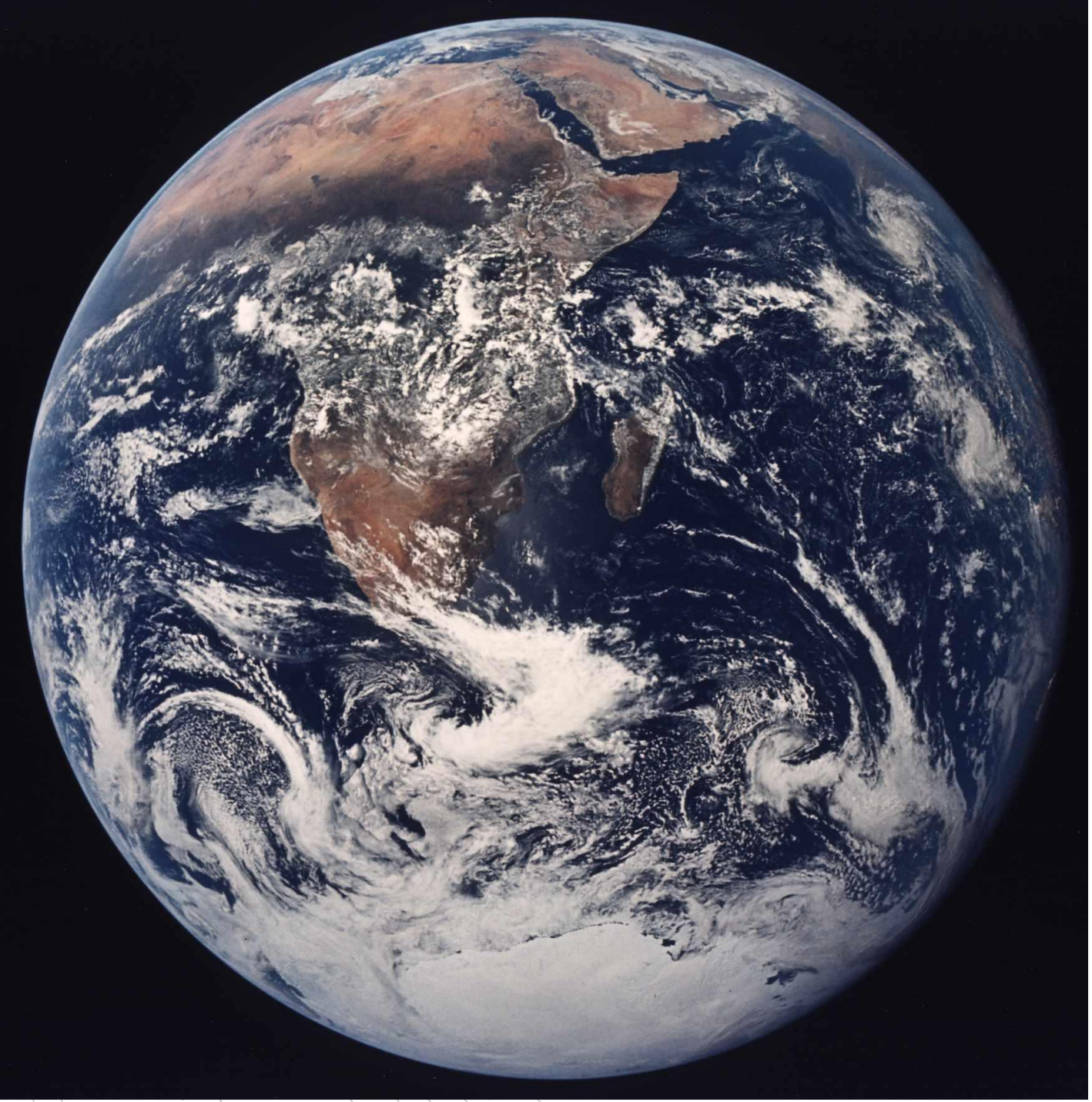
-Where did life start?

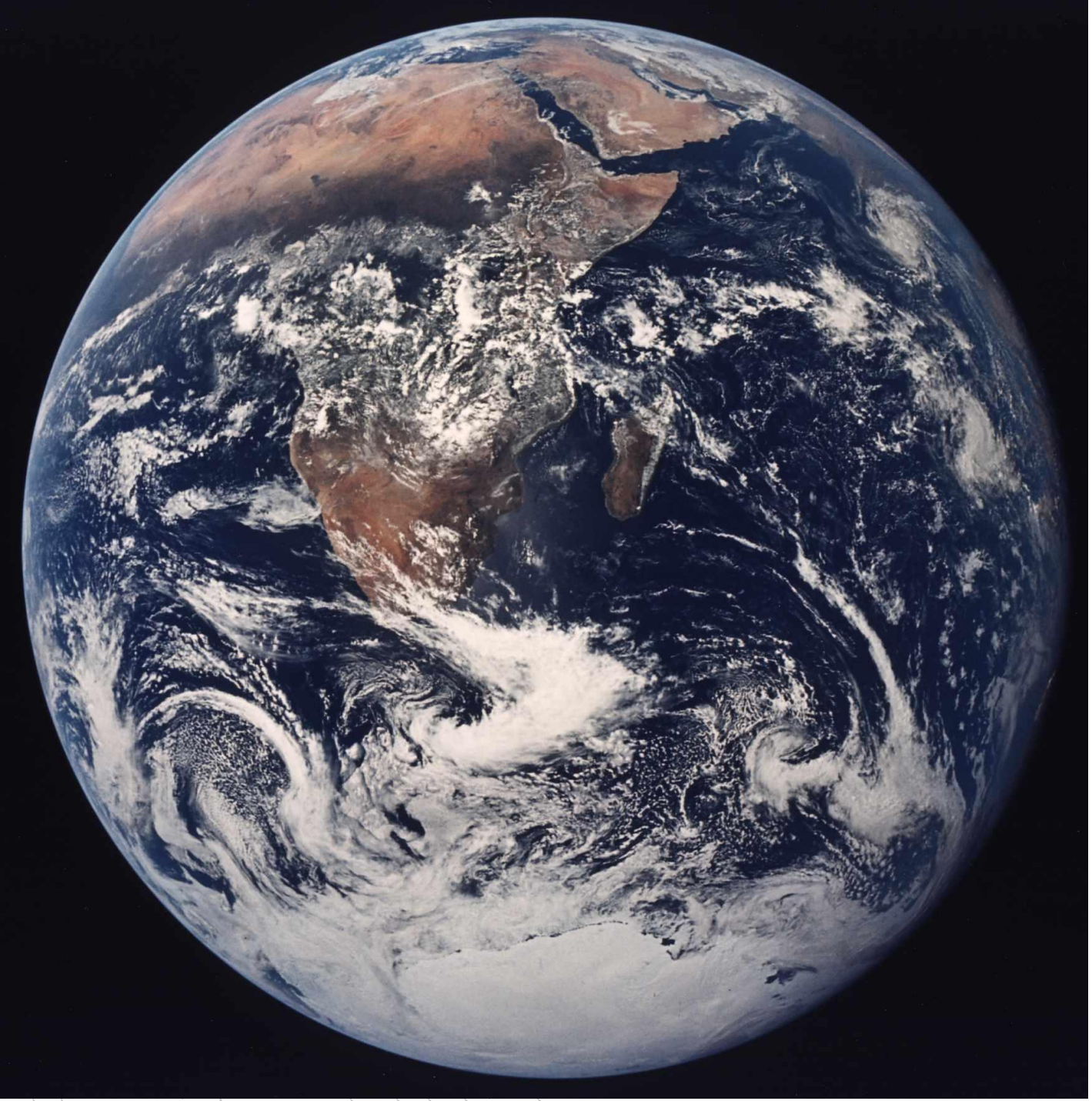
-Do all warm blooded animals live on land?

-What significant research on animals and on DNA itself has given us new insight into evolution?

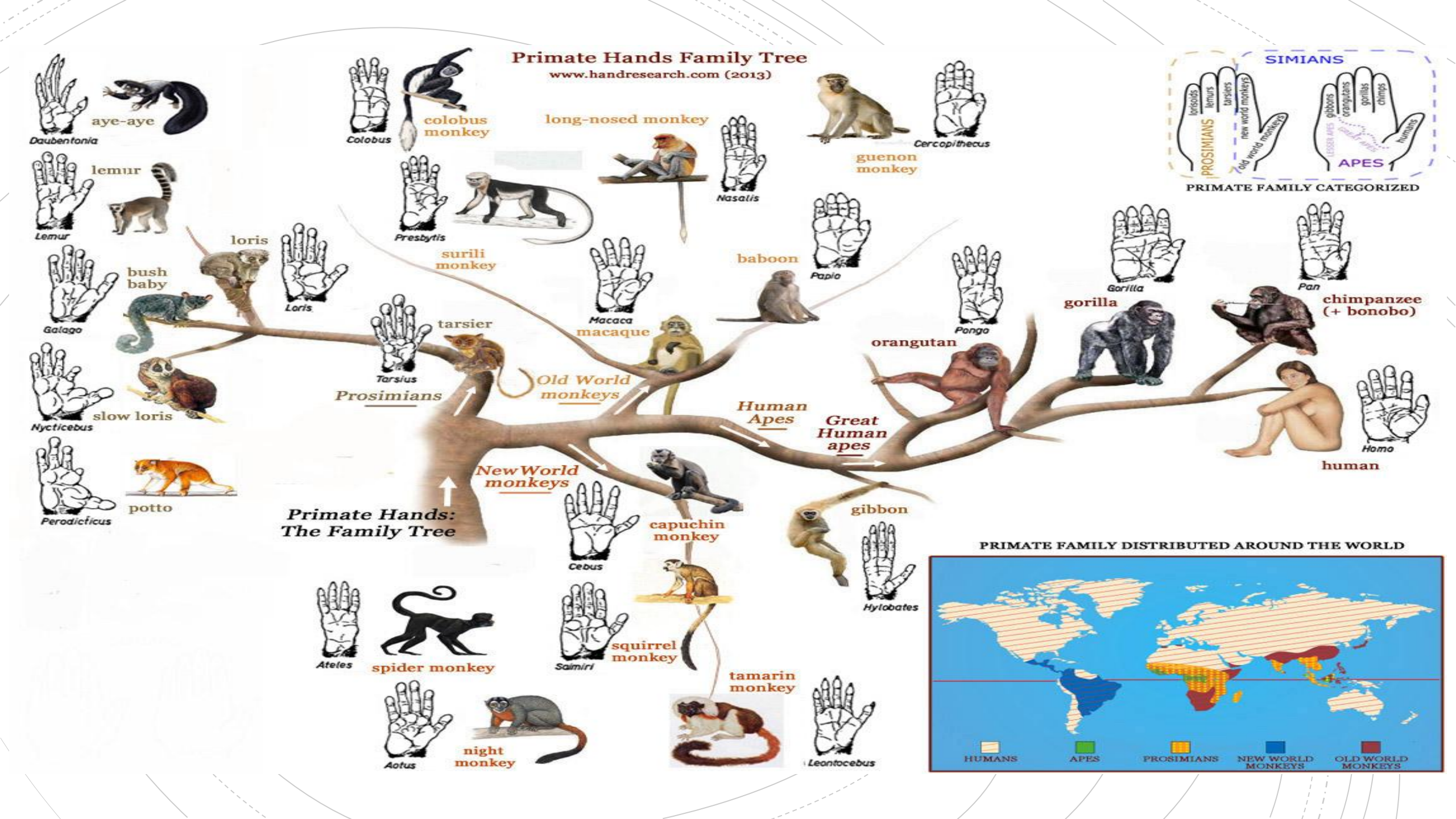








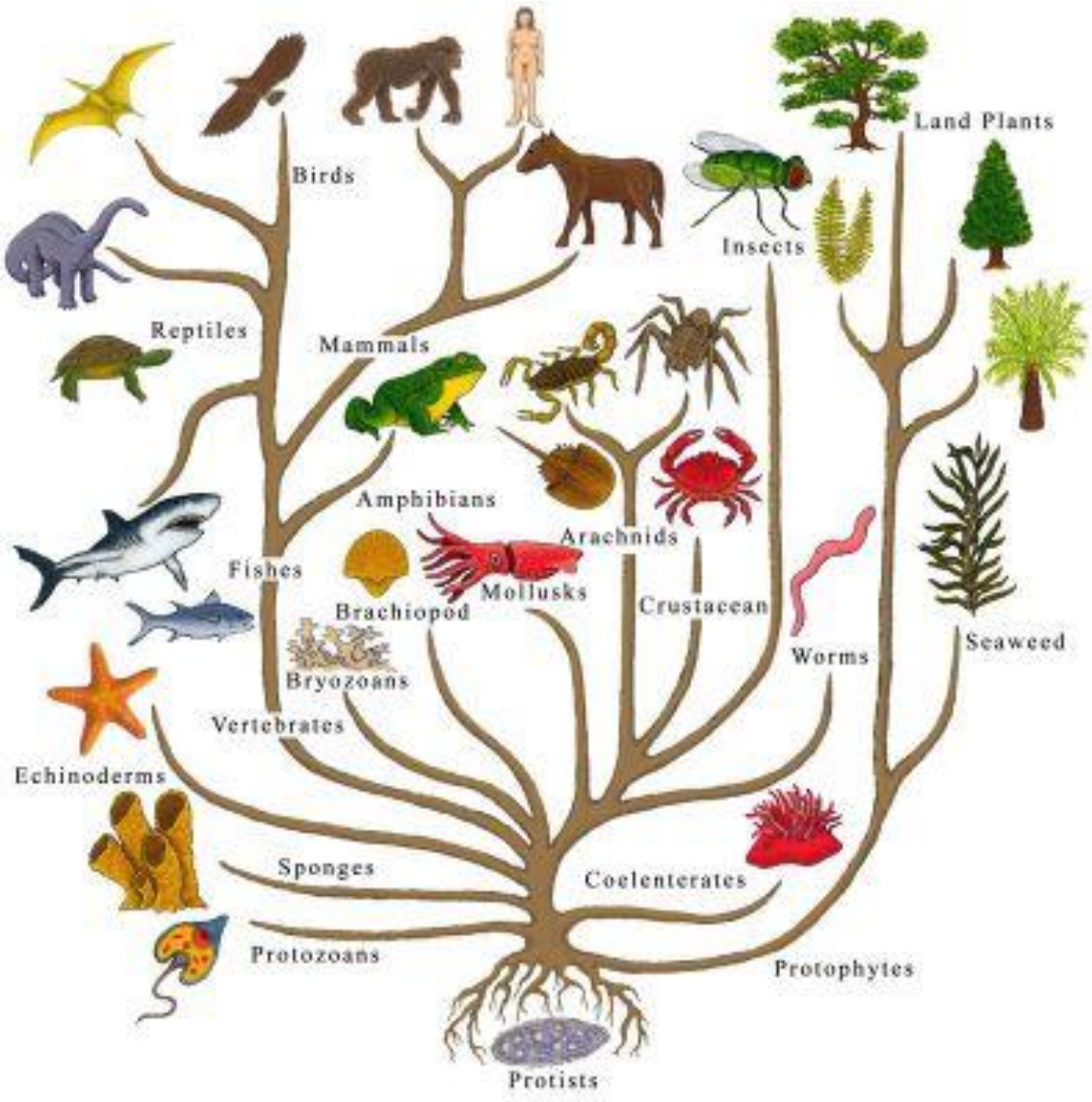
Earth
3.6 billion years old
[As we know it/ [with liquid water]

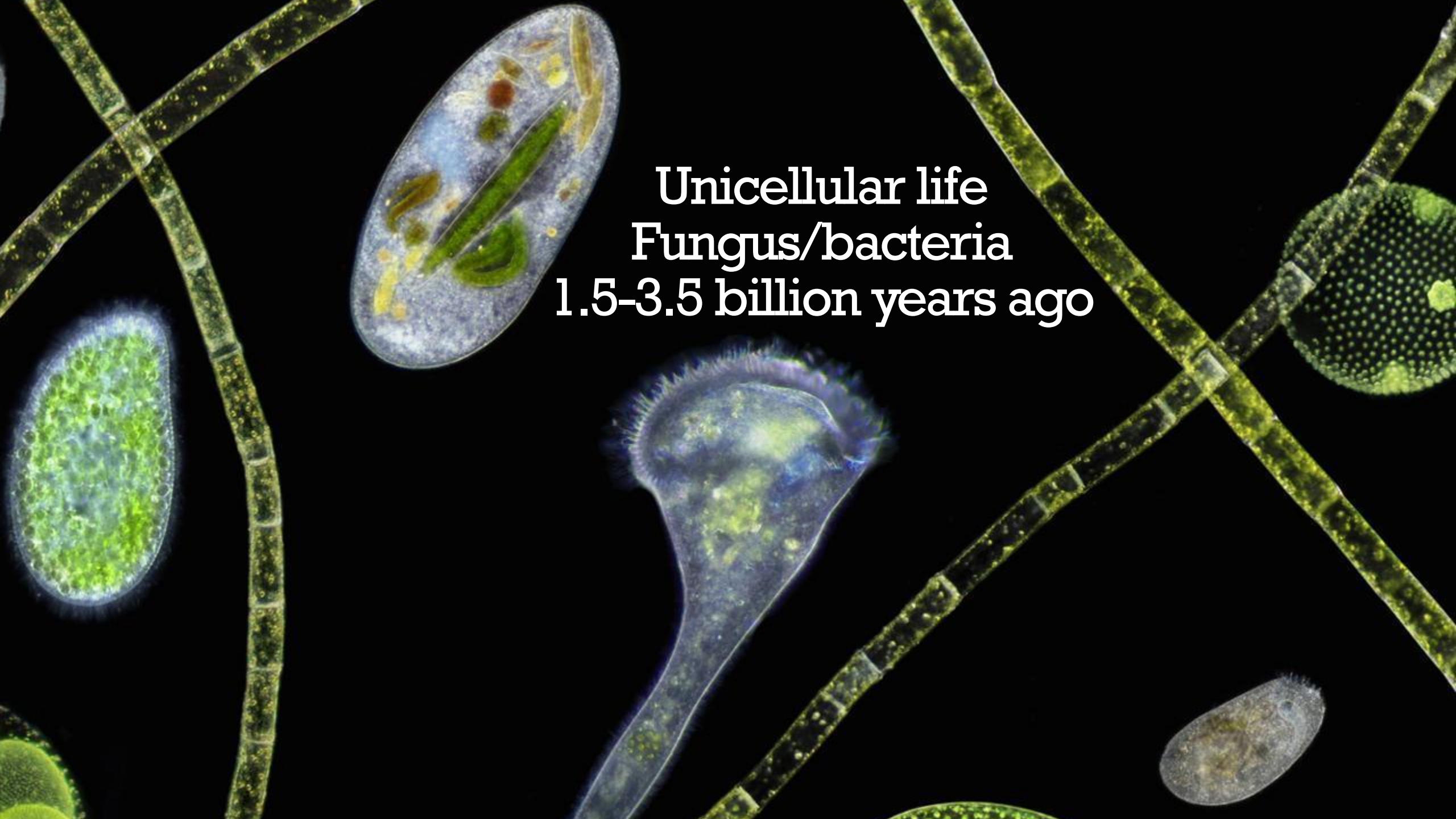

Primate Hands Family Tree
www.handresearch.com (2013)
Daubentonia
aye-aye
Lemur
lemur
Galago
bush baby
Nycticebus
slow loris
Perodicticus
potto
loris
Loris
Colobus
colobus monkey
Presbytis
surili monkey
long-nosed monkey
Nasalis
guenon monkey
Cercopithecus
Macaca
macaque
baboon
Papio
Tarsius
tarsier
Prosimians
Old World monkeys
Pongo
orangutan
Gorilla
gorilla
Pan
chimpanzee (+ bonobo)
Homo
human
Human Apes
Great Human apes
New World monkeys
Primate Hands: The Family Tree
Cebus
capuchin monkey
Hylobates
gibbon
Ateles
spider monkey
Saimiri
squirrel monkey
tamarin monkey
Aotus
night monkey
Leontocebus
SIMIANS
PROSIMIANS
lorisoids
lemurs
tarsiers
new world monkeys
old world monkeys
APES
gibbons
orangutans
gorillas
chimps
humans
LESSER APES
GREAT APES
PRIMATE FAMILY CATEGORIZED
PRIMATE FAMILY DISTRIBUTED AROUND THE WORLD
HUMANS
APES
PROSIMIANS
NEW WORLD MONKEYS
OLD WORLD MONKEYS

The Tree of Life

All species on earth evolved from prokaryotic organisms.

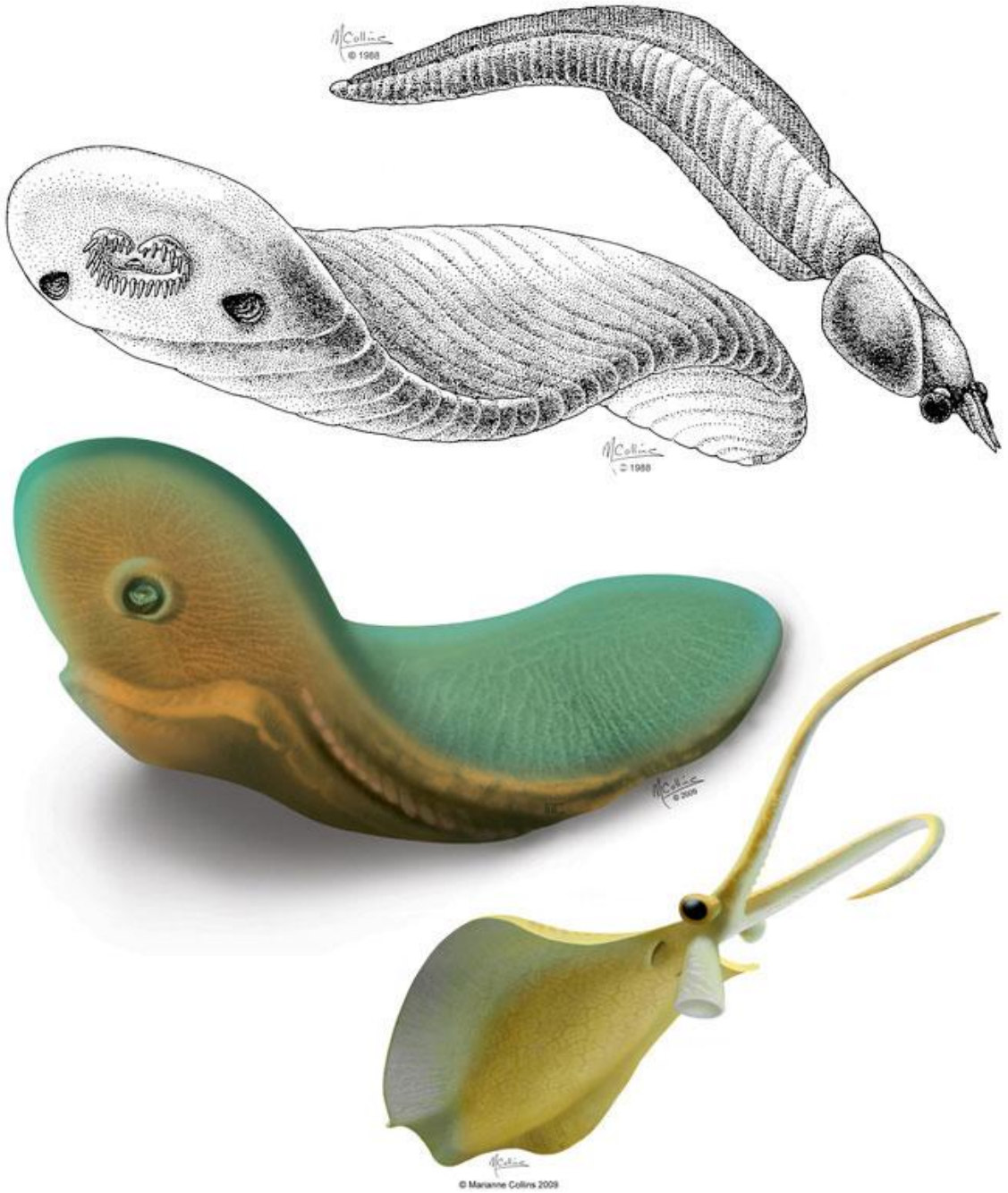
Humans are apart of this tree – more current model than the famous ‘line’ of monkeys/apes merging into humans.




Unicellular life
Fungus/bacteria
1.5-3.5 billion years ago

The Origin of Life:

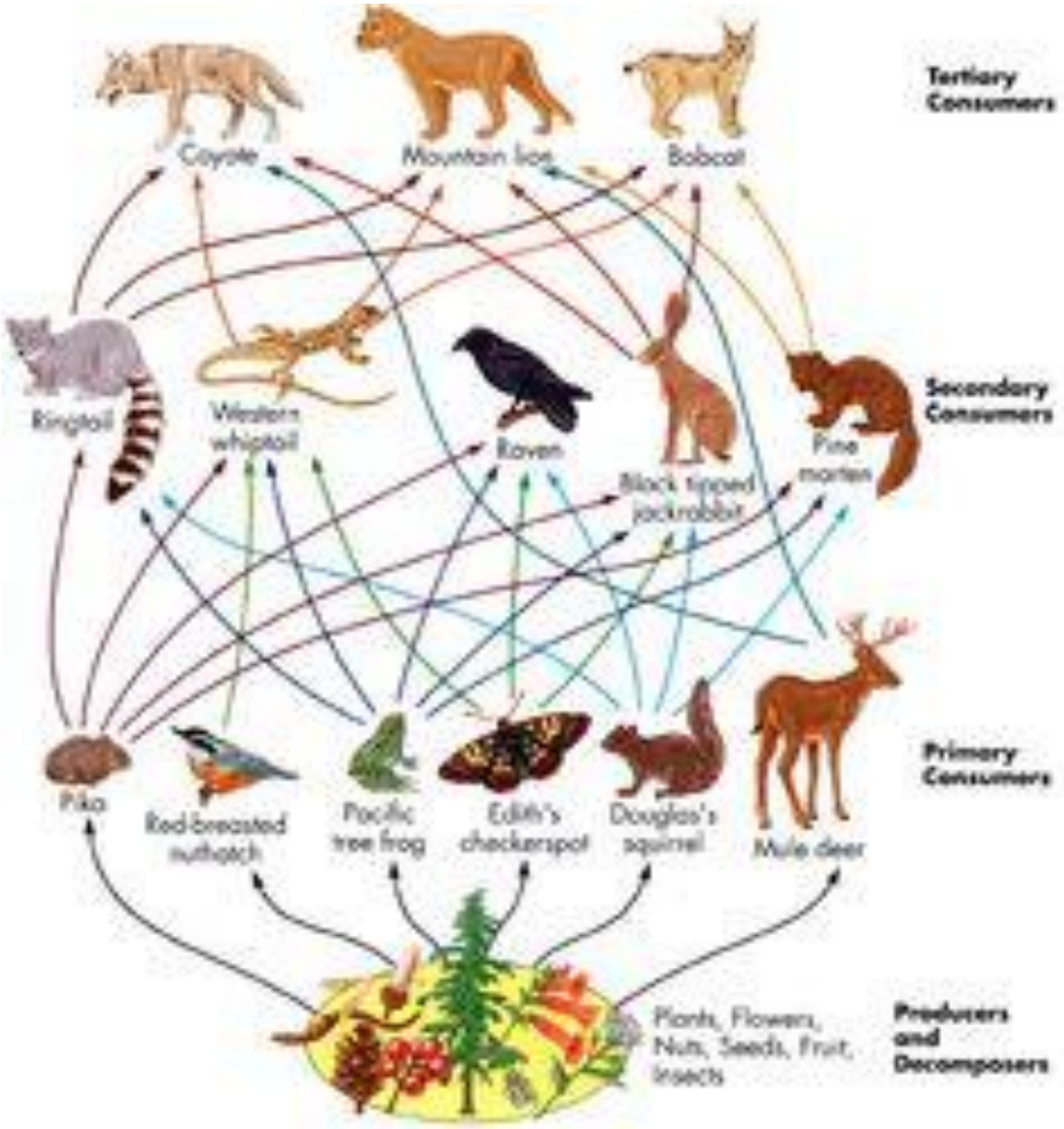
The Ocean!



The Cambrian Explosion
-Multicellular life
800 million years ago

Animal Evolution

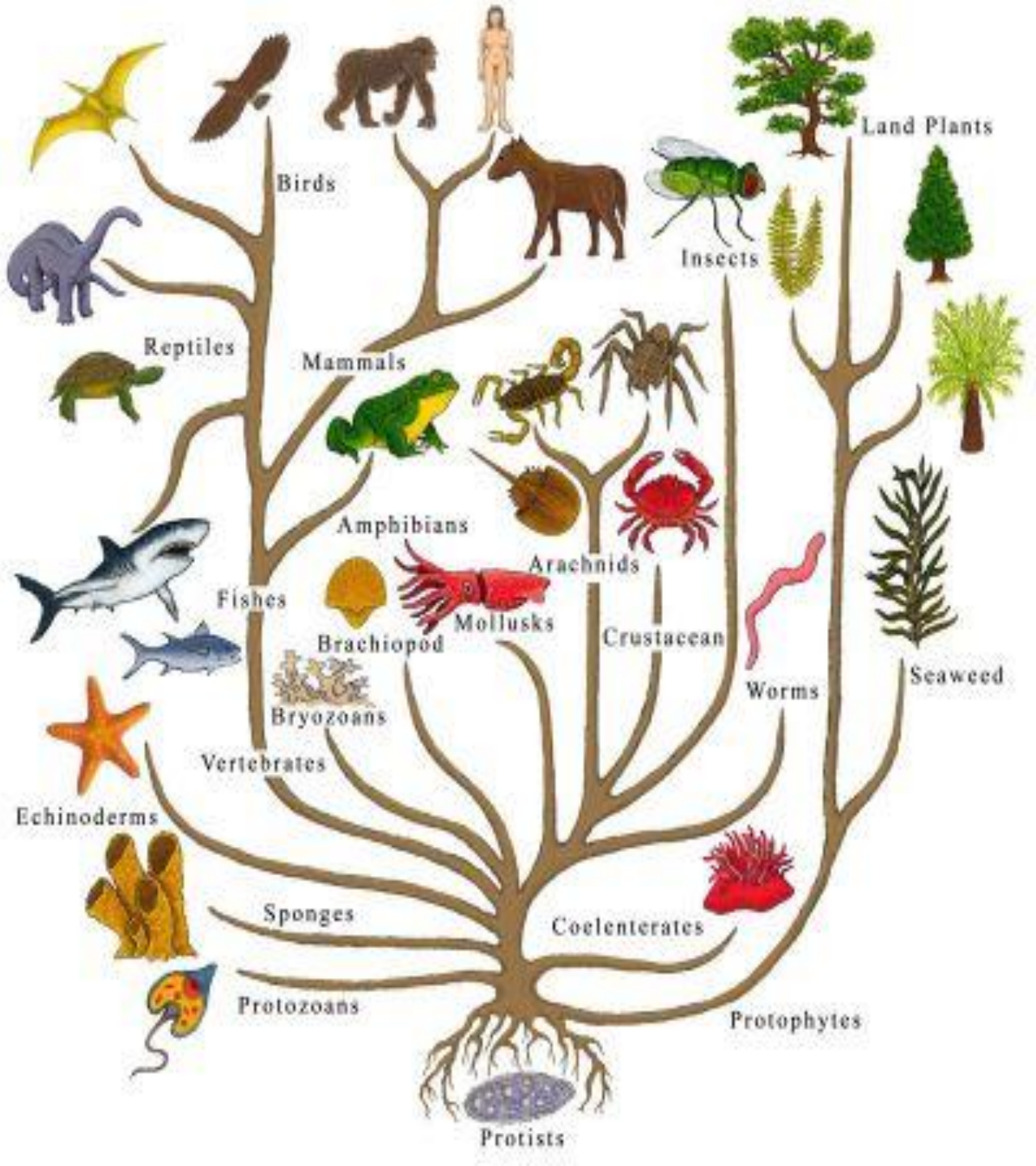
- Transformation of species over many generations that leads to species-change
- Reproductive descent with modification /inheritance of traits through parental lineage



Macro-evolution:

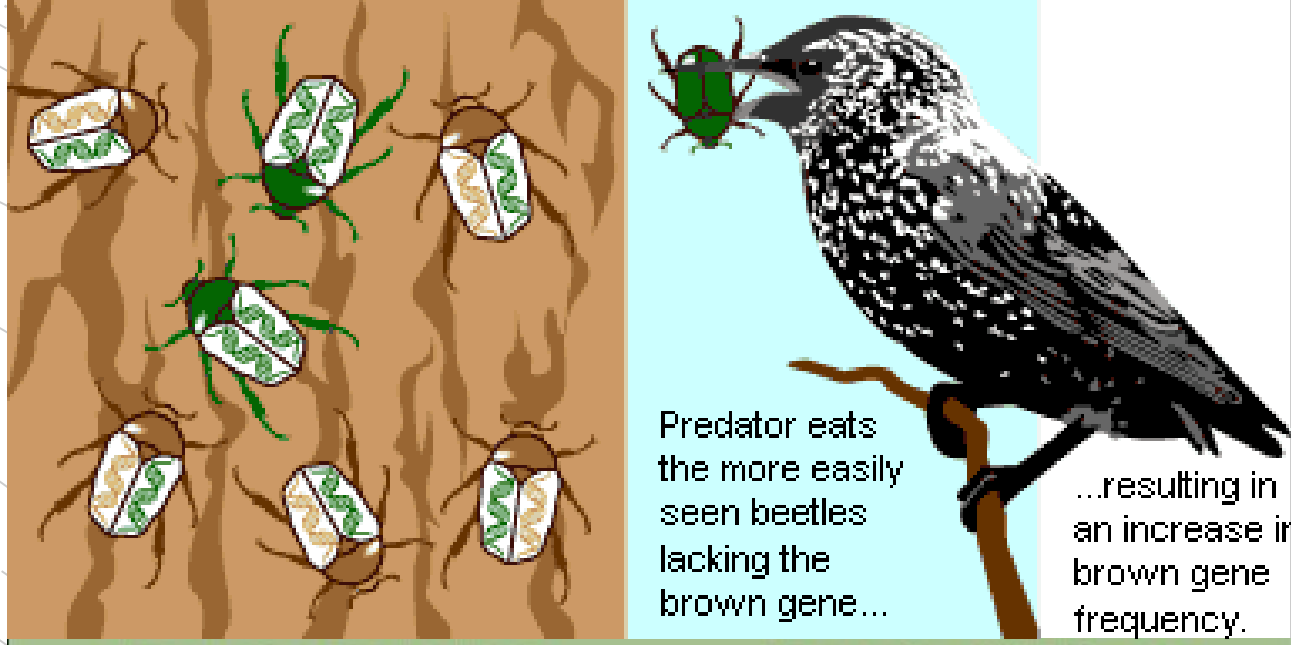
Species: “Group of related organisms whose members can interbreed to produce offspring that can live and reproduce” (Kottak 2017)

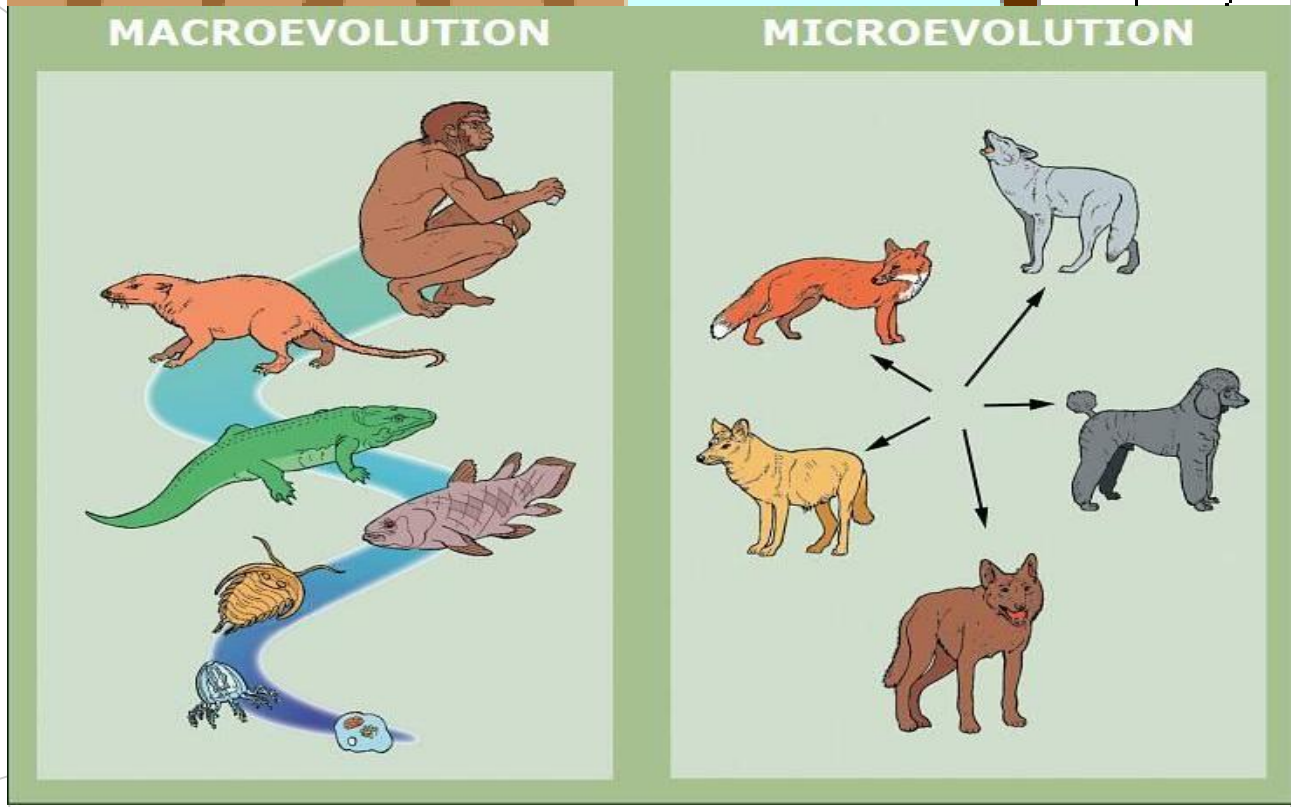
Speciation: “the formation of new species” (Kottak 2017)



Micro-evolution:

Microevolution: evolutionary shifts in a single species that occur over a few generations / during a relatively short time span.






Dinosaurs: extinct 600 million years ago
Roamed for 165 million years

Human Origins: Timeline

250 million years ago – No birds or mammals on Earth

2,300,000 years old - Genus: Homo

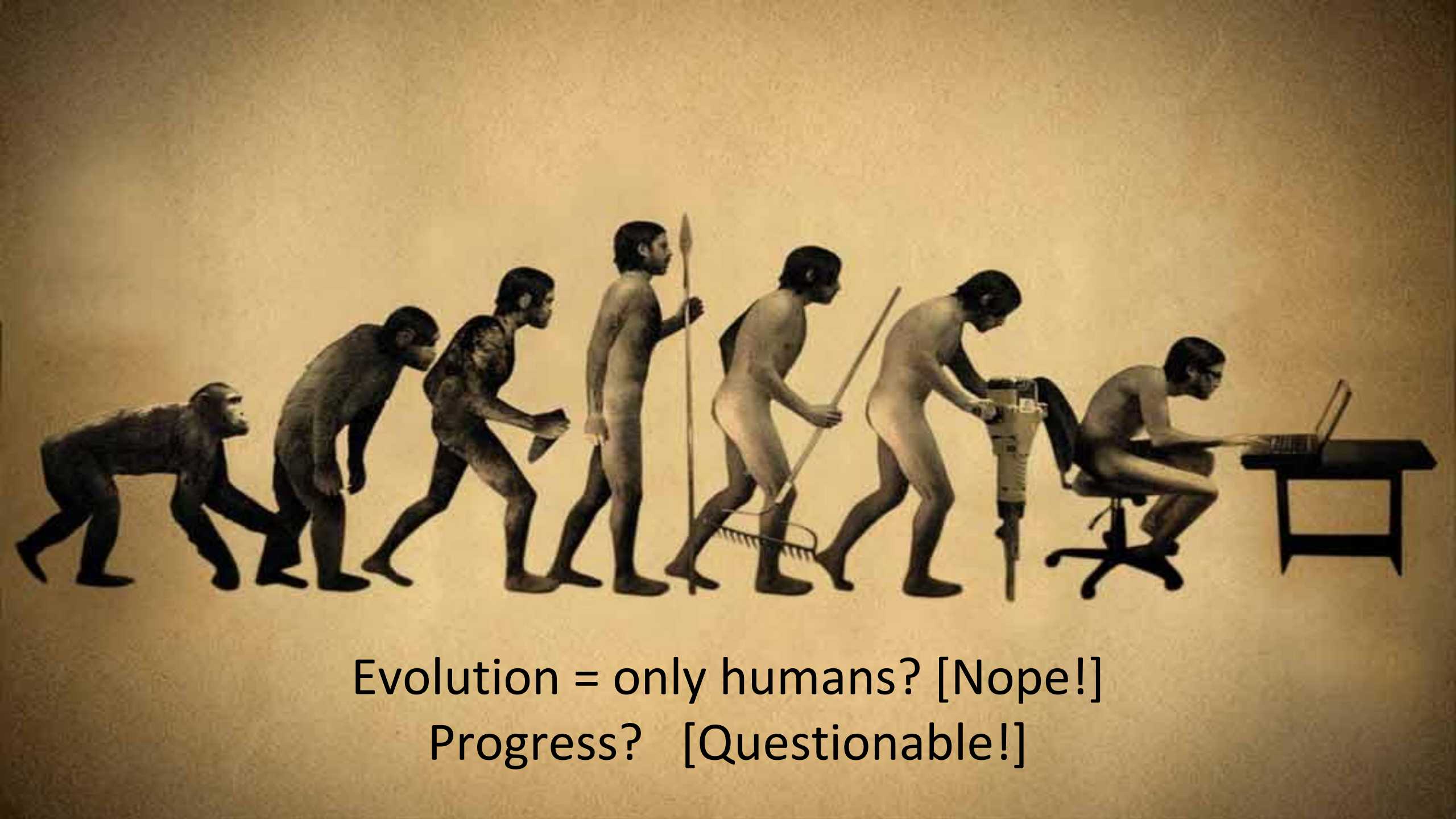
200,000 years old – Homosapiens

120,000-130,000 years – Symbolic thought/language appears

74,000 years ago – <igration outside Africa to Indonesia [volcanic winter]

12,000 years ago– Agriculture

12,000-14,000 years ago – Settling of the future Americas [via Bering Strait]



Evolution = only humans? [Nope!]

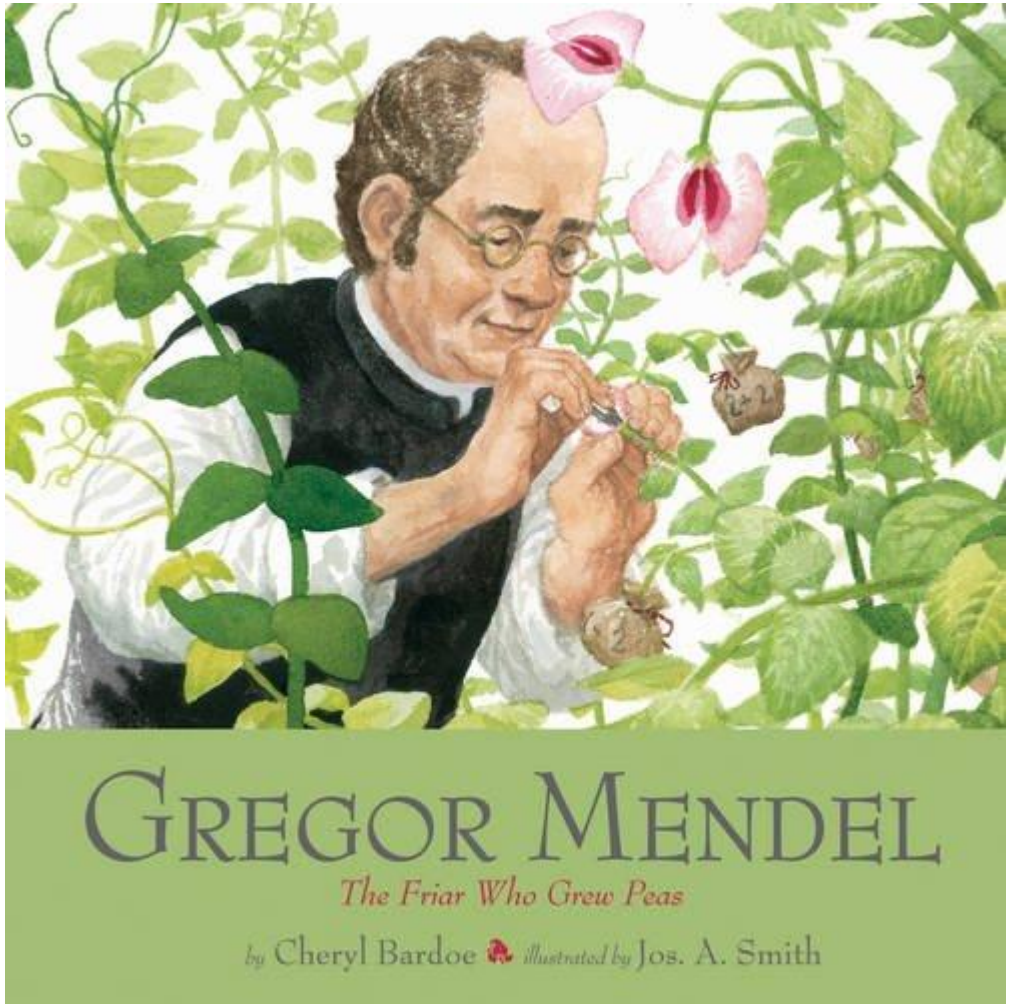
Progress? [Questionable!]

Early Genetics Research

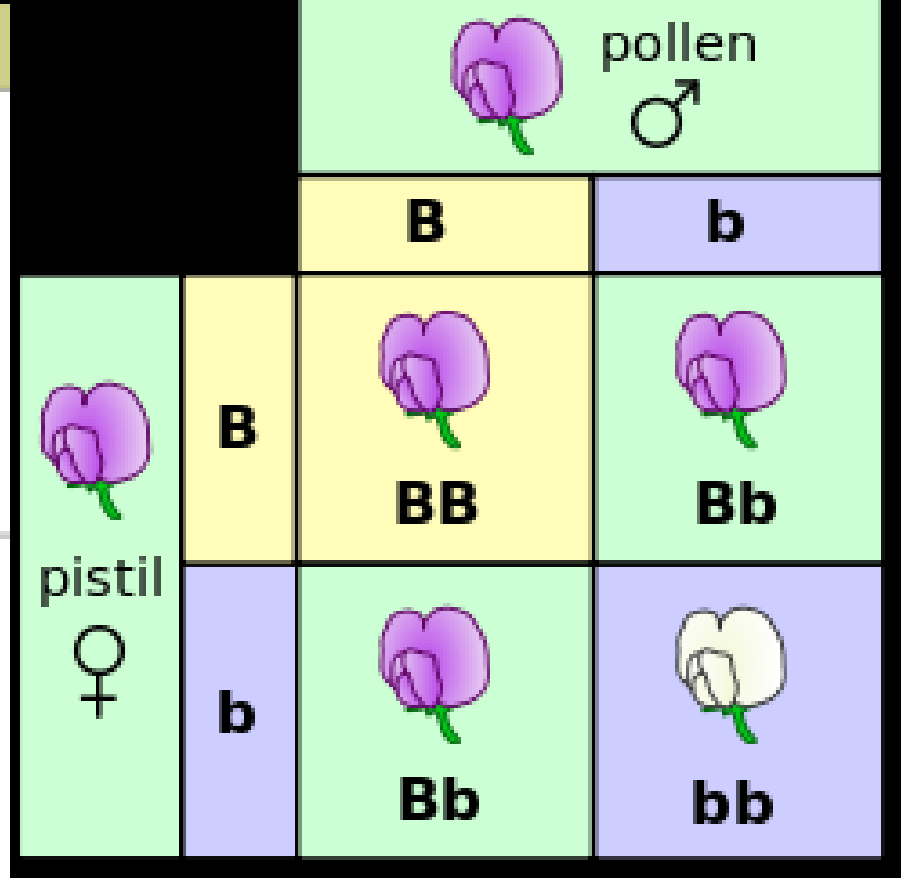
Mendel and Darwin, observing the natural world

Gregor Mendel
“The Father of Modern Genetics”

1822 - 1884

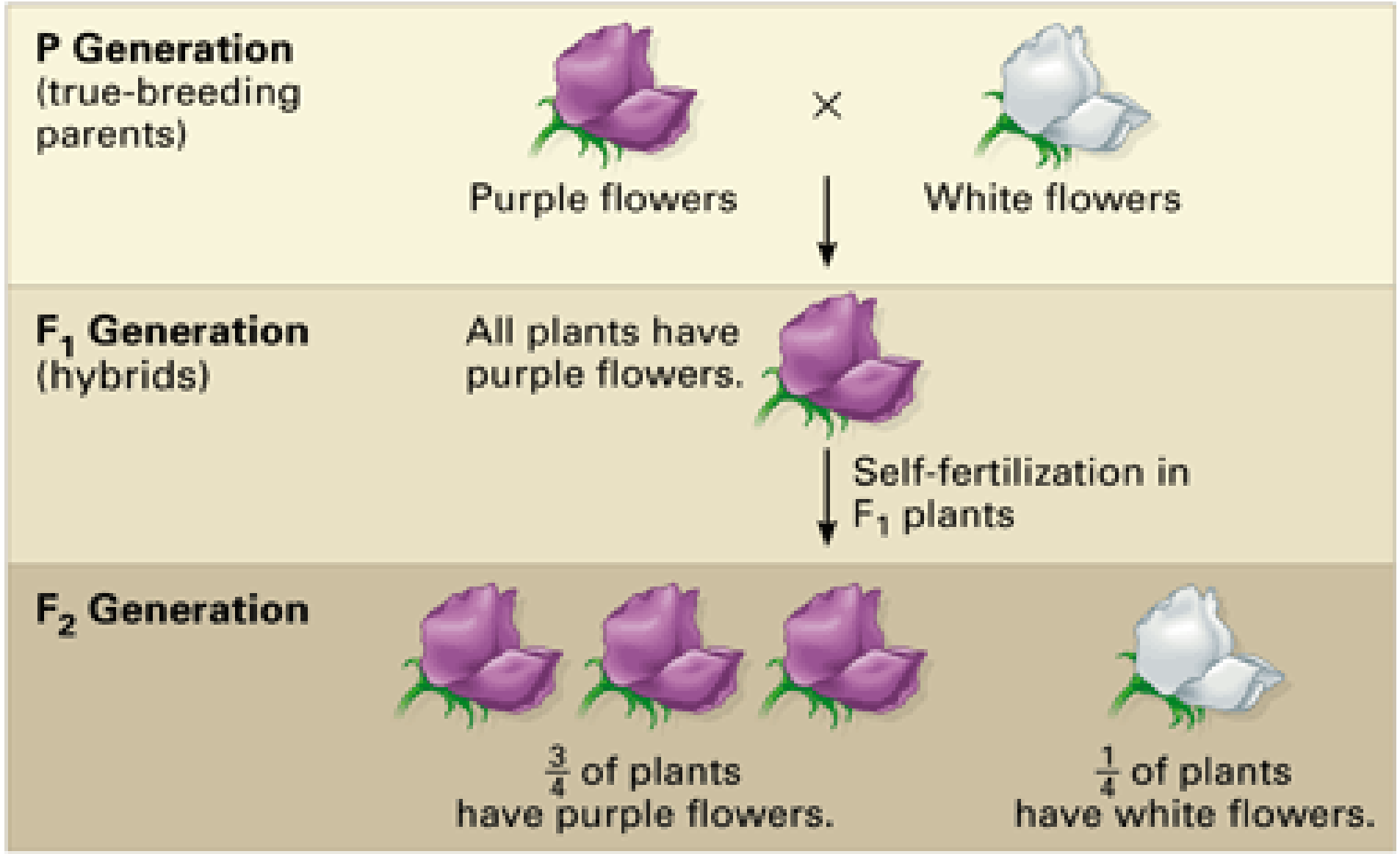


	Flower color	Flower position	Seed color	Seed shape	Pod shape	Pod color	Stem length
P	Purple × White	Axial × Terminal	Yellow × Green	Round × Wrinkled	Inflated × Constricted	Green × Yellow	Tall × Dwarf
F_1	Purple	Axial	Yellow	Round	Inflated	Green	Tall

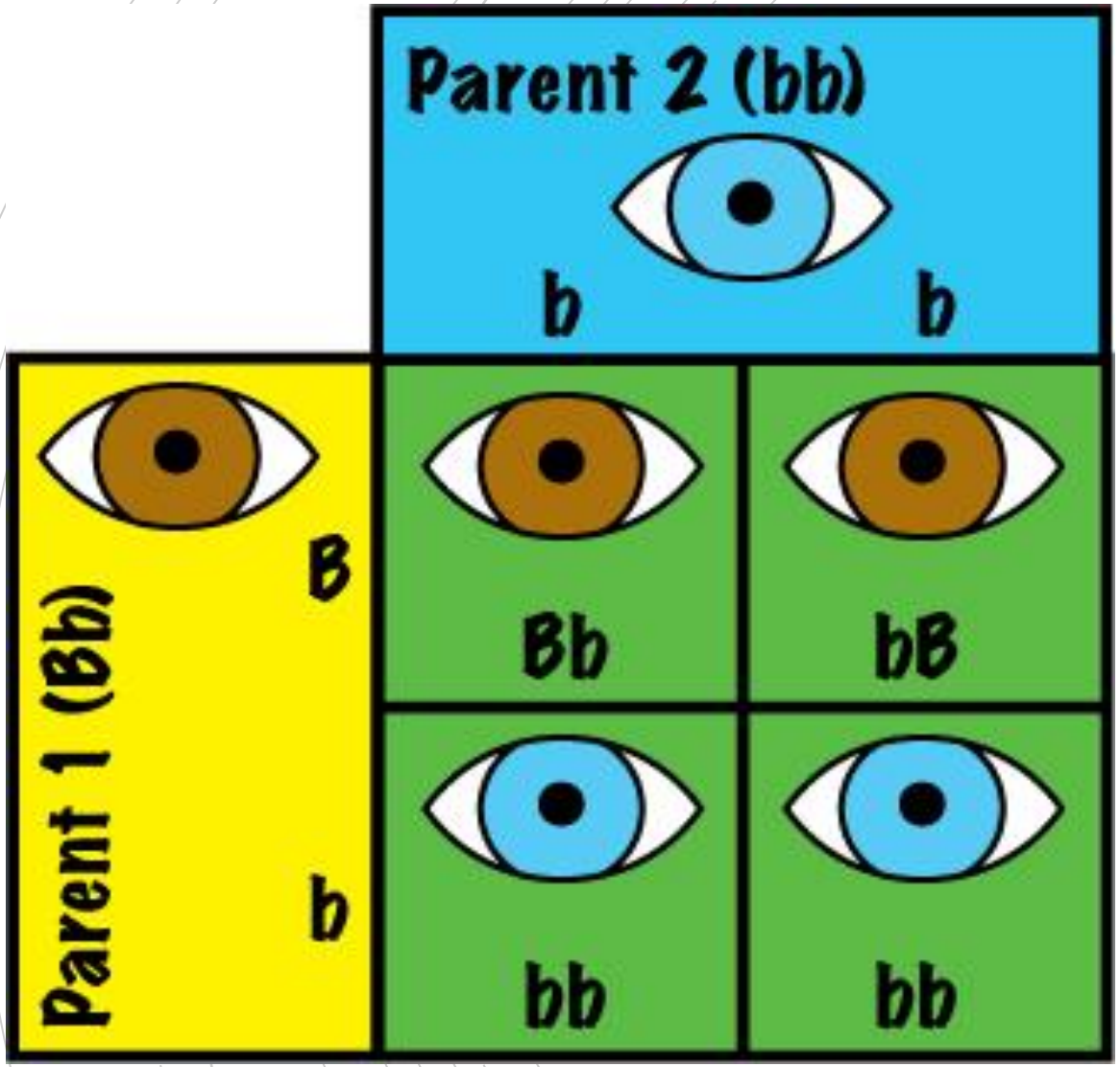


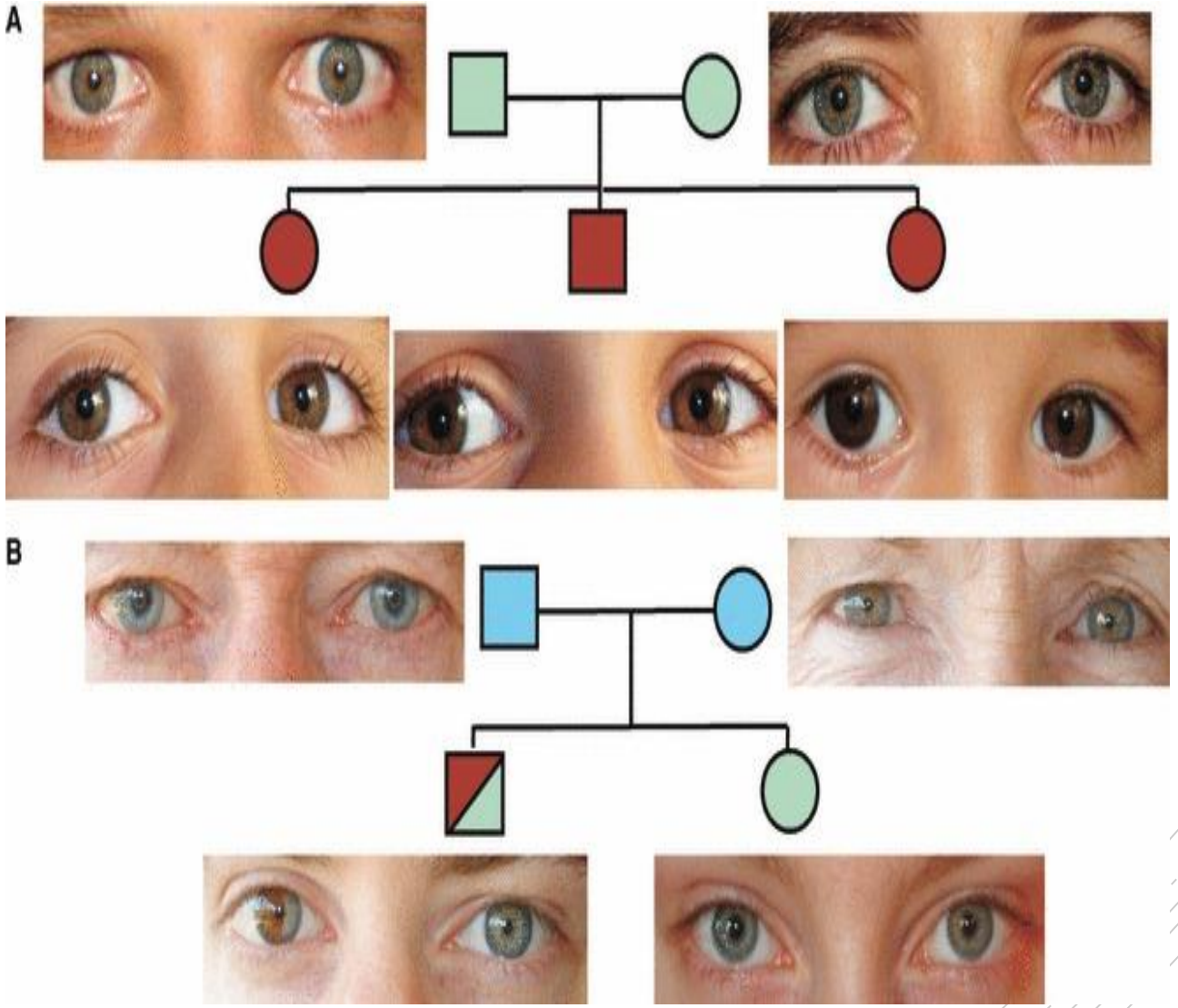
Mendel's Experiments

Mendel's Experiments



Mendel's Experiments



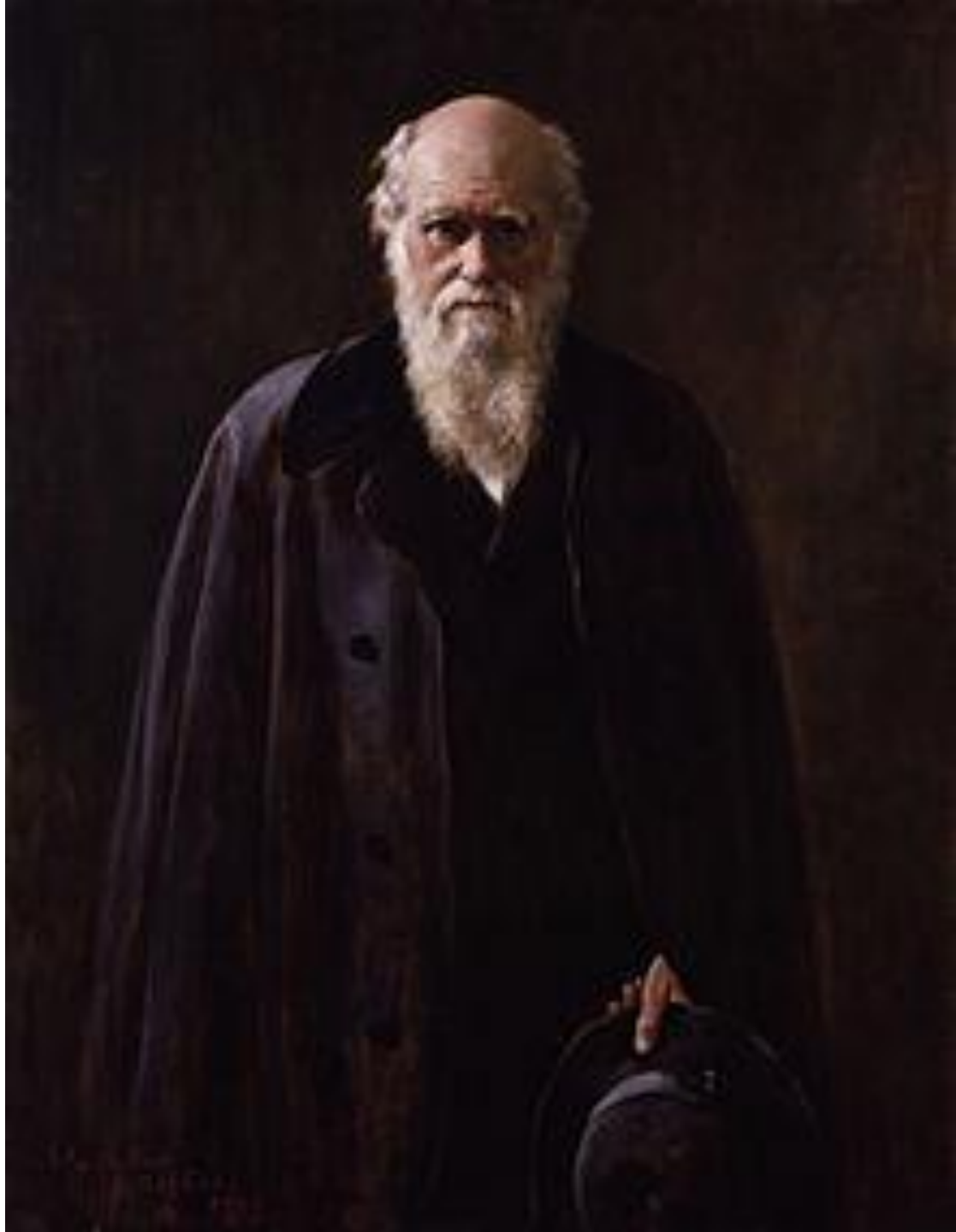


English Naturalist **Charles Darwin** 1809-1882

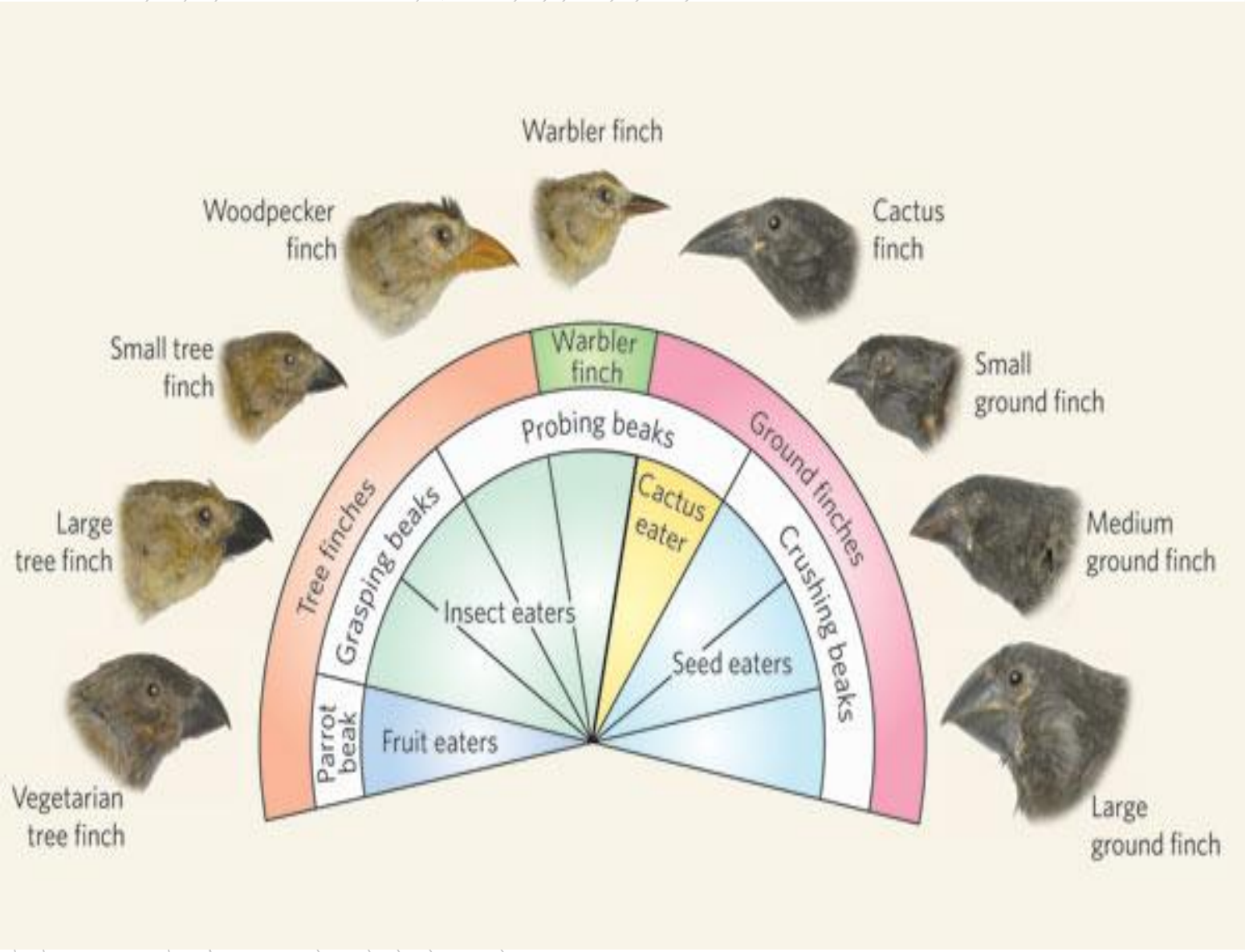
“The Theory of Evolution”

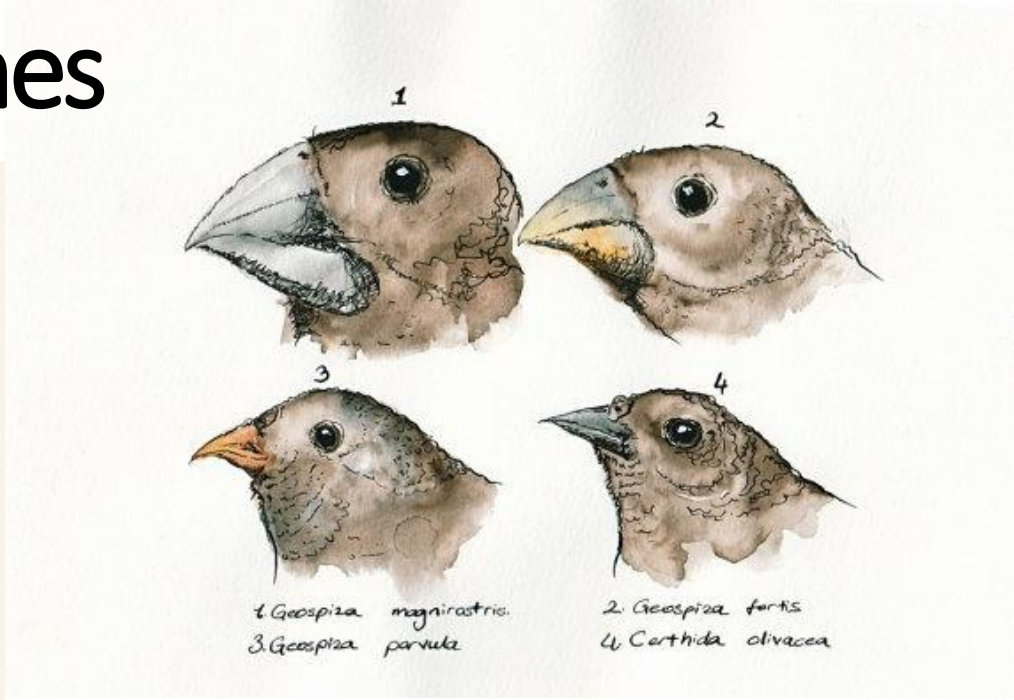
Famous for work on Natural Selection

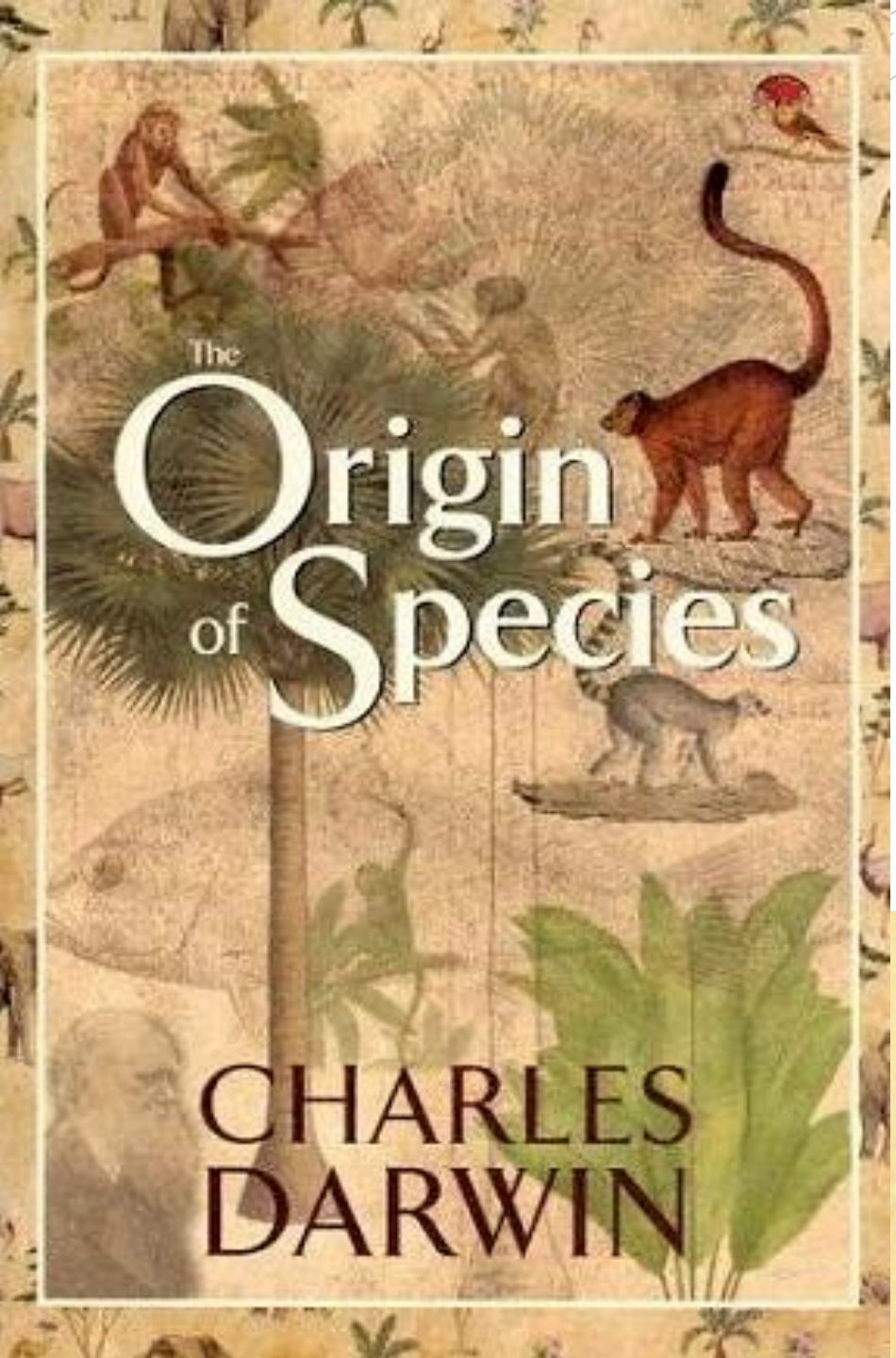
Above – with son, William 1842

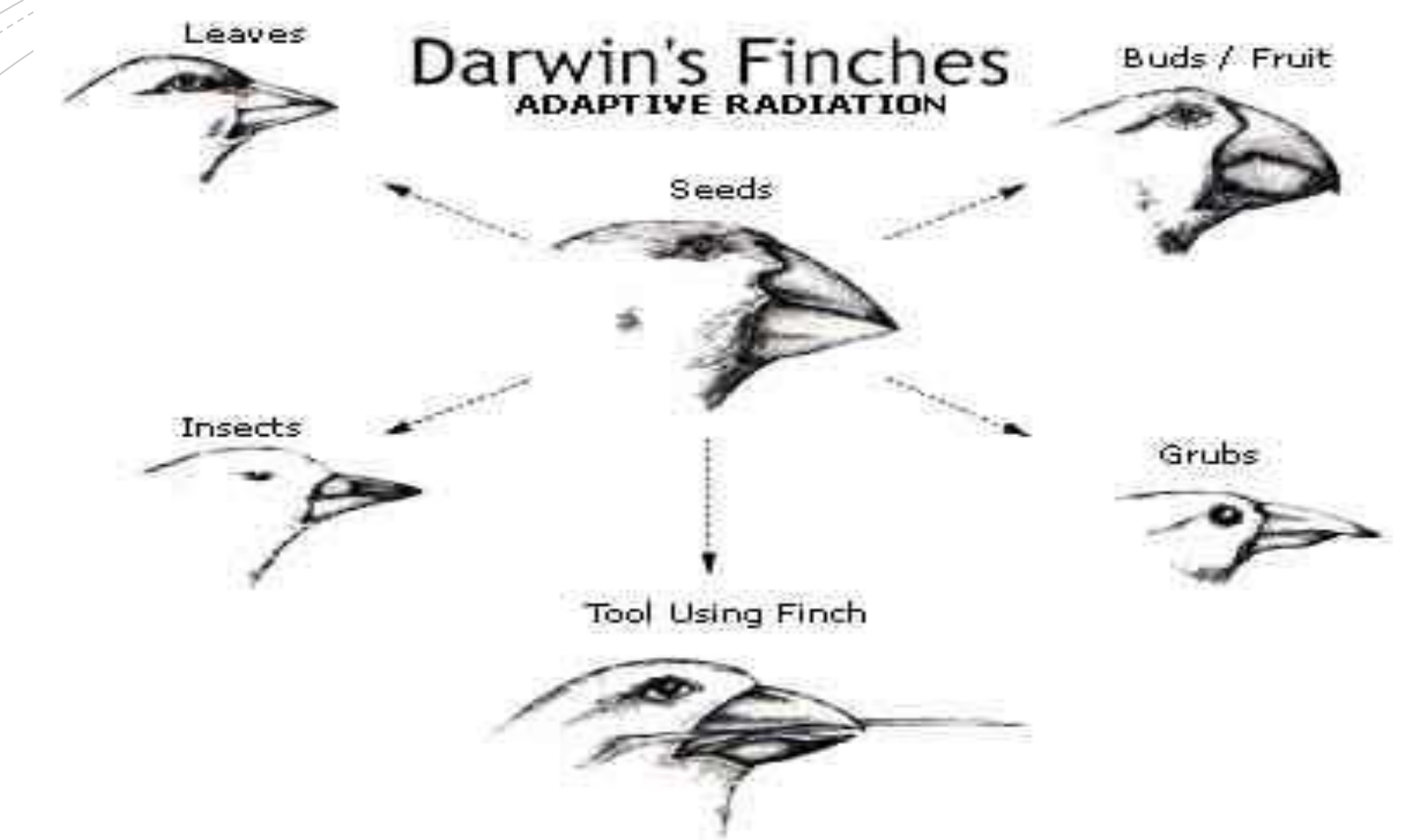


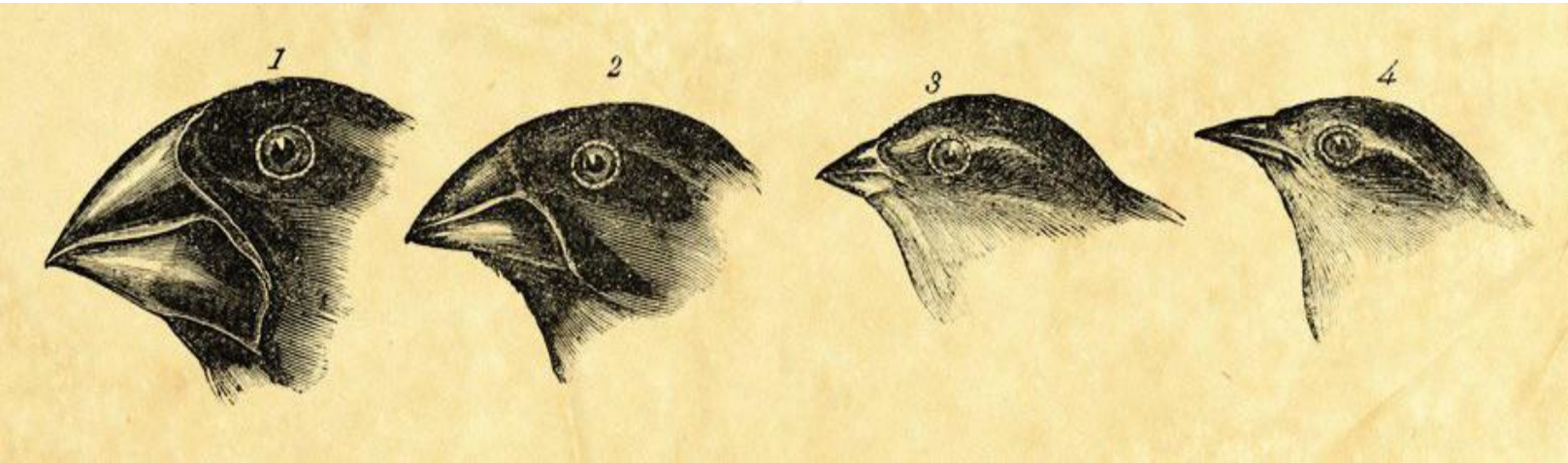
Darwin's Finches

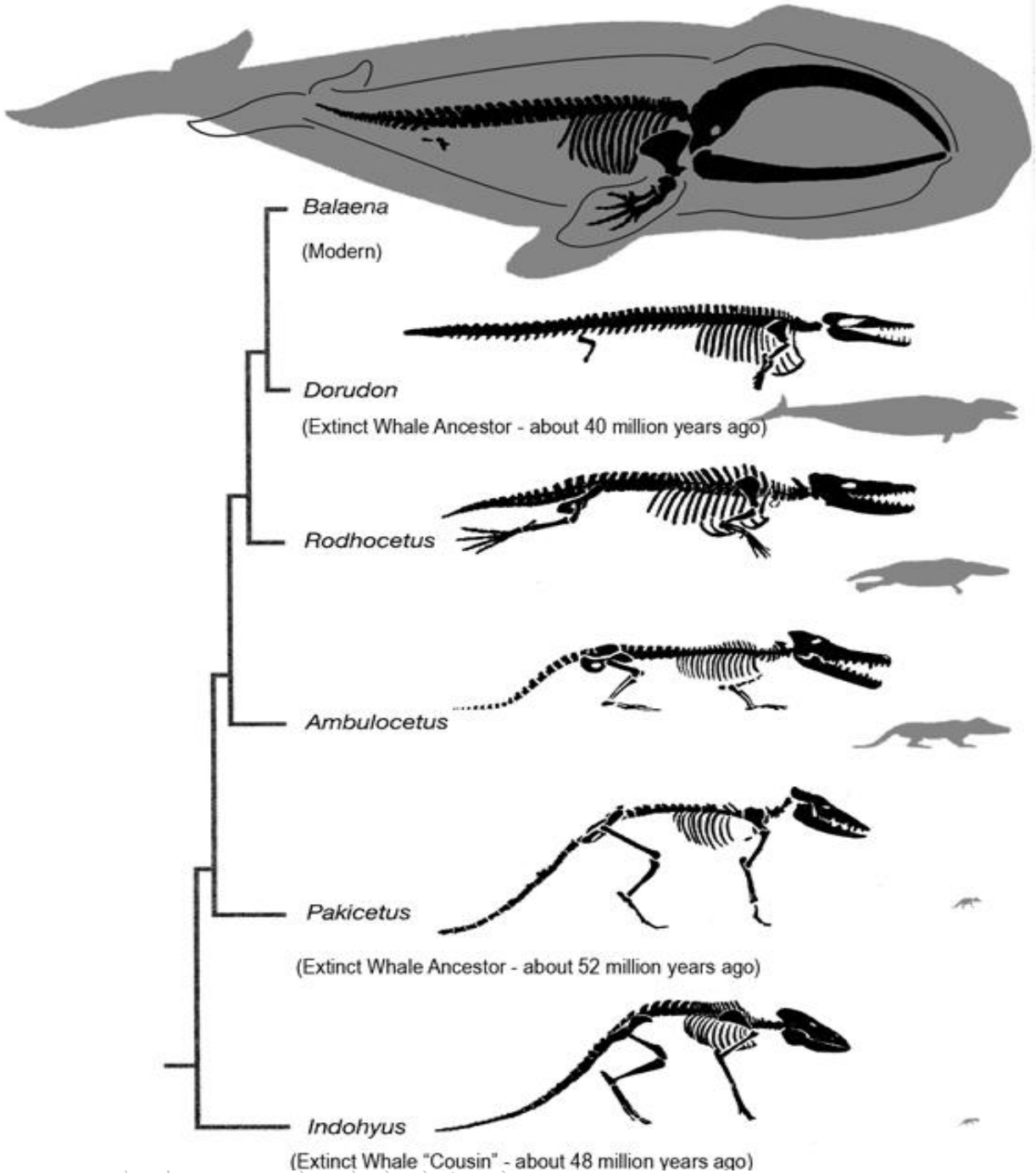


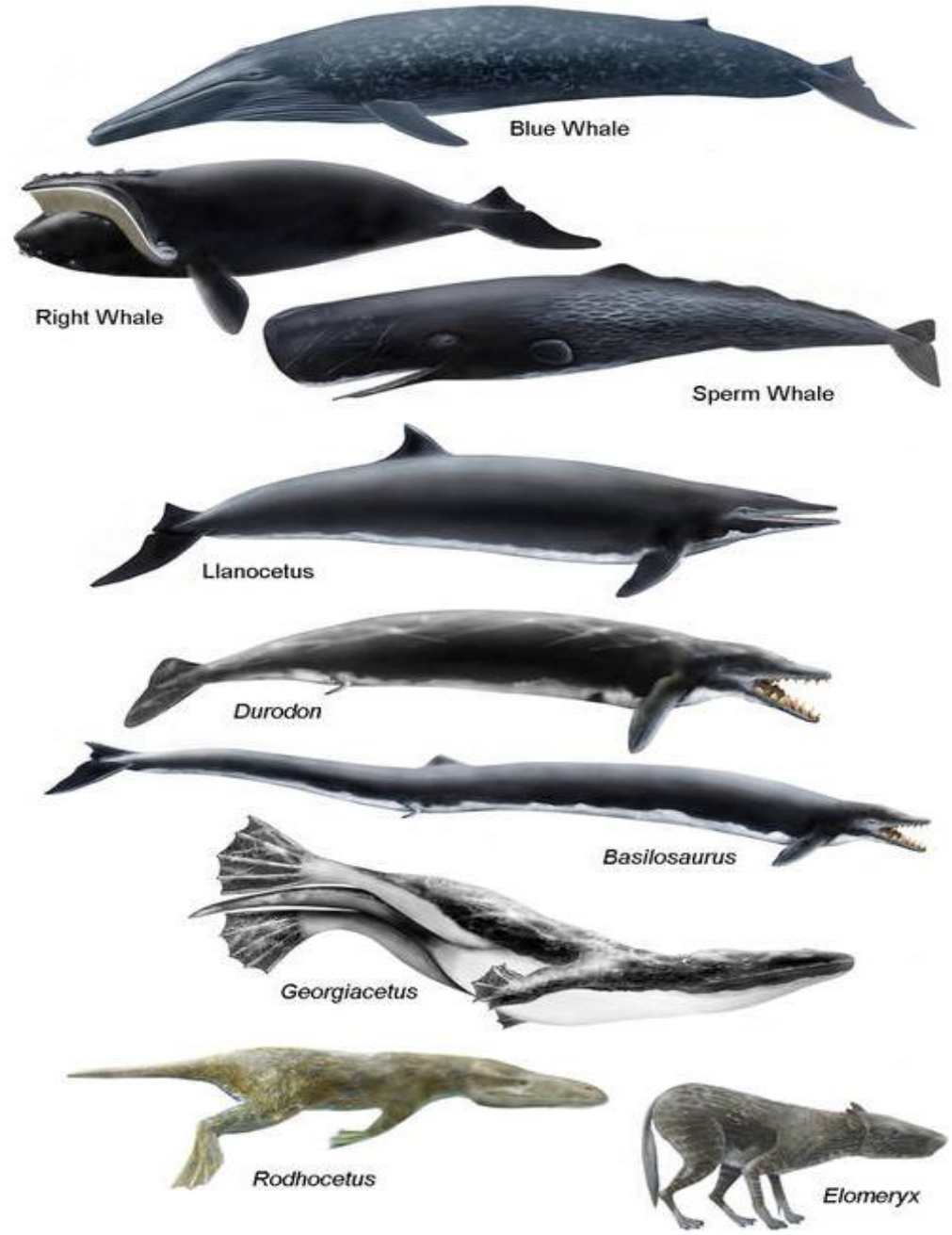



The
Origin
of Species
CHARLES
DARWIN

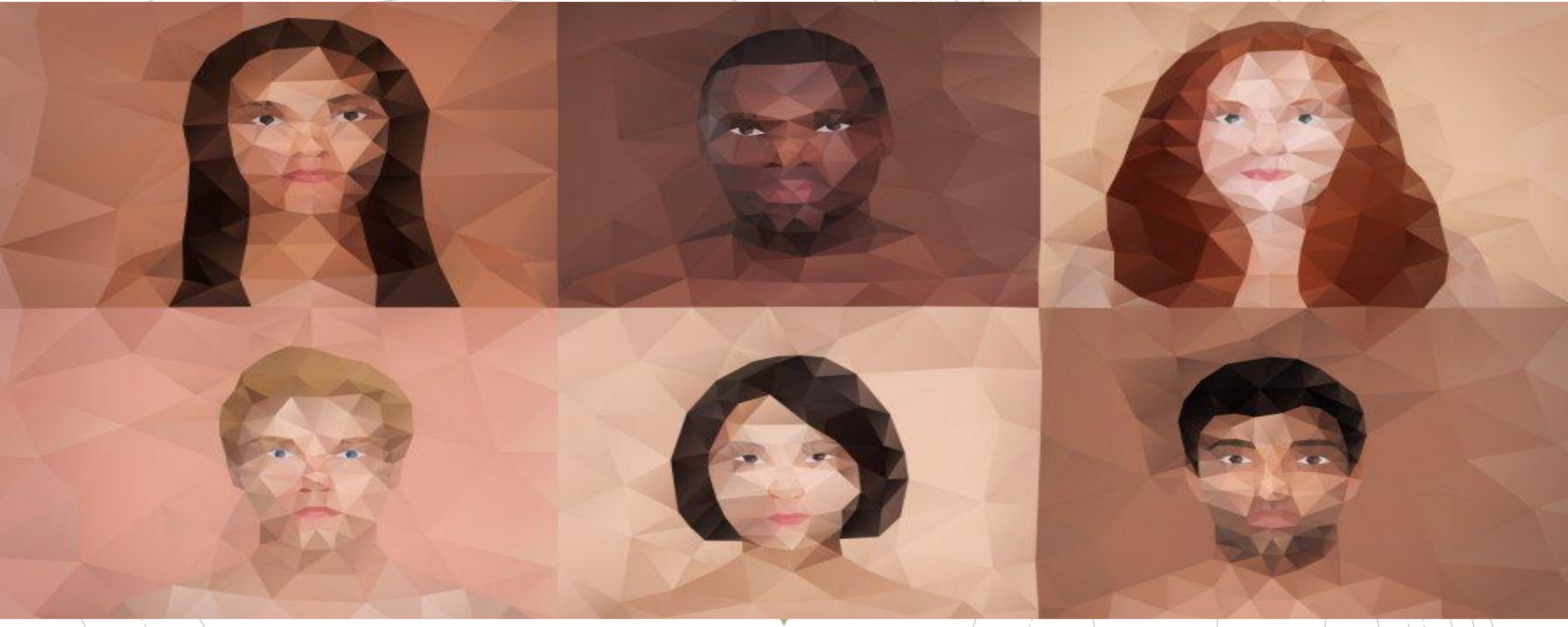

Darwin's Finches
ADAPTIVE RADIATION
Leaves
Buds / Fruit
Seeds
Insects
Grubs
Tool Using Finch


1
2
3
4

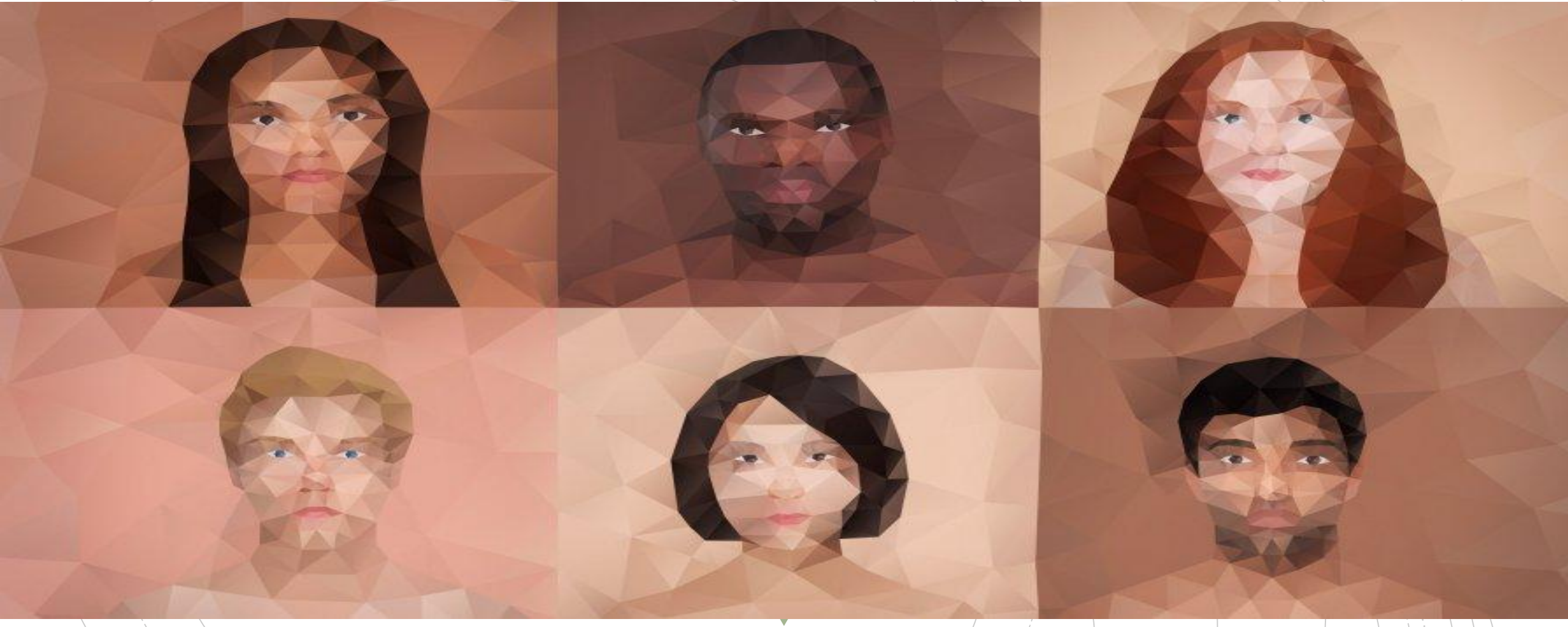

Balaena
(Modern)
Dorudon
(Extinct Whale Ancestor - about 40 million years ago)
Rodhocetus
Ambulocetus
Pakicetus
(Extinct Whale Ancestor - about 52 million years ago)
Indohyus
(Extinct Whale "Cousin" - about 48 million years ago)


Blue Whale
Right Whale
Sperm Whale
Llanocetus
Durodon
Basilosaurus
Georgiacetus
Rodhocetus
Elomeryx

Central Question: Why is there Human Variation?



Central Question: Why is there Human Variation?



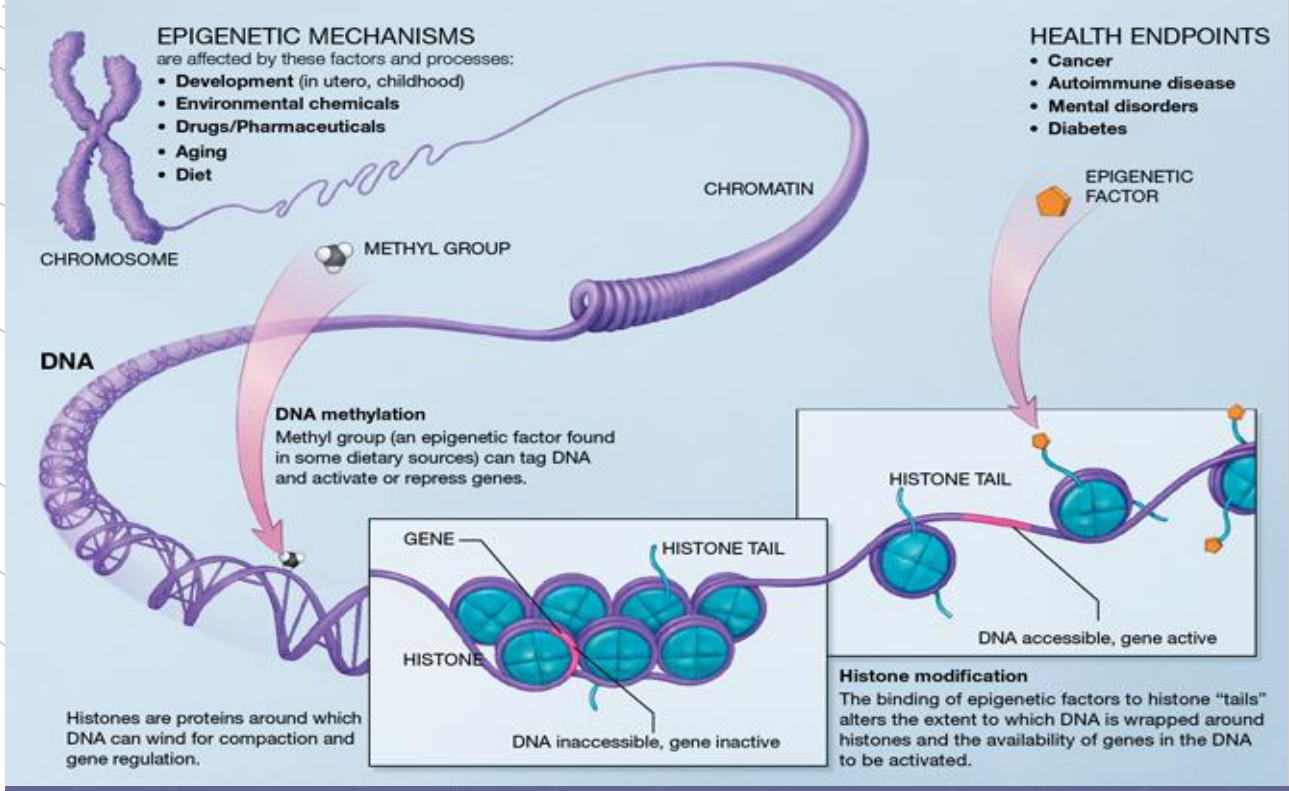
Answer: Caused by processes of heredity [mutation/gene flow/genetic drift/natural selection] and adaptation [Genetic; Developmental; Physiological; Behavioral; and cultural]

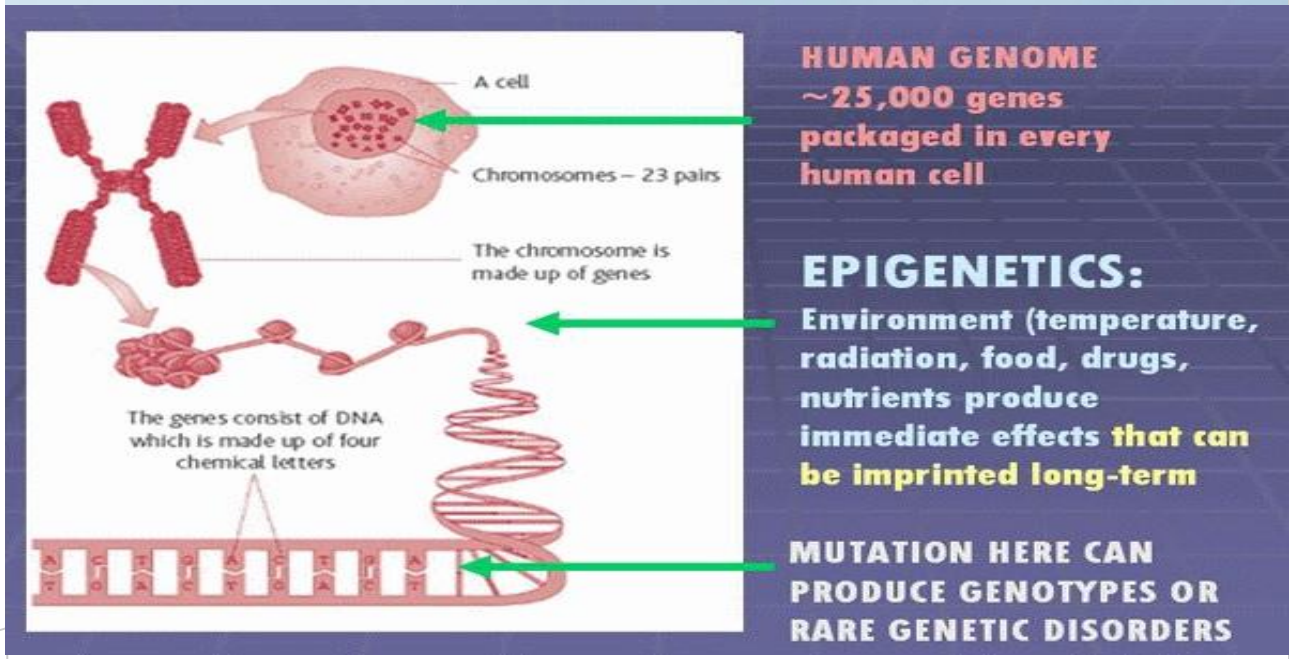
Genetics and Epigenetics: Topics

Genes and the Human Body

Genetics

Genetics is the study of heredity in living organisms through a focus on molecular structures such as genes, and the causes and results of genetic variation.

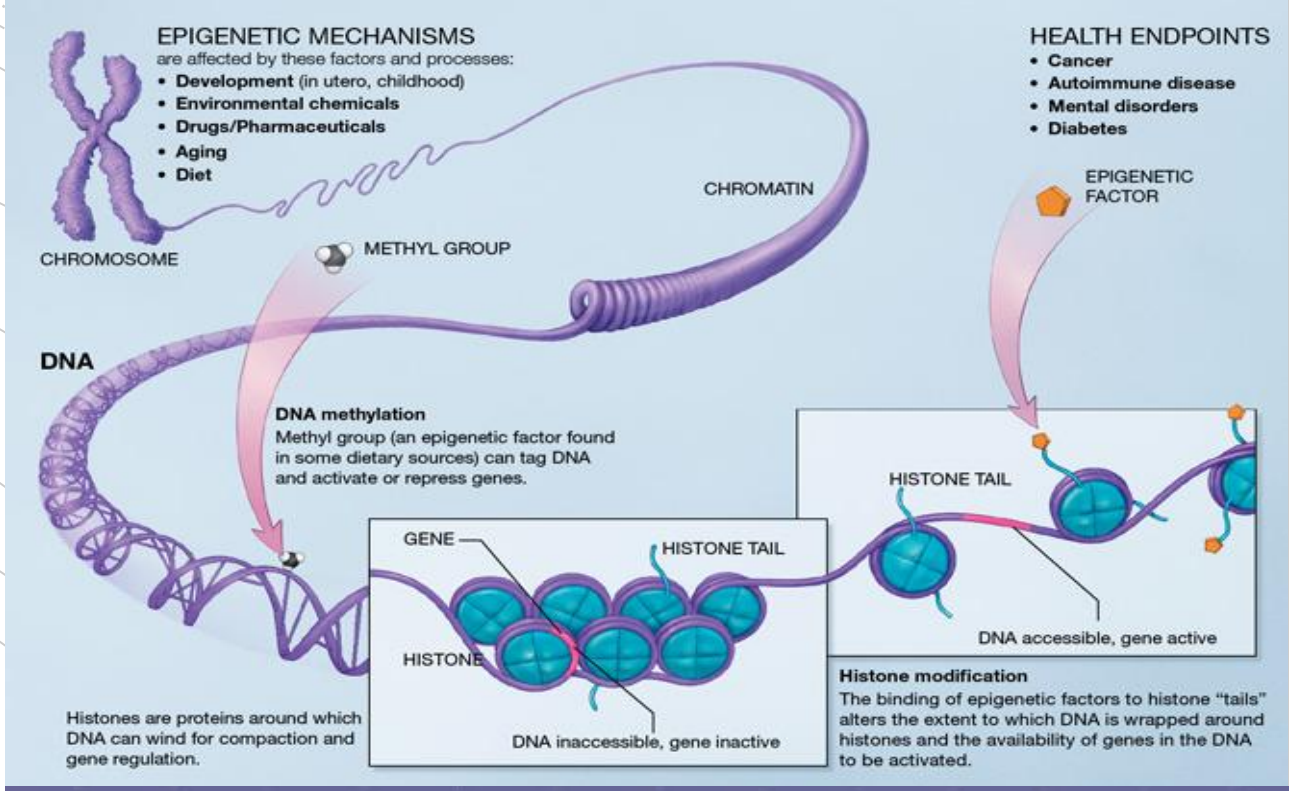


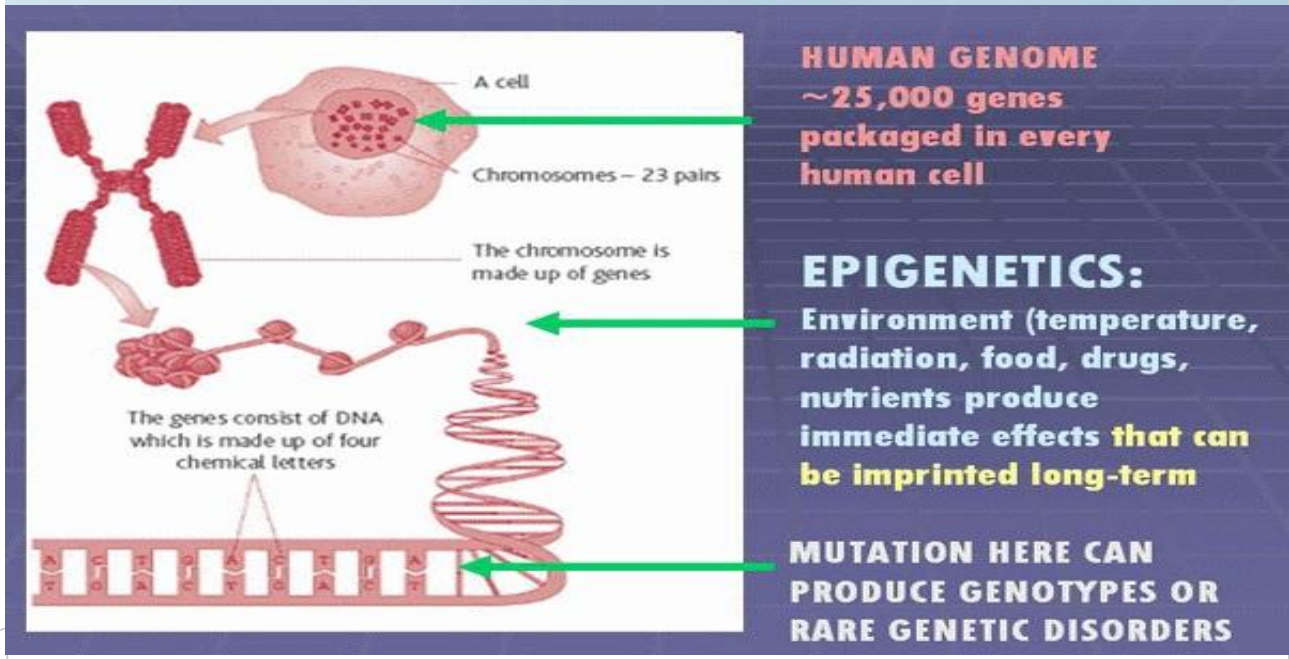


Epigenetics

Epigenetics is the study of the external modifications to DNA that turn genes "on" or "off."

Modifications do not change DNA sequence, but determine which proteins are transcribed and thus which trait appears.

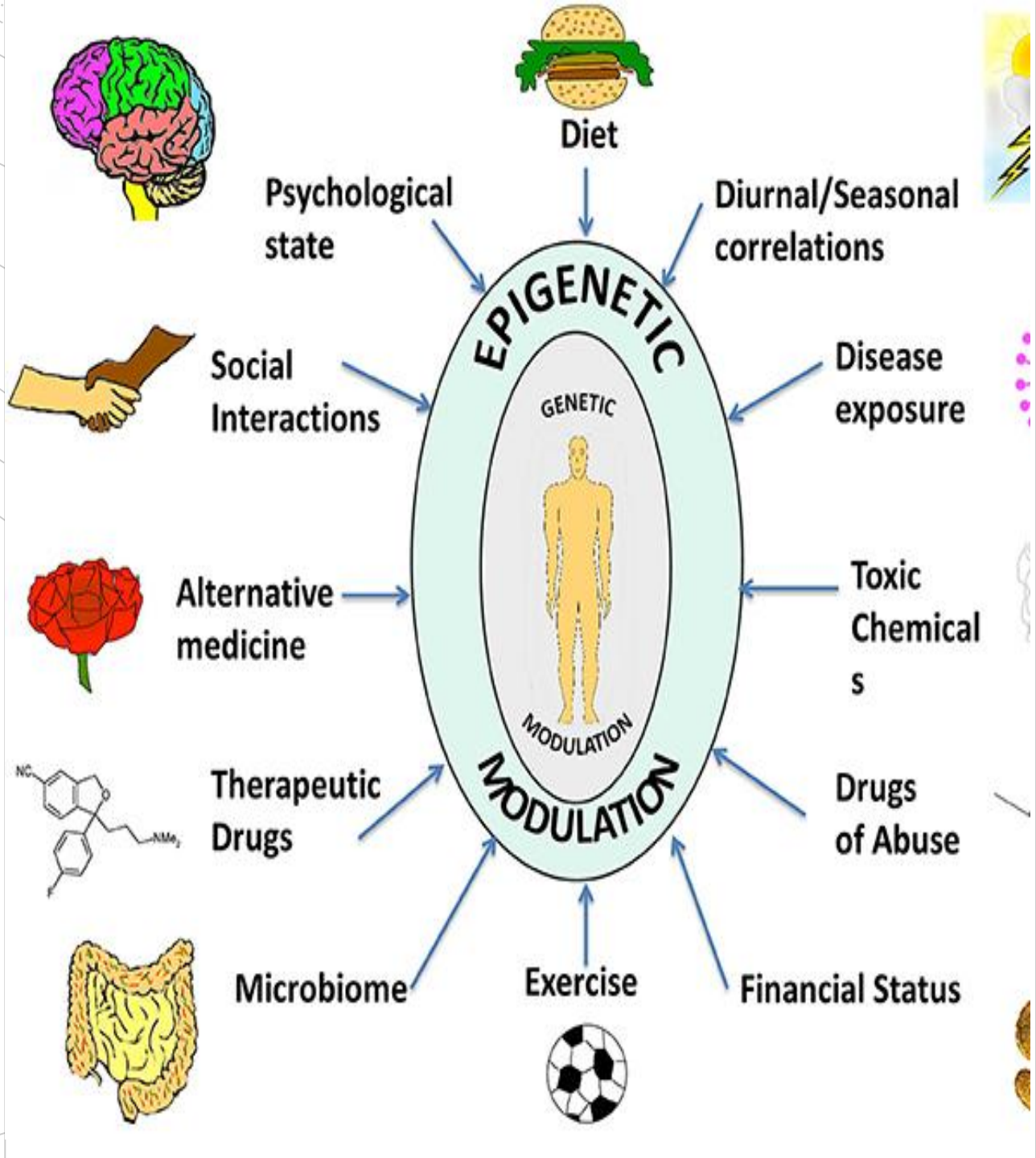




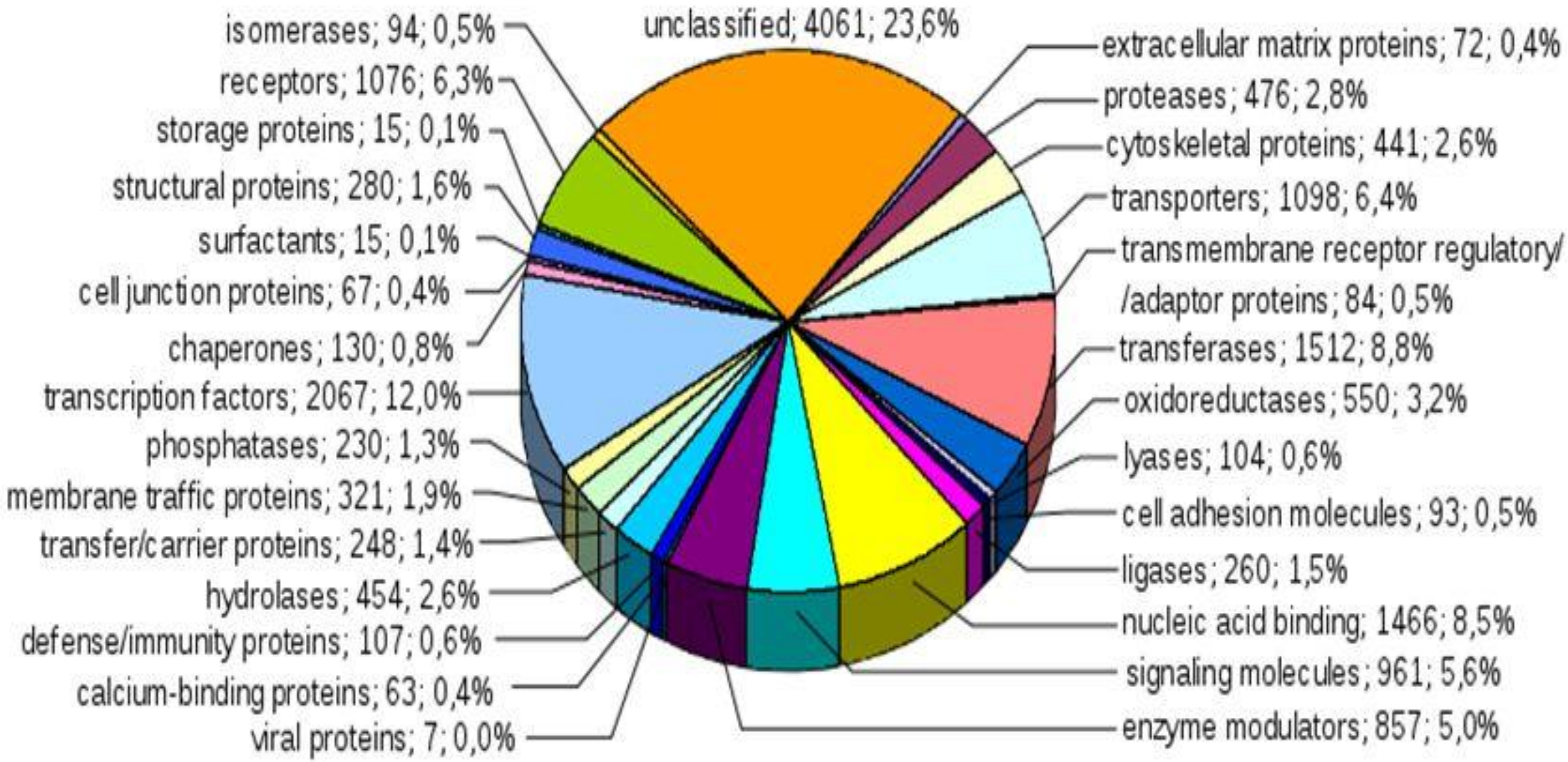
Epigenetics

Epigenetics is the study of the external modifications to DNA that turn genes "on" or "off."

Epigenetics also studies how RNA, DNA, and genes are affected by environmental factors in ways that can be passed down across generations.

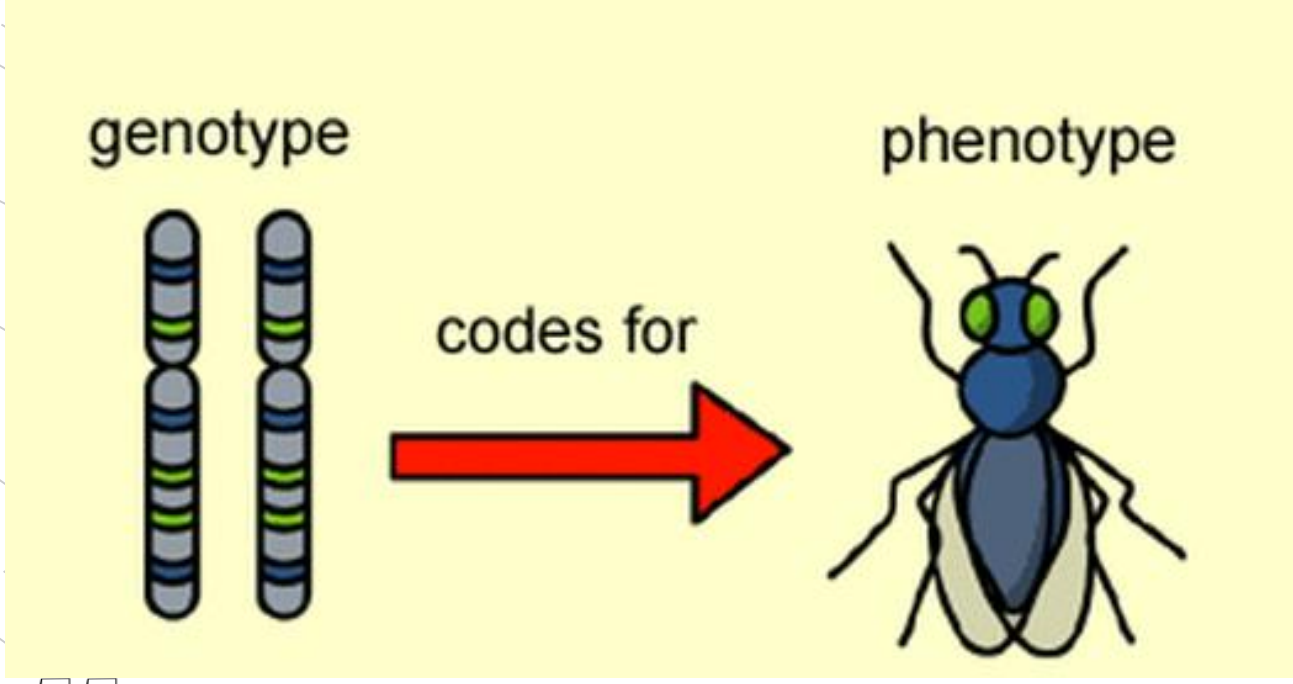


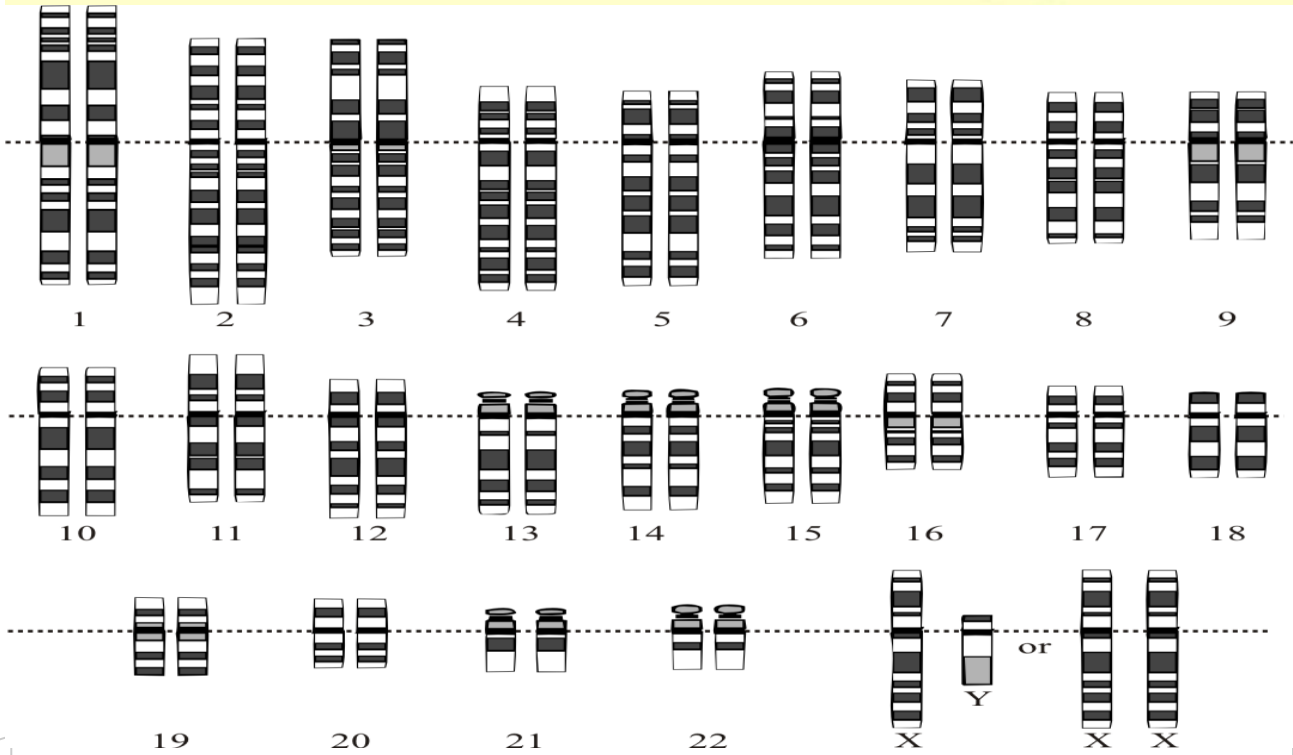
Human Genome Project



Genotype

Genotype the complete genetic identity / unique genome of an individual organism or group of organisms, with reference to a single trait, set of traits, or an entire complex of traits; the sum total of heritable genes transmitted from parent to offspring.

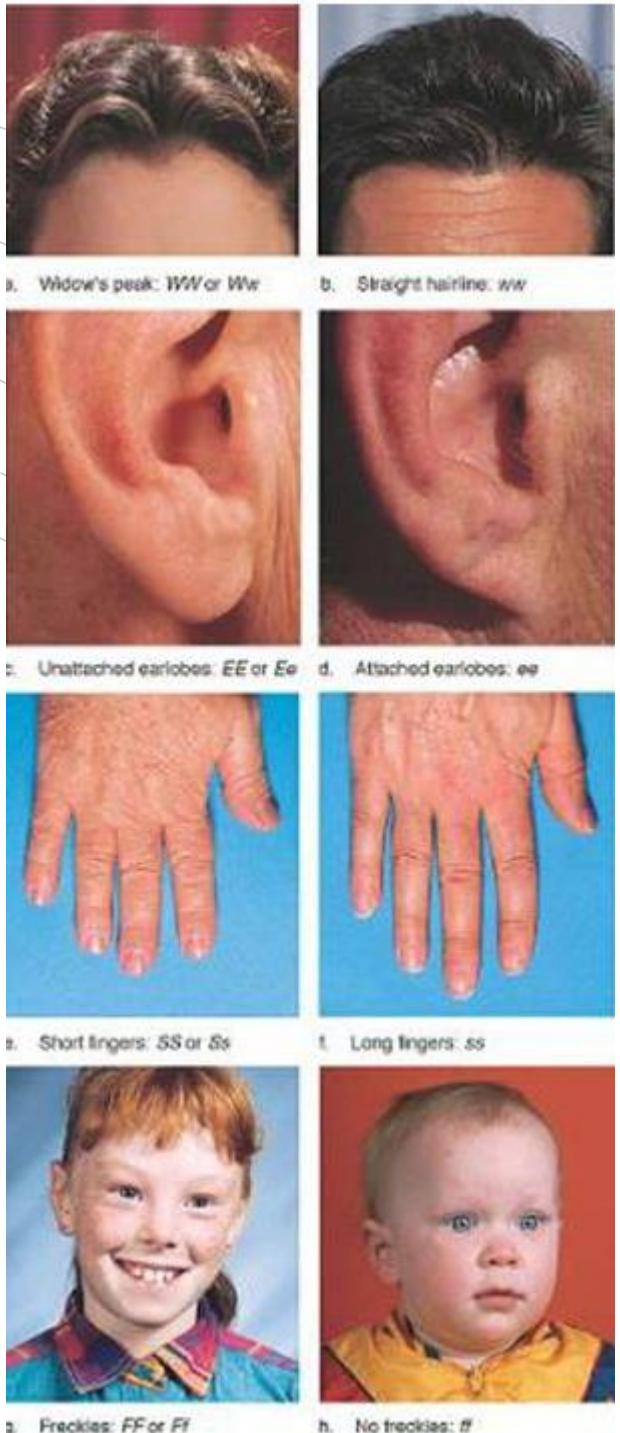


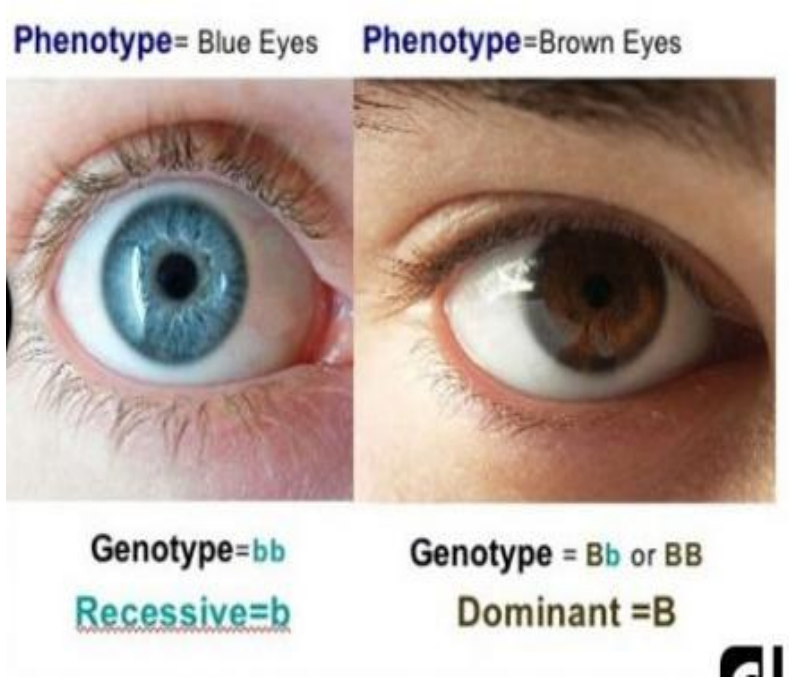


Phenotype

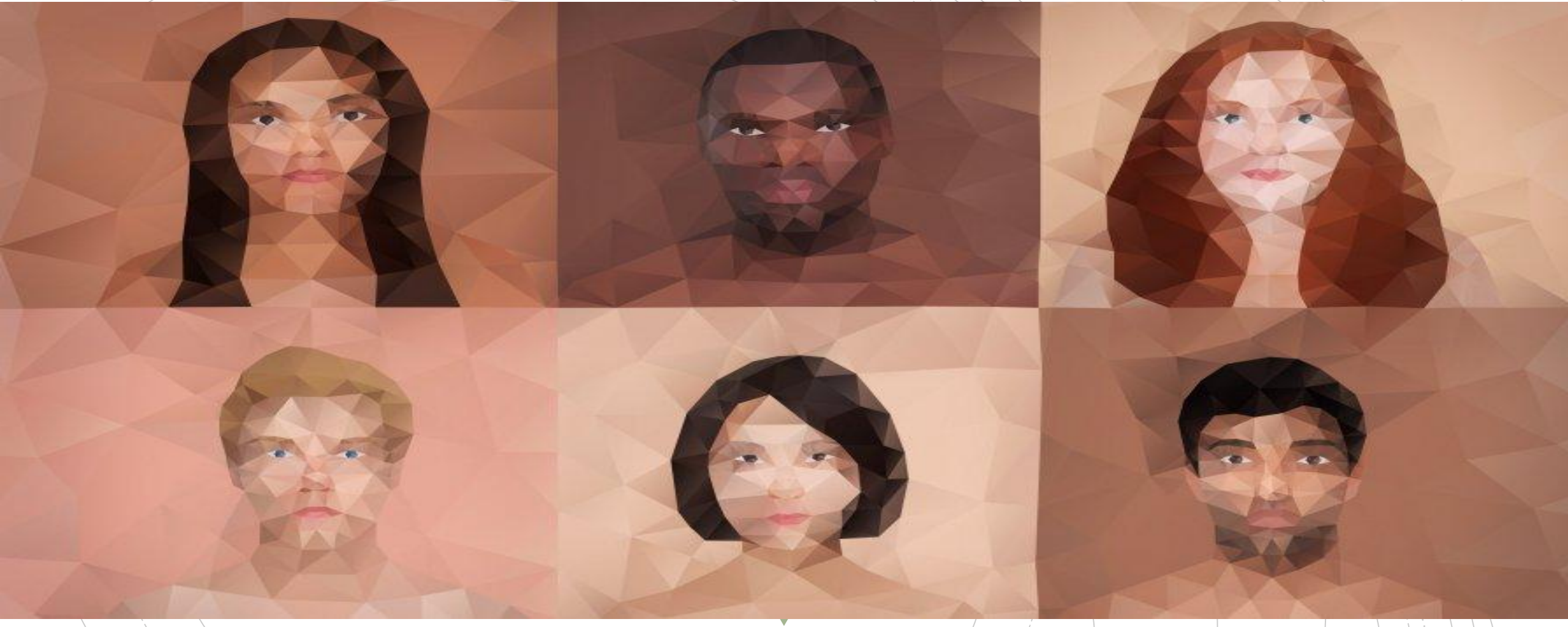
Phenotype is set of observable physical or biochemical characteristics of an individual resulting from the interaction of the genetic makeup [genotype] with the environment.

Examples: Stature, eye color, skin color, hair color.





Human Variation



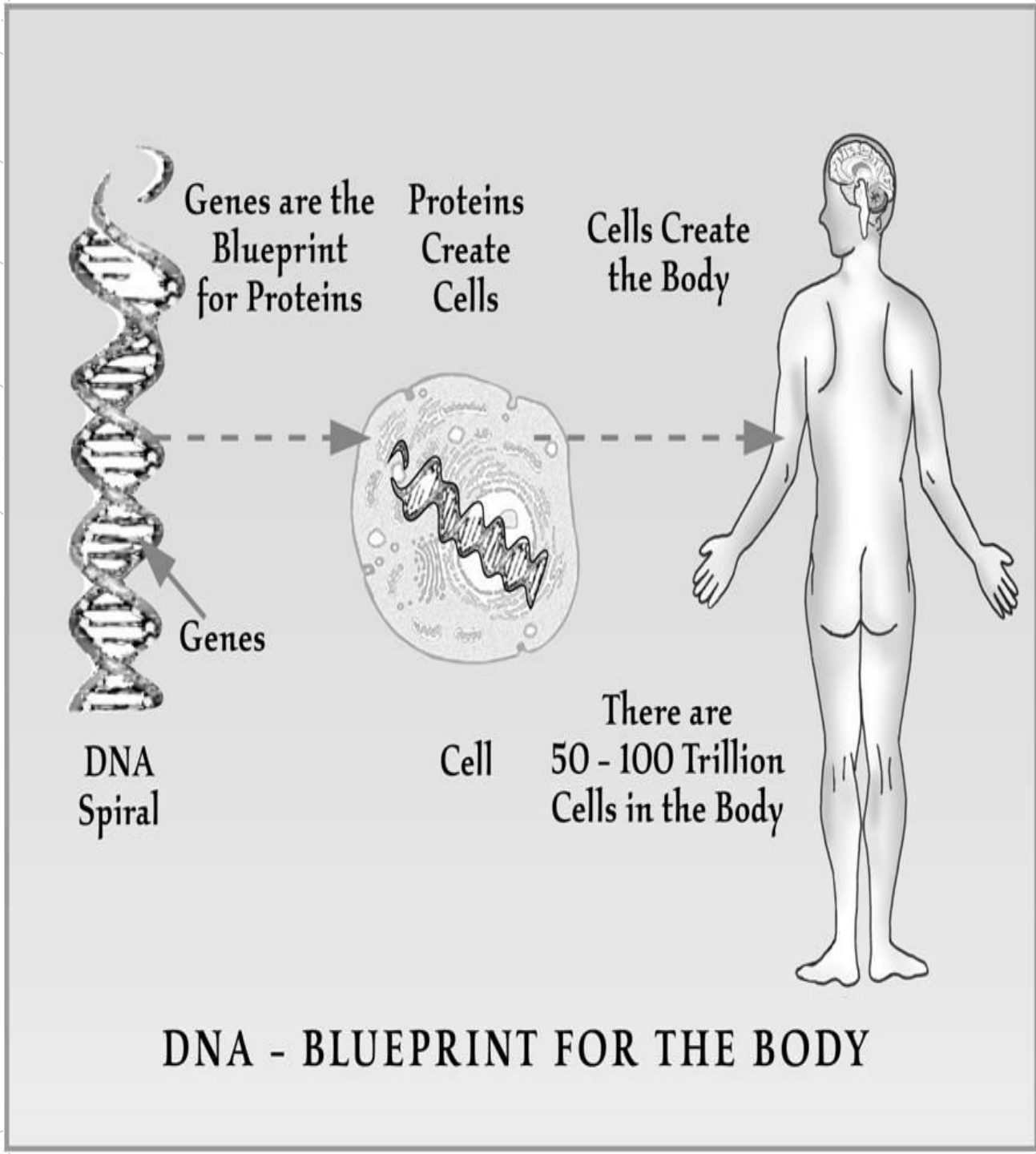
Differences in genotype and phenotype amongst a population or amongst populations. Caused by factors of heredity [recombination, mutation/gene flow/genetic drift/natural selection] as well as differential adaptation strategies in different organisms/species.

Human Body

Contains 37.2 trillion cells

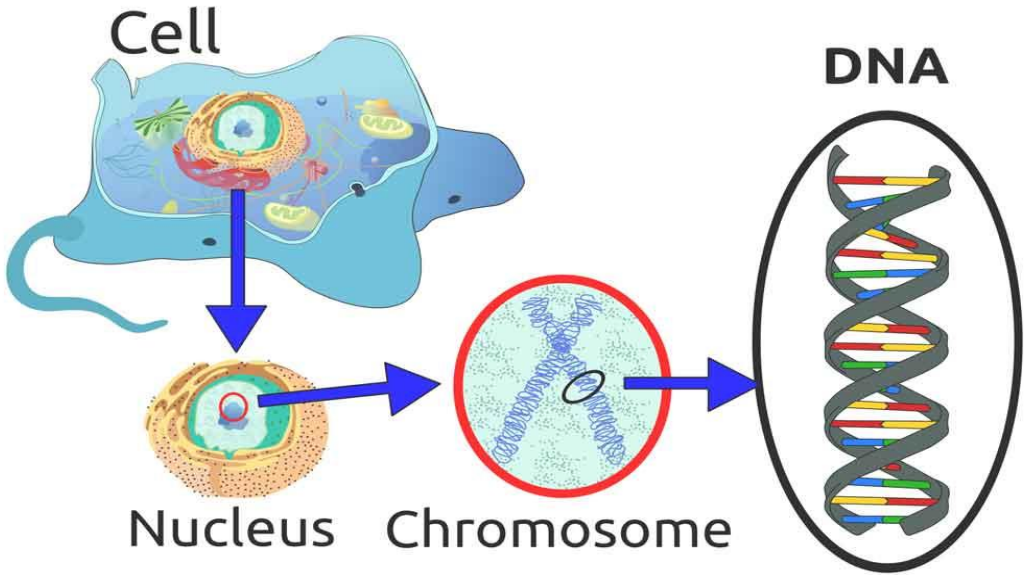
19,000-30,000 genes

46 chromosomes = 23 chromatid pairs



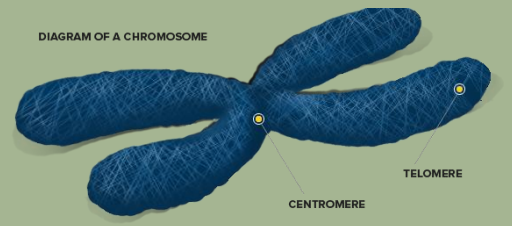
DNA Coding

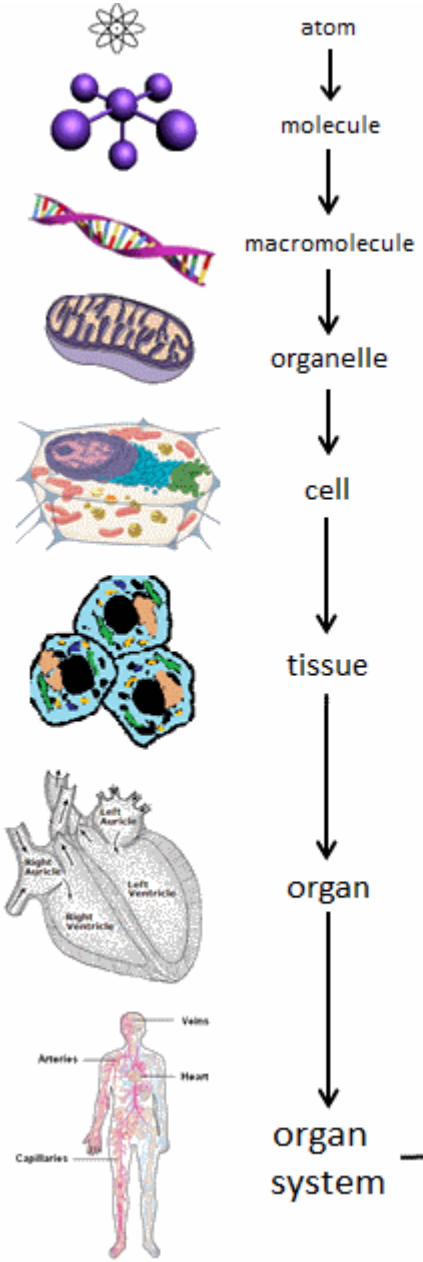
Within the nucleus of our cells, there are **chromosomes** on which sit **DNA** molecules.



Human Body

46 chromosomes = 23 chromatid pairs
22 pairs of Autosomes
1 pair of sex chromosomes



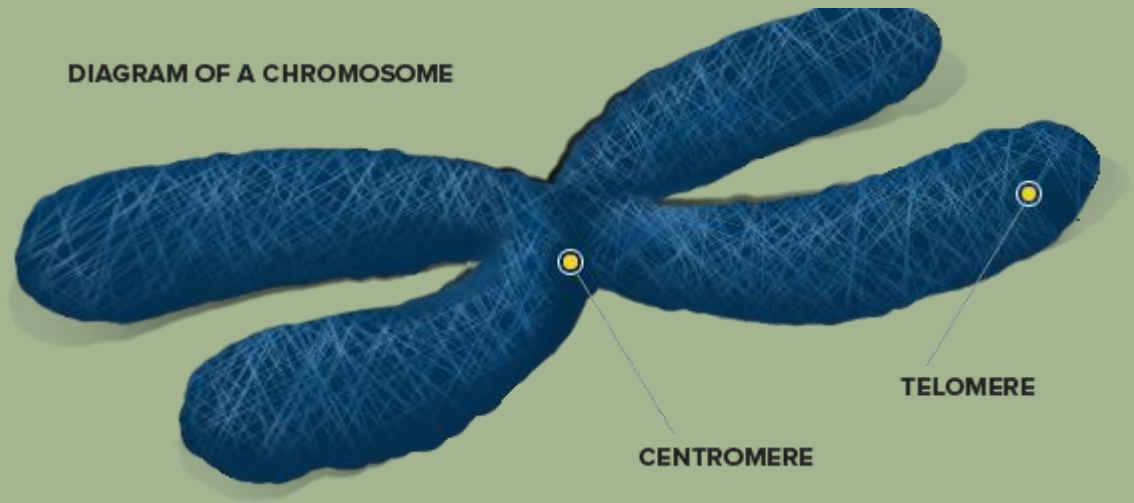


whole organism

How and why does evolution occur?

Chromosomes

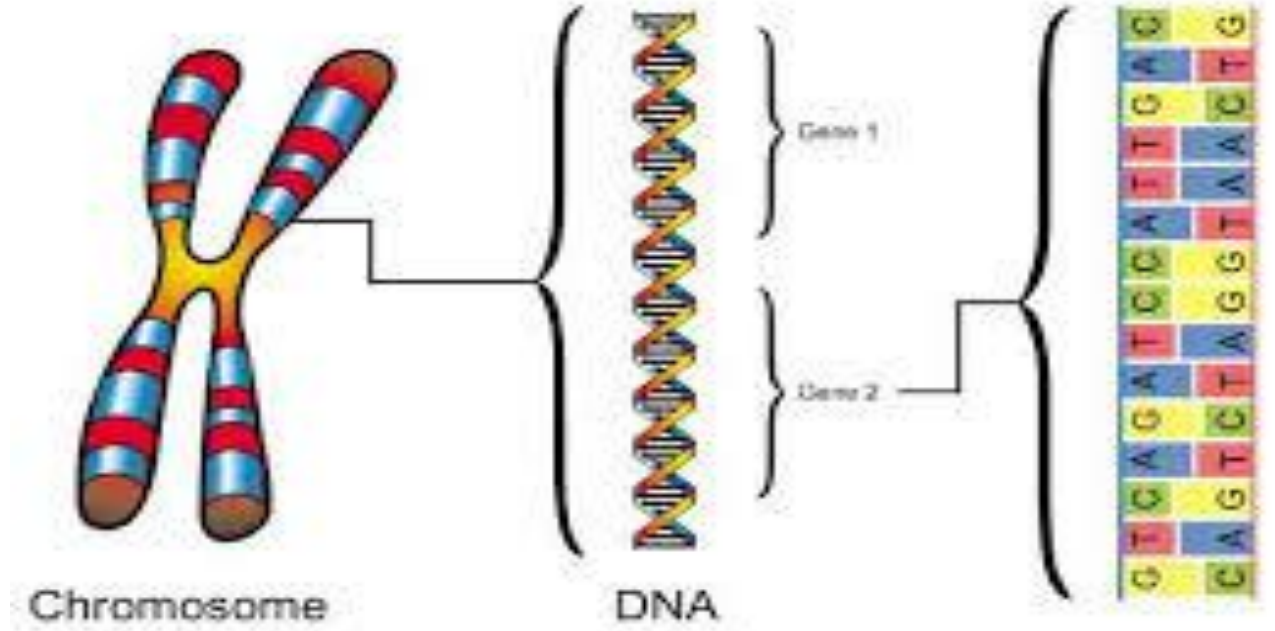
Chromosomes are basic genetic units, arranged in matching pairs.

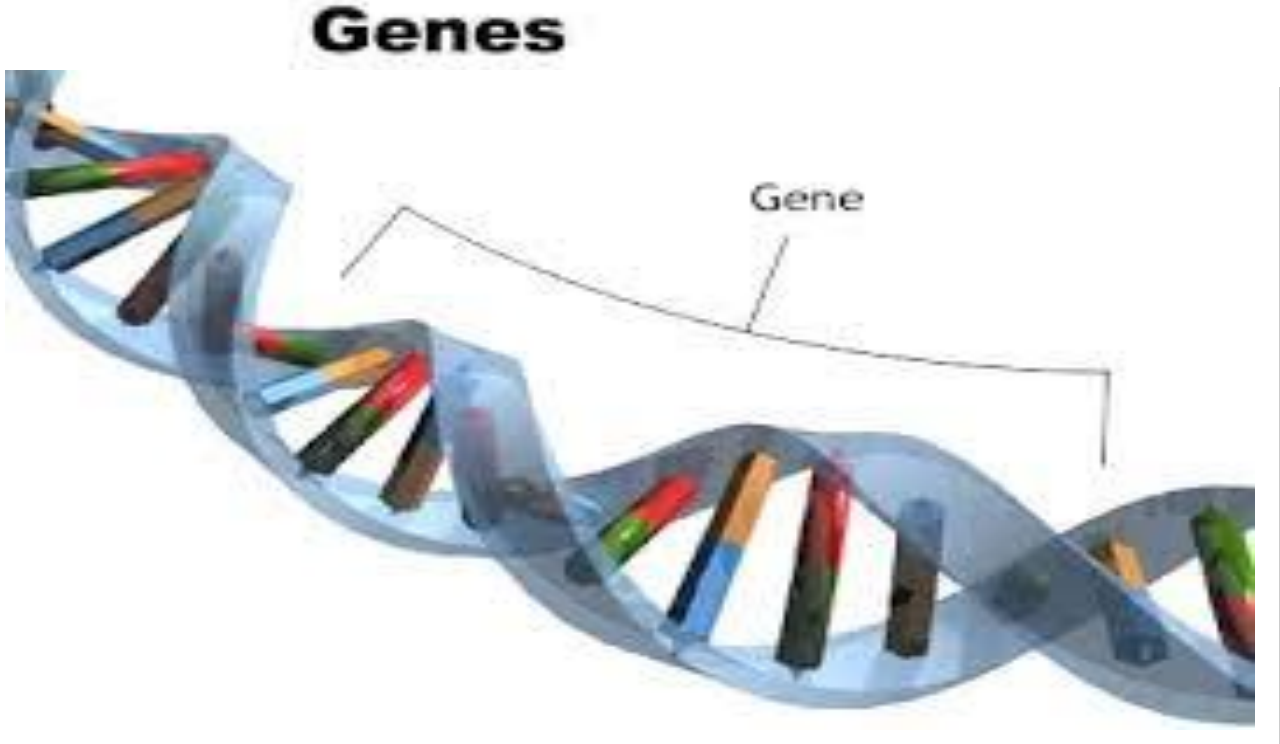


Humans: 46 chromosomes – 23 pairs

Gene:

Gene: the location on a chromosome that helps determines a particular trait of the organism

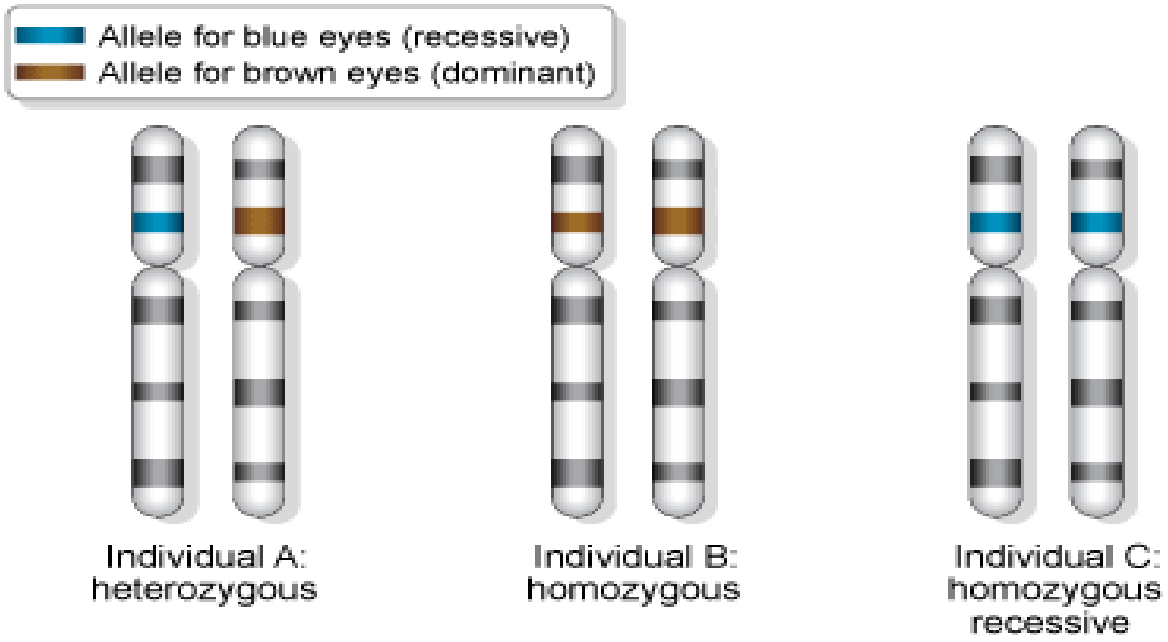


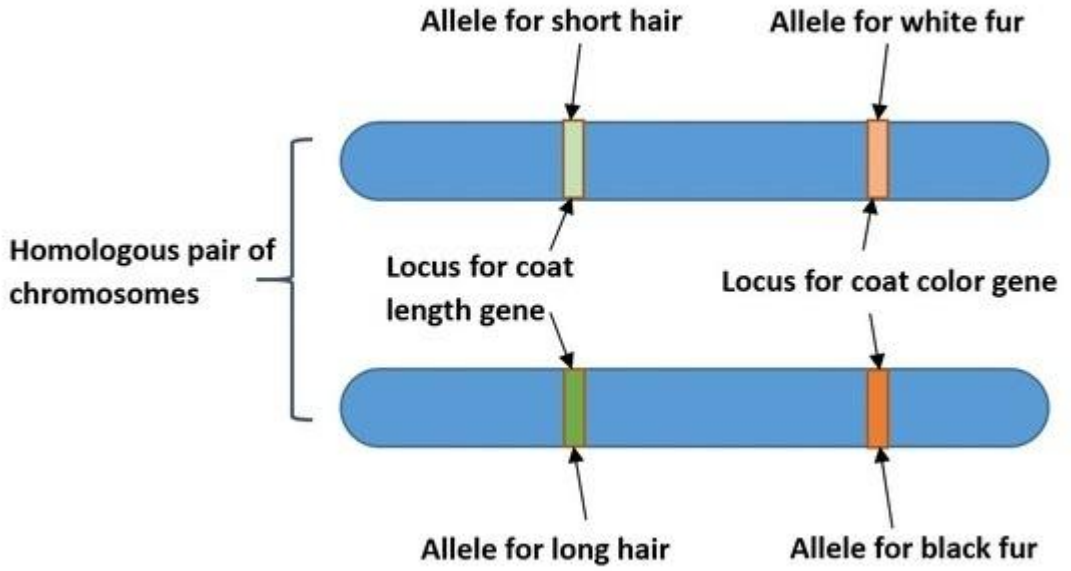


Allele

Allele- a variant/alternative form of a gene that occupies a given locus (position) on a chromosome

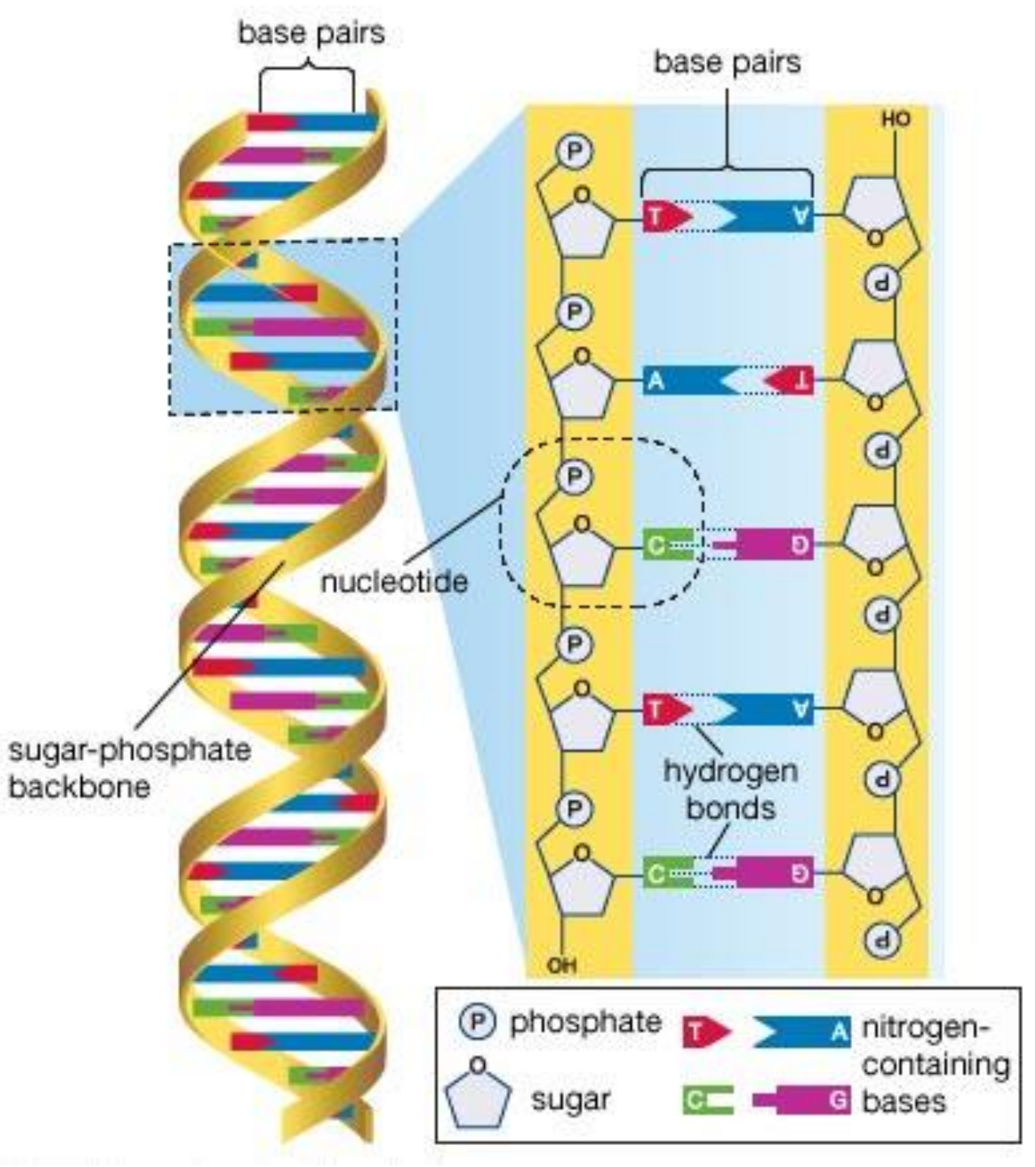
Active in DNA coding.





DNA

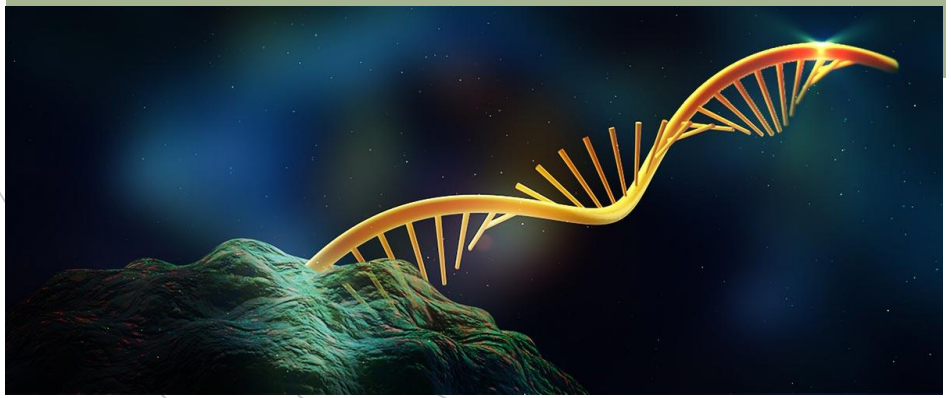
DNA (deoxyribonucleic acid) **:**
“a molecule that carries genetic instructions used in the growth, development, functioning and reproduction of all known living creatures”; basic hereditary units that lead to inheritance of traits from parent lineages in reproduction

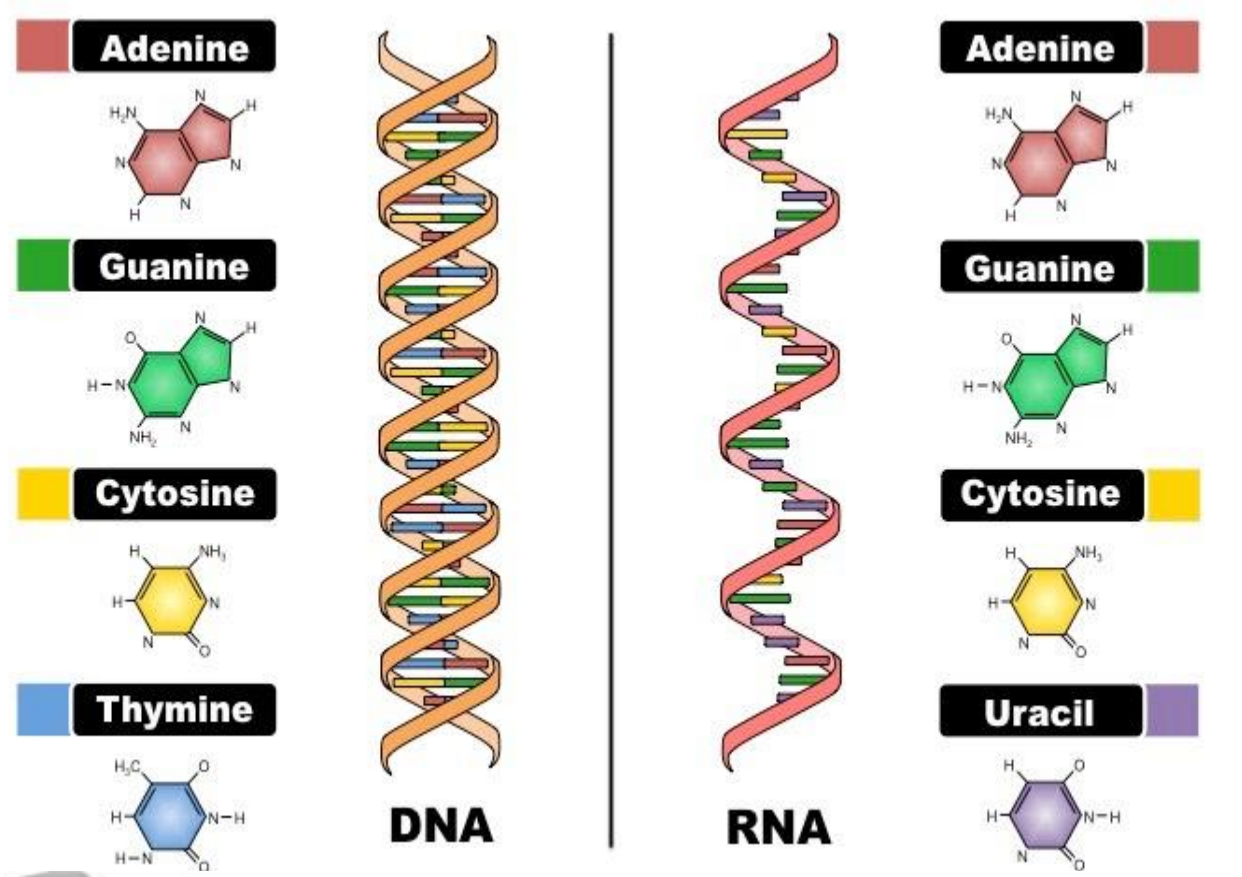


RNA

Ribonucleic acid (**RNA**) is a polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes.

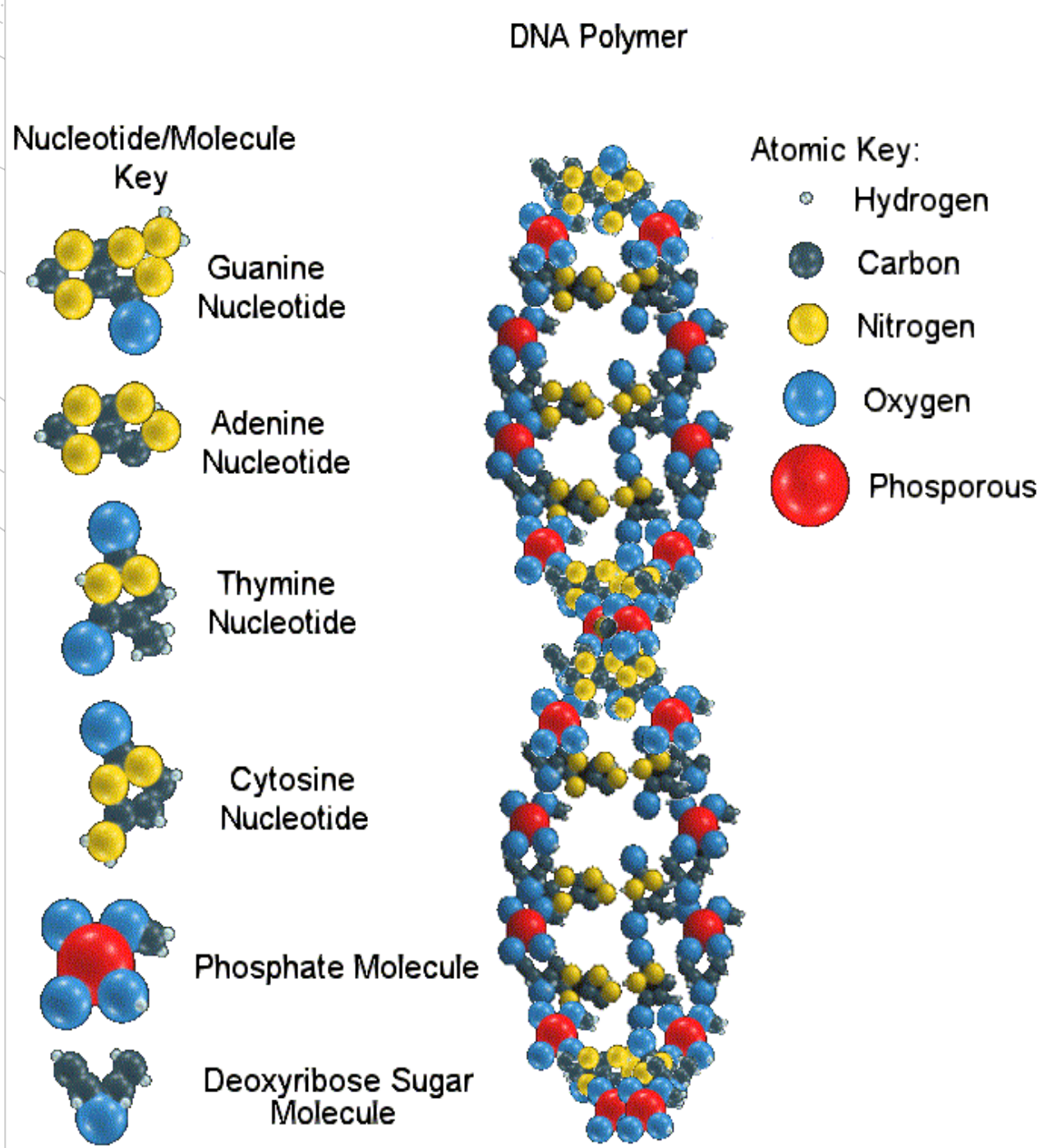
Both RNA and DNA are nucleic acids containing complementary base pairs of nucleotides





Nucleotide

building blocks of nucleic acids which form complementary pairs of chemical structures in DNA and RNA [Guanine; Adenine; Thymine; Cytosine]; Composed of 3 parts: five-sided sugar. * phosphate group. * nitrogenous base (nitrogen containing)



Nucleotide

The four main nucleobases found in the nucleic acids DNA and RNA:

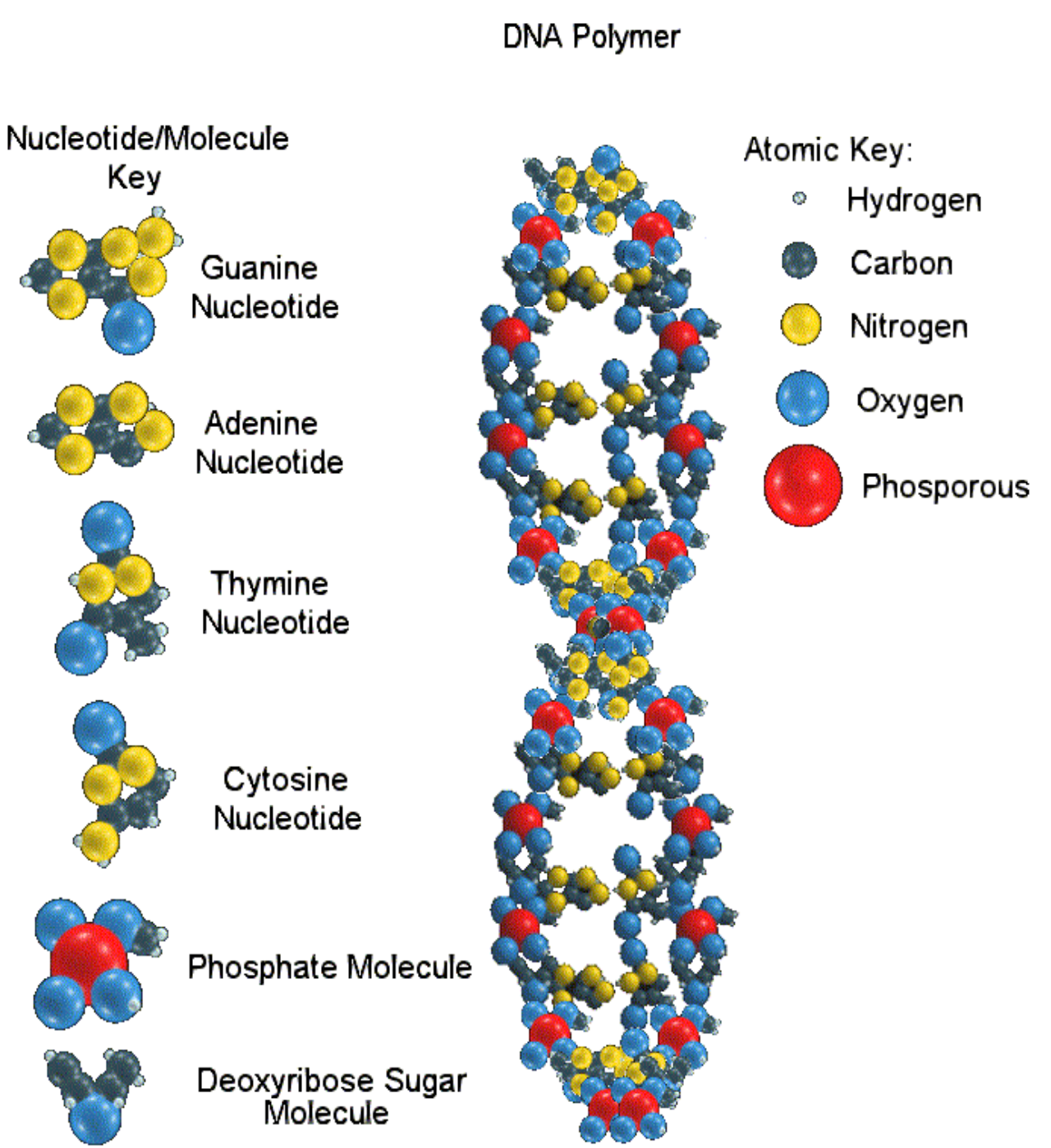
Guanine

Adenine

Thymine

Cytosine

+Uracil [RNA only]



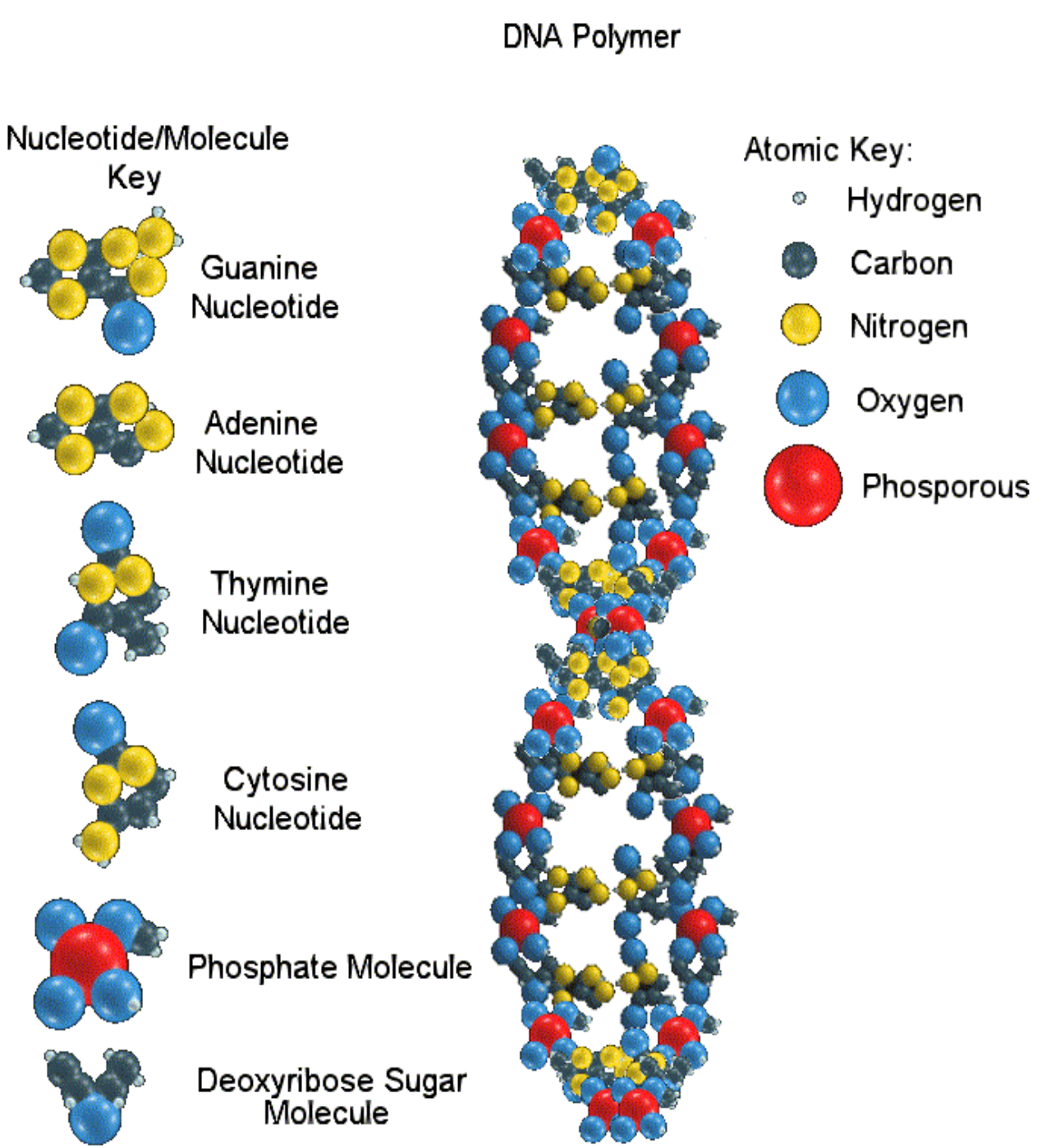
Nucleotide

Guanine – paired with Cytosine [G/C] ; purine derivatives

Adenine – binds to Thymine in DNA; Uracil in RNA; purine derivatives

Thymine – binds to Adenine in DNA; pyrimidine derivatives

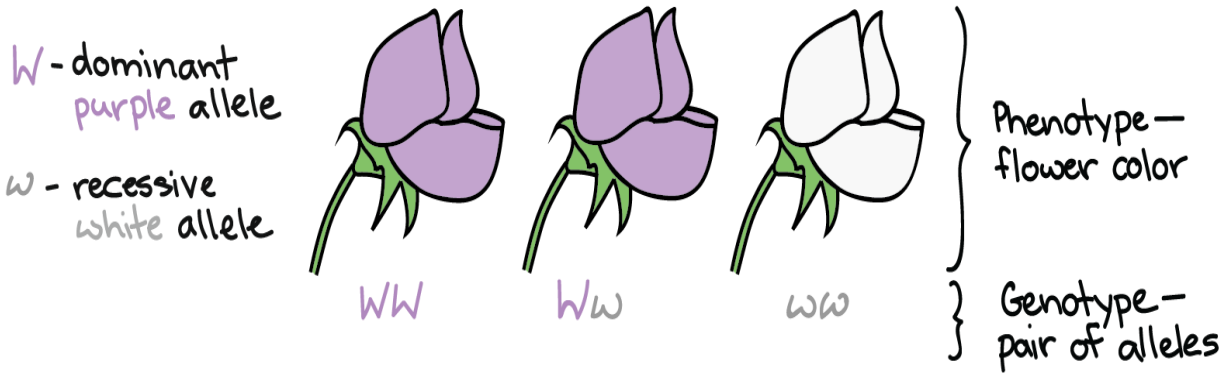
Cytosine – Pairs with Guanine in DNA ; pyrimidine derivatives



Dominant Allele

Dominant trait/allele– coordinate/trait on gene that masks another allele/ is brought to full expression and causes another potential trait to be recessive.

Table C-1: Expression of Dominant and Recessive Alleles	
Alleles Present	**Allele Expressed**
Dominant, Dominant	Dominant
Dominant, Recessive	Dominant
Recessive, Recessive	Recessive

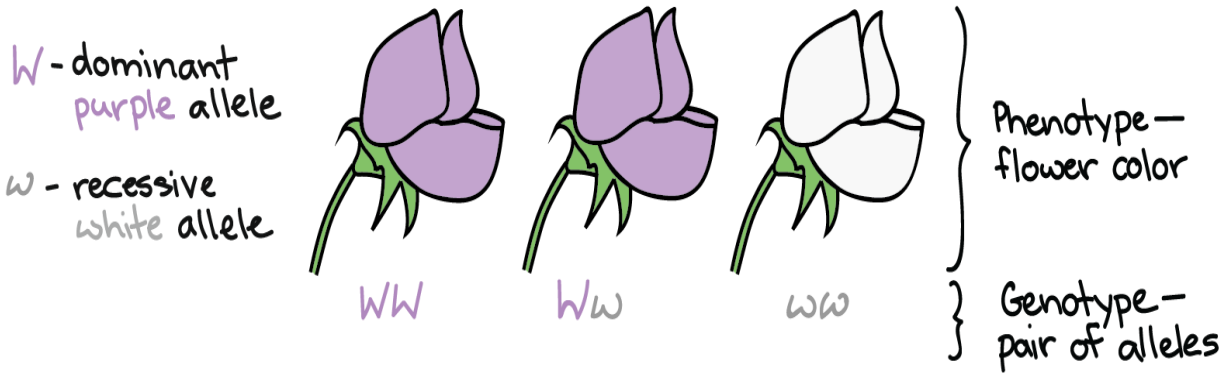


Recessive Allele

Recessive trait/allele- coordinate/trait on gene masked by another allele/ is not brought to full expression but remains in the genetic code

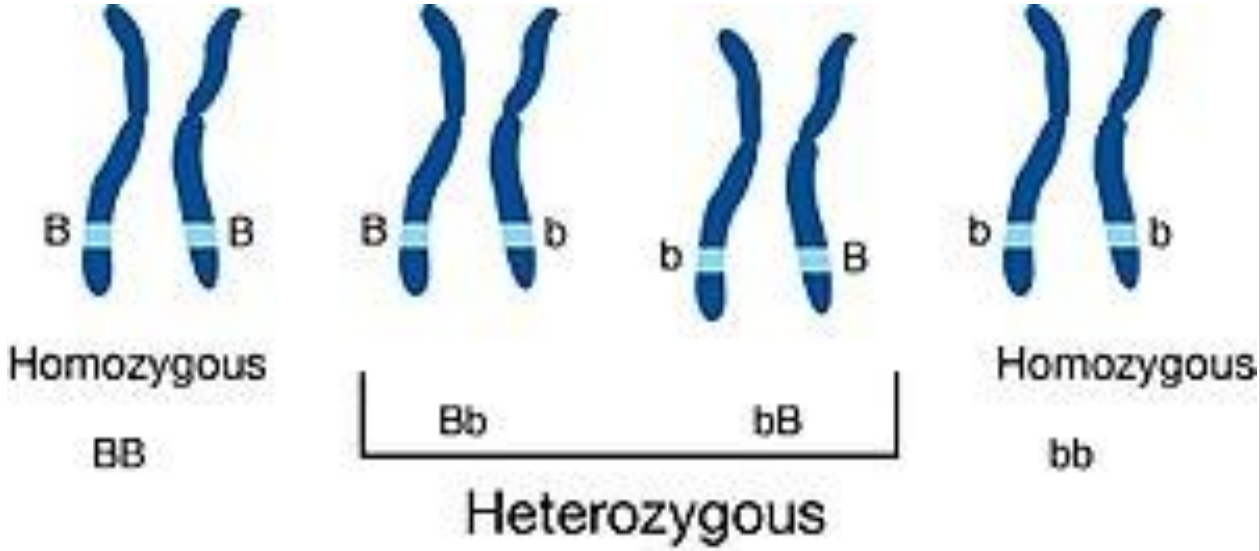
Table C-1: Expression of Dominant and Recessive Alleles

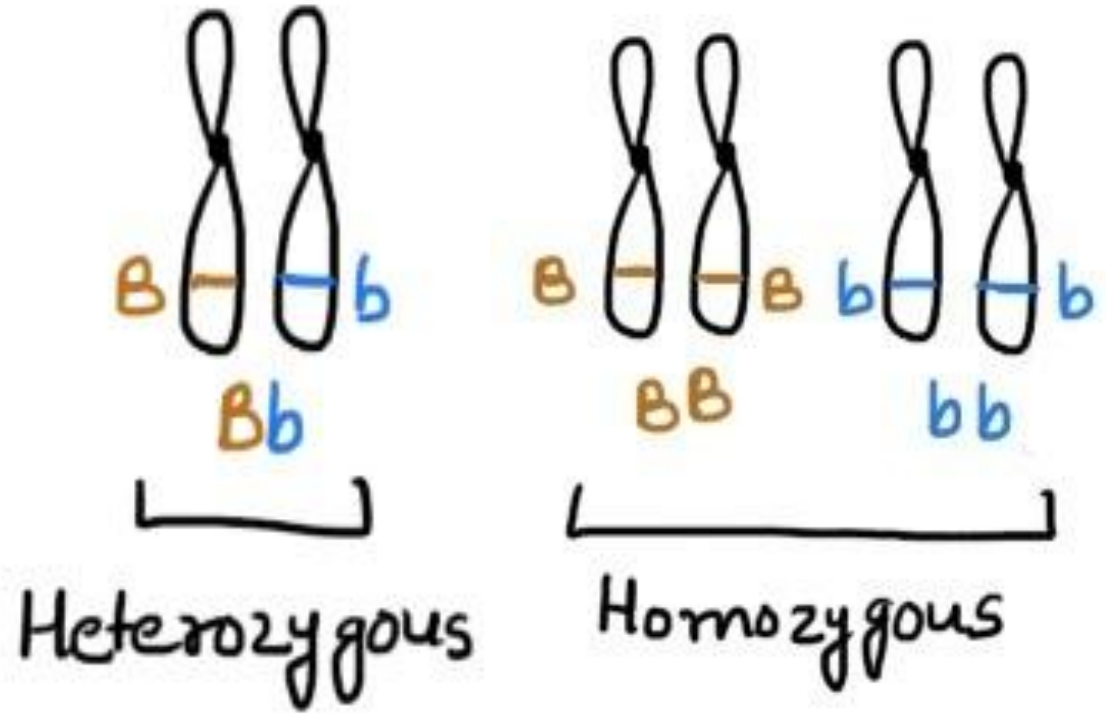
Alleles Present	Allele Expressed
Dominant, Dominant	Dominant
Dominant, Recessive	Dominant
Recessive, Recessive	Recessive



Heterozygous

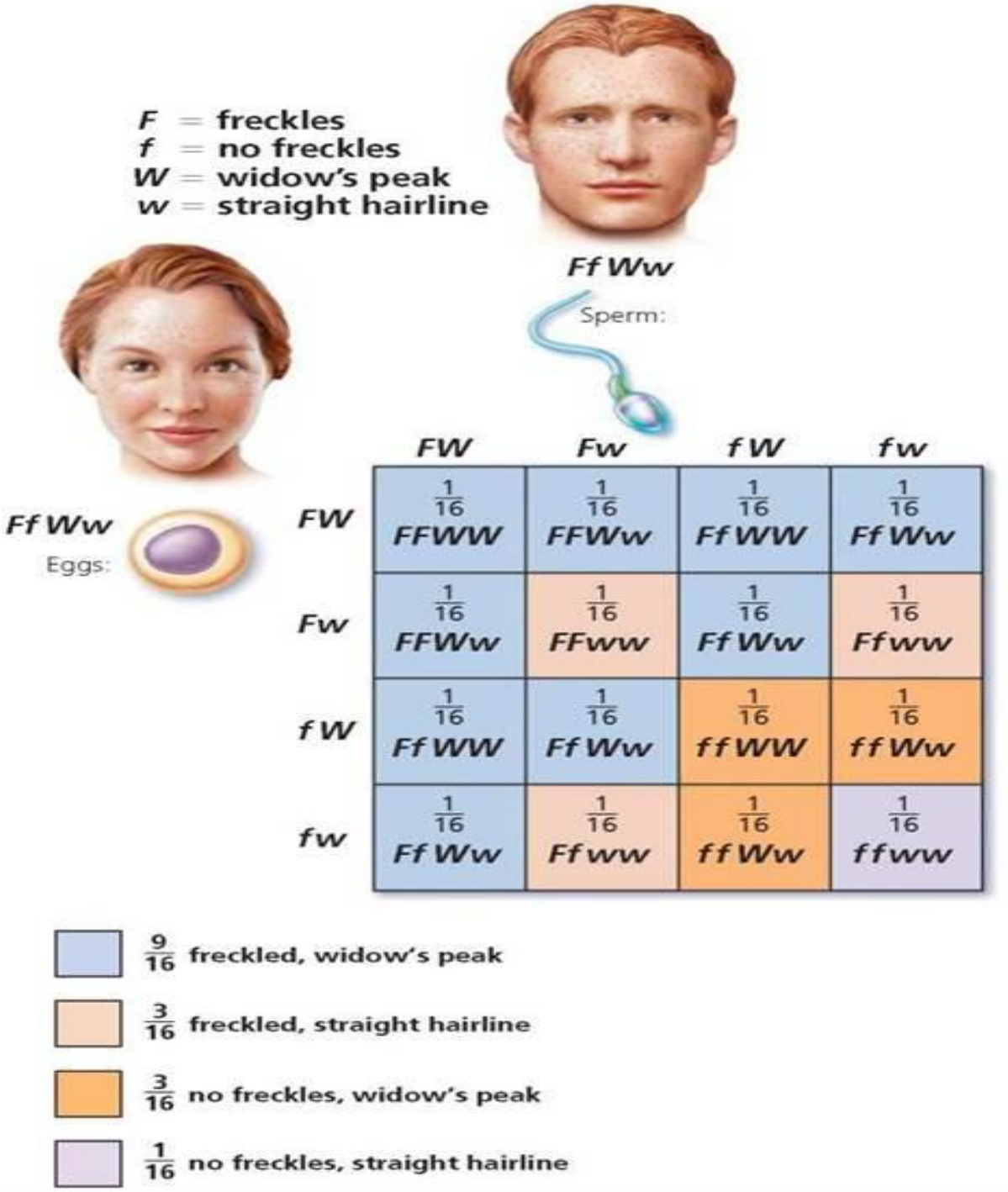
When a gene locus of a diploid organism contains two different alleles of a gene, it is heterozygous.



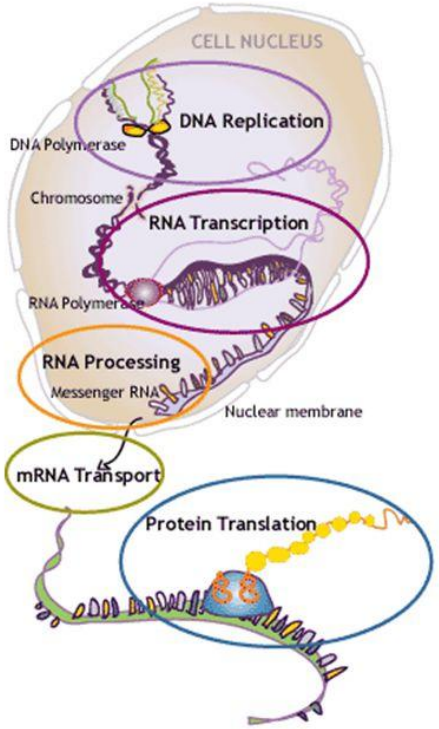


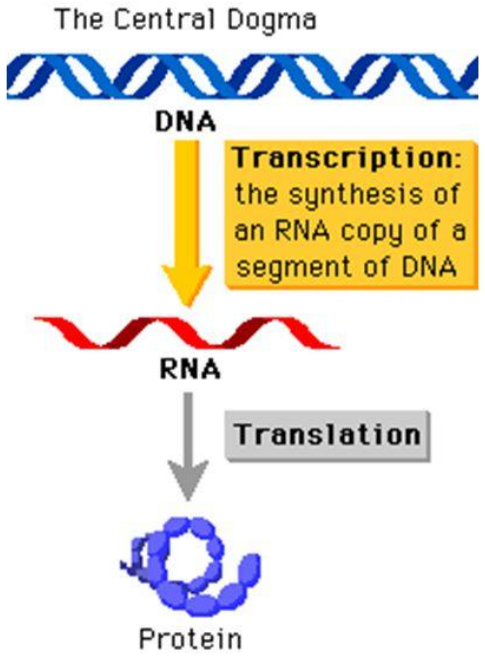
Homozygous

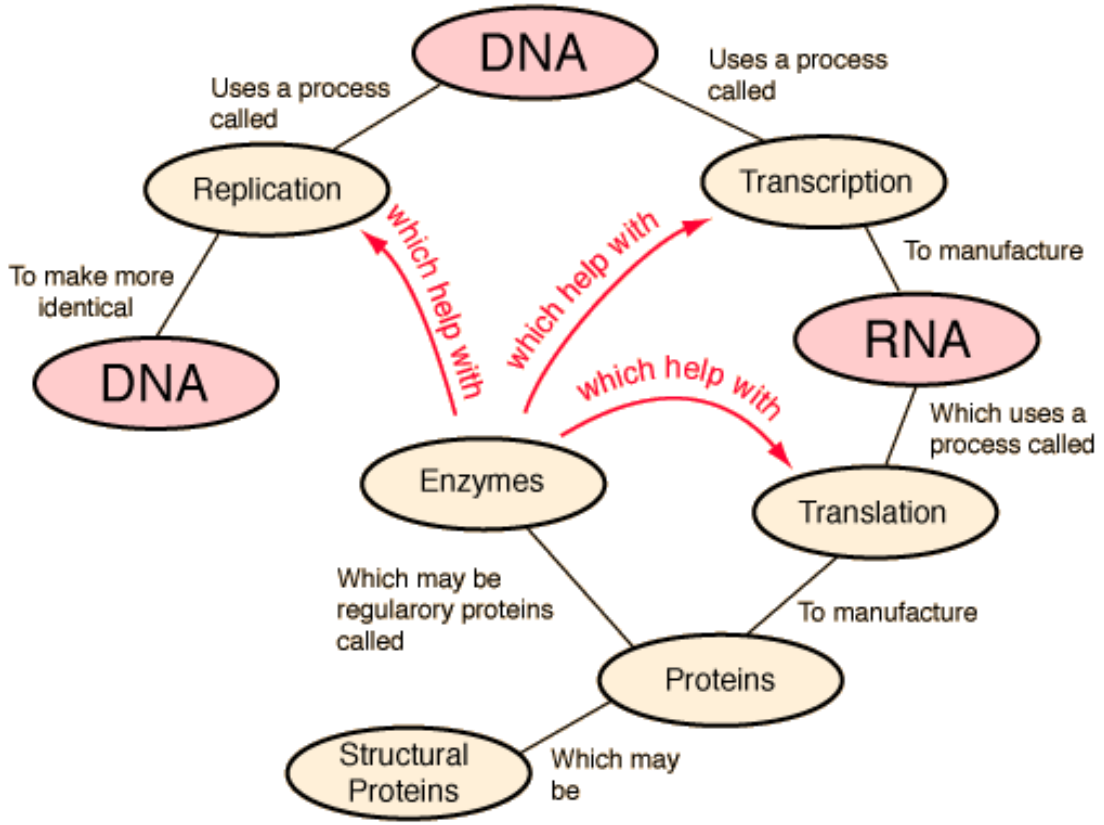
When a gene locus of a diploid organism contains two identical alleles of a gene, it is homozygous.



DNA → RNA → Protein







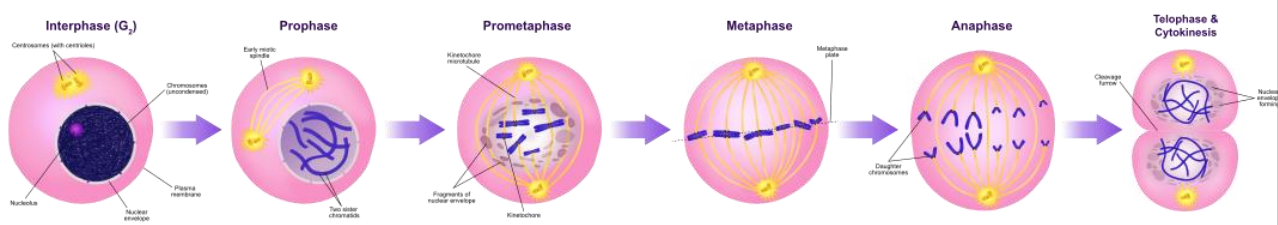
Protein Coding – DNA Processes

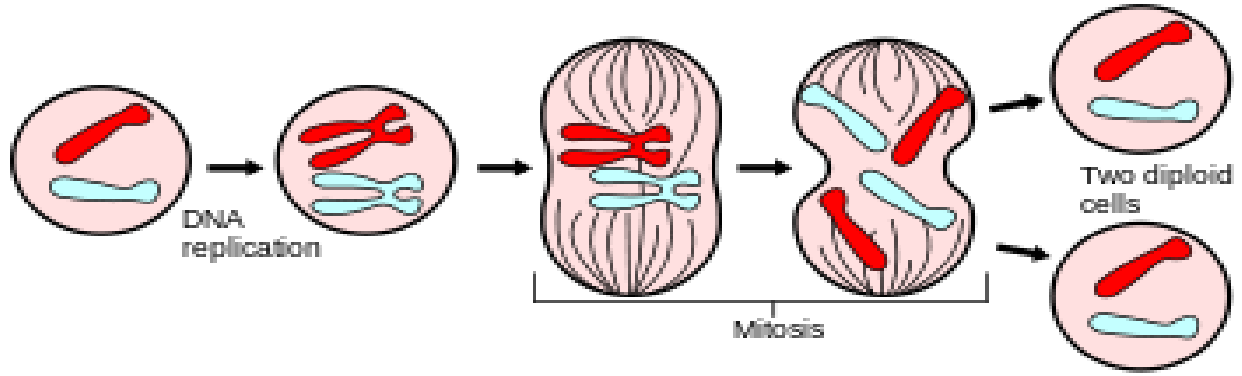
Methods

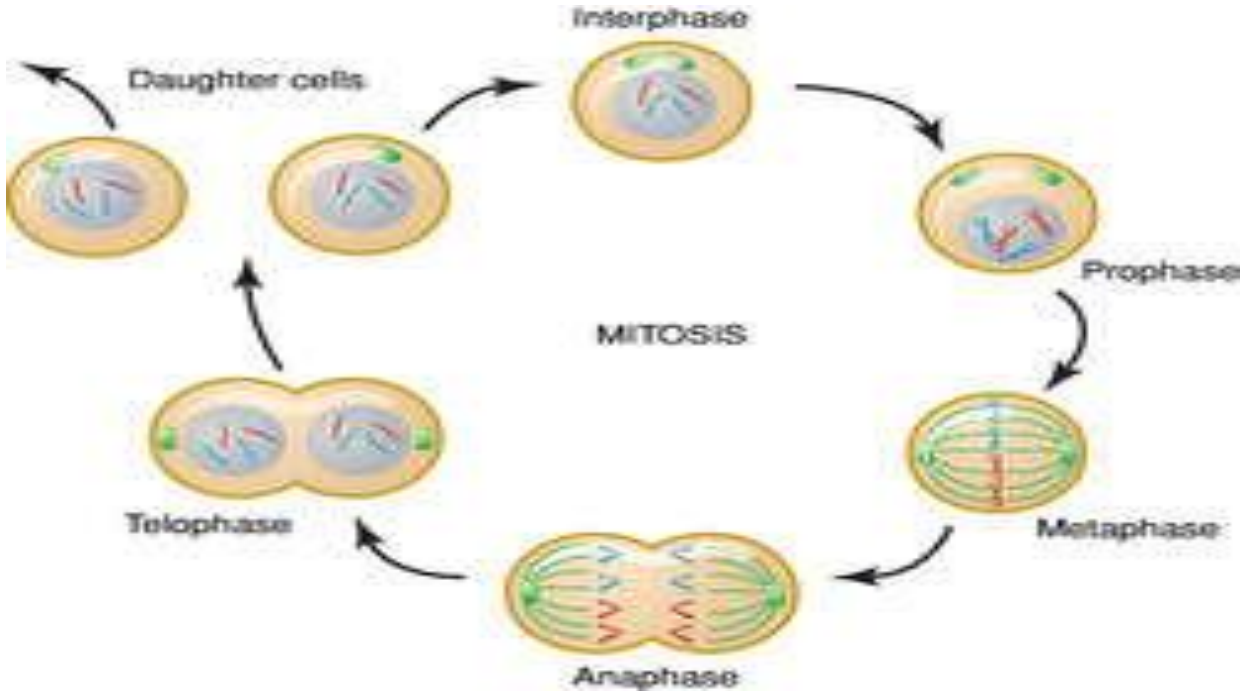
Human Reproduction at the Molecular Level

Mitosis

Mitosis: a form of cell division which results in the creation of two daughter cells with the same kind and number of chromosomes as the parent nucleus.



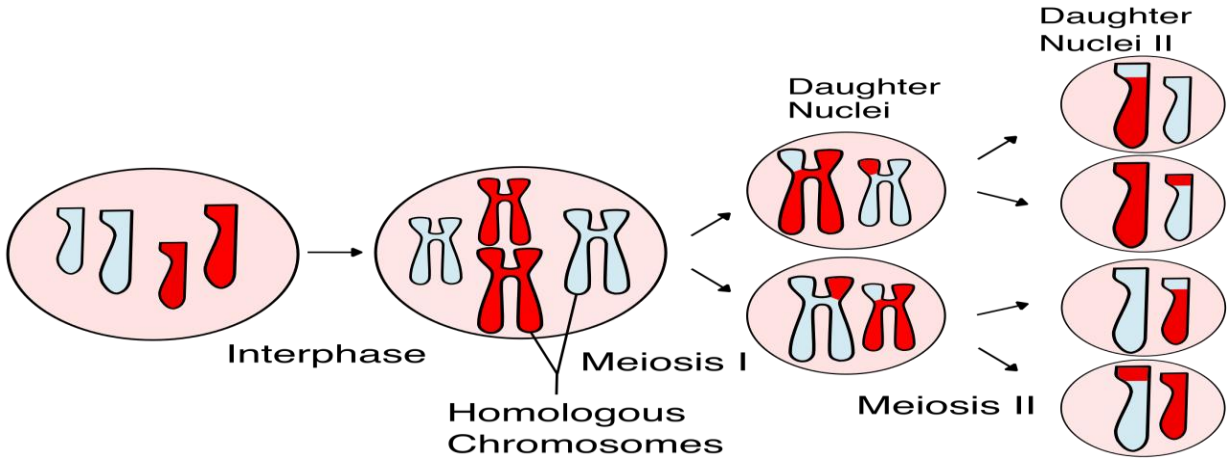


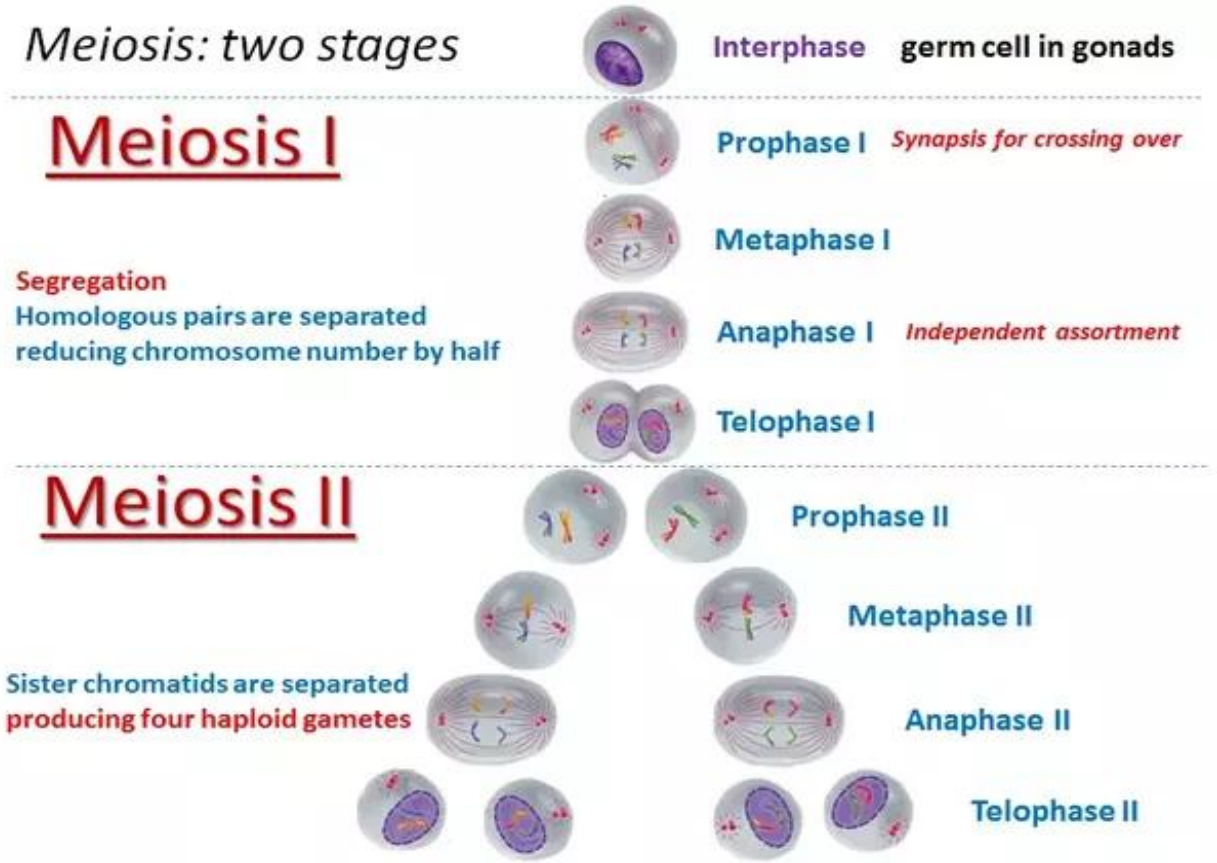


Meiosis

a form of cell division where a single cell divides twice to result in four daughter cells, each with half the number of chromosomes of the parent cell / half of the original genetic information.

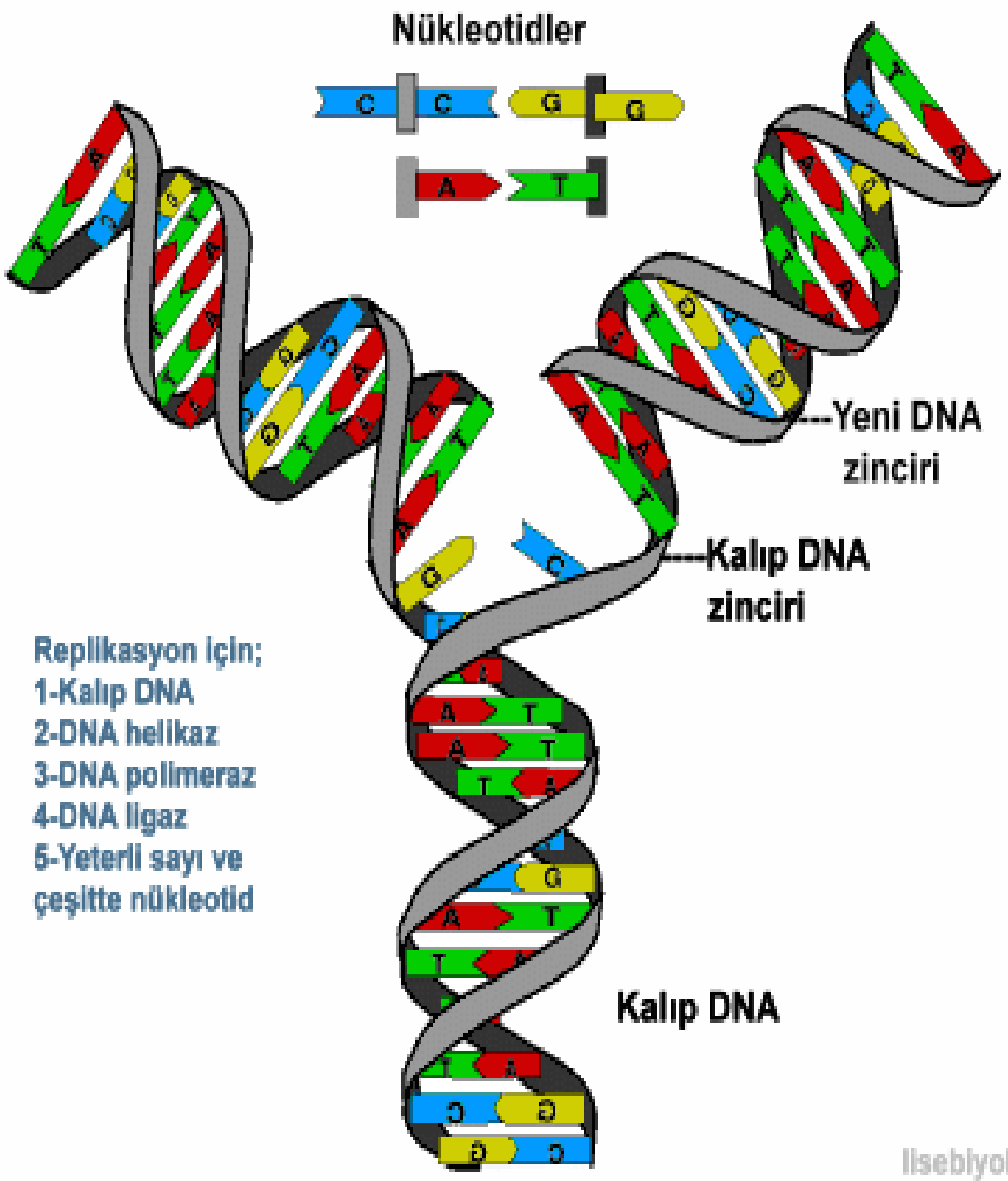
[gametes/sex cells; plant spores]





Replication and Recombination

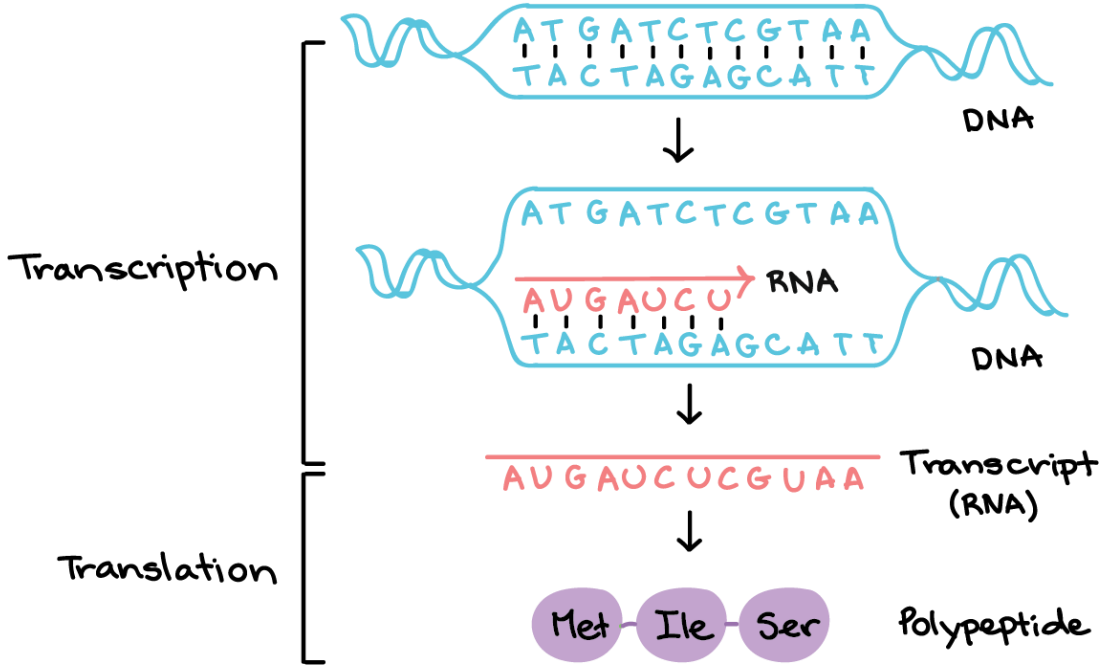
DNA replication - biological process of one DNA molecule producing two identical replicas of the original.

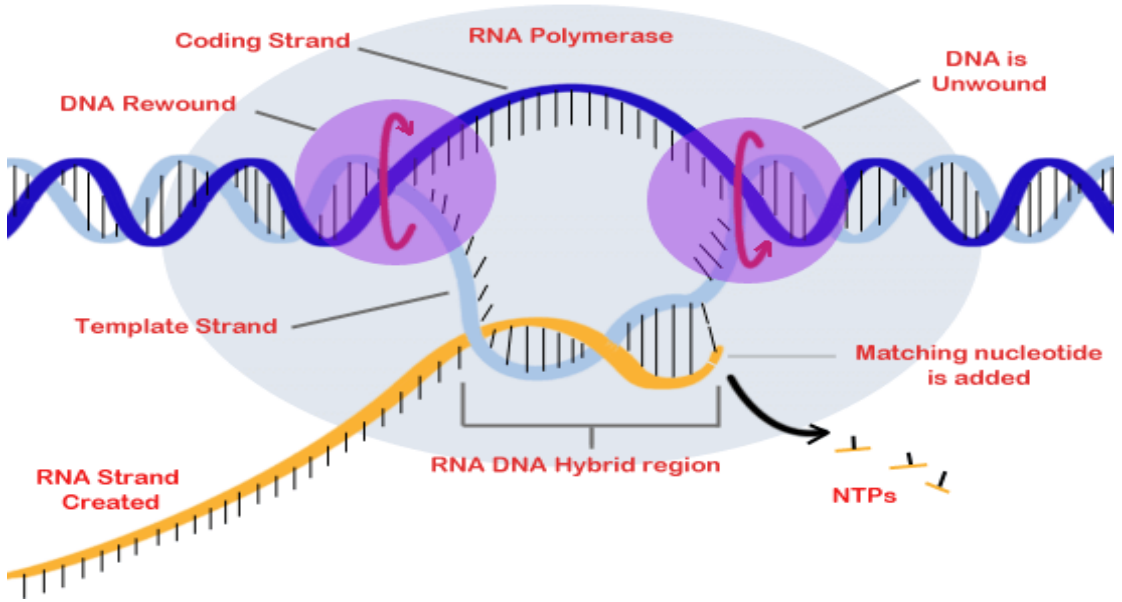


Transcription

Transcription – a process by which a segment of DNA is copied by/onto RNA/ mRNA.

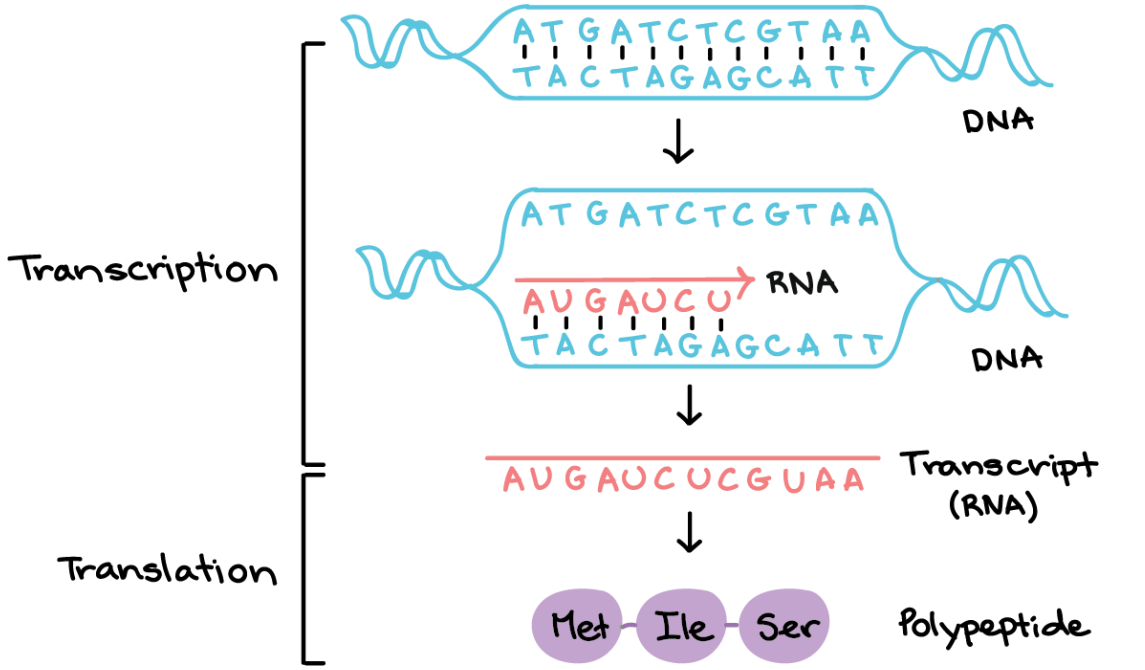
The first phase of gene expression

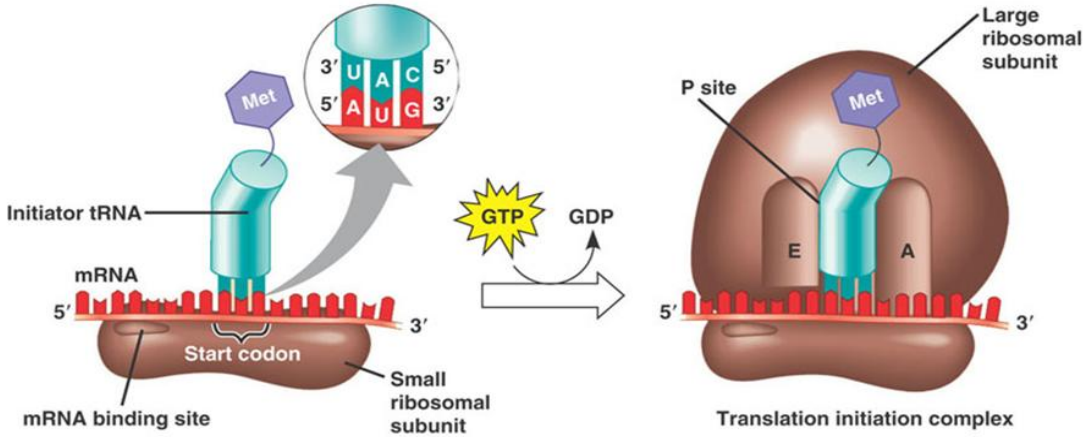




Translation

messenger **RNA** (mRNA) is the next stage of gene expression. mRNA is decoded outside the nucleus by a ribosome, which creates a polypeptide (amino acid chain). This polypeptide then folds into an active protein, performing specific functions inside the person's cells.





Methods, Part II

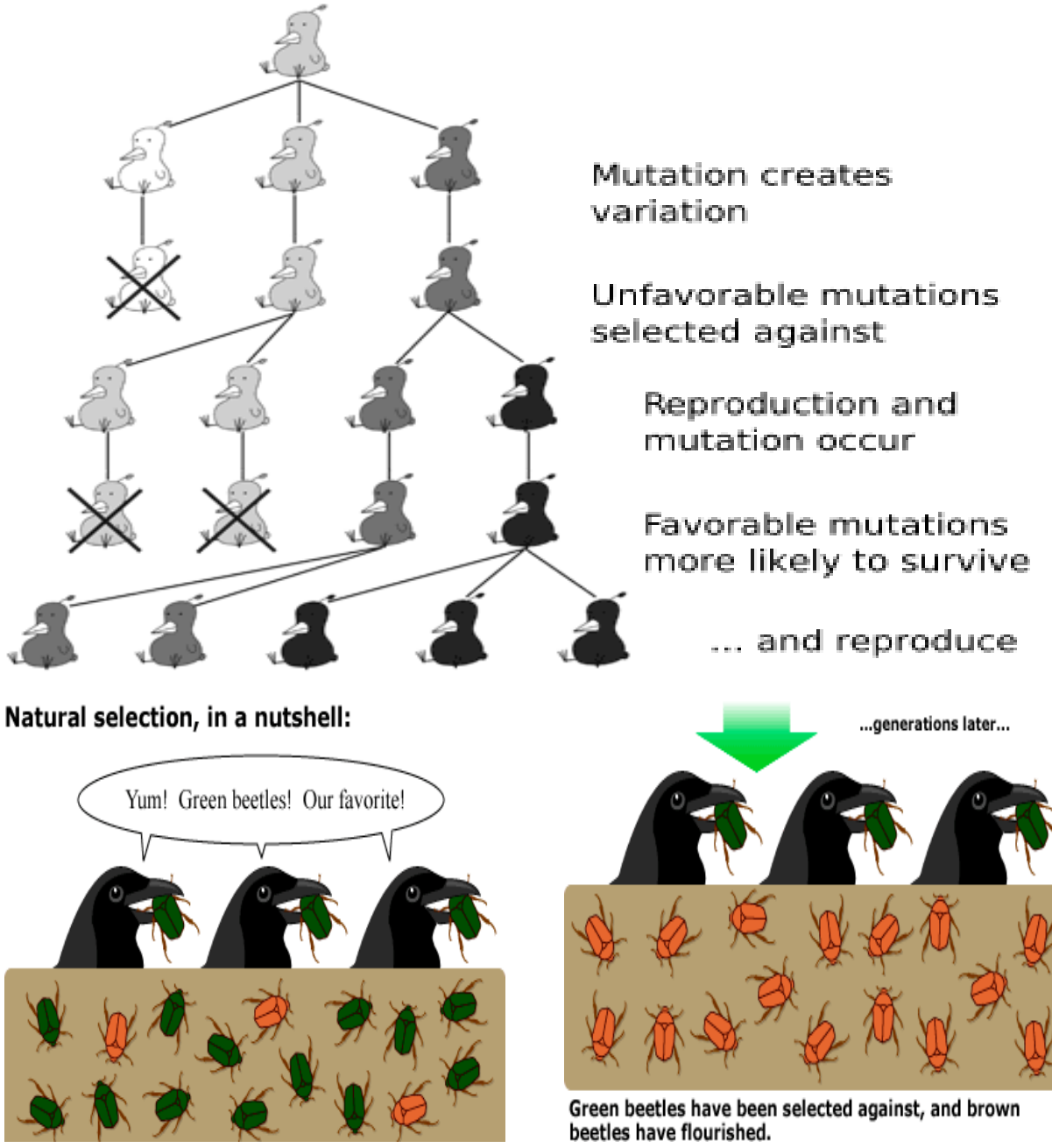
Human Evolution at the Molecular Level

How and why does evolution occur?

Natural Selection:

Natural Selection is “the process by which those characteristics that allow individuals to have more offspring become more widely spread in the population (selected for) and those that allow individuals to have fewer offspring traits become rarer (Selected against)” (Mielke 2006)

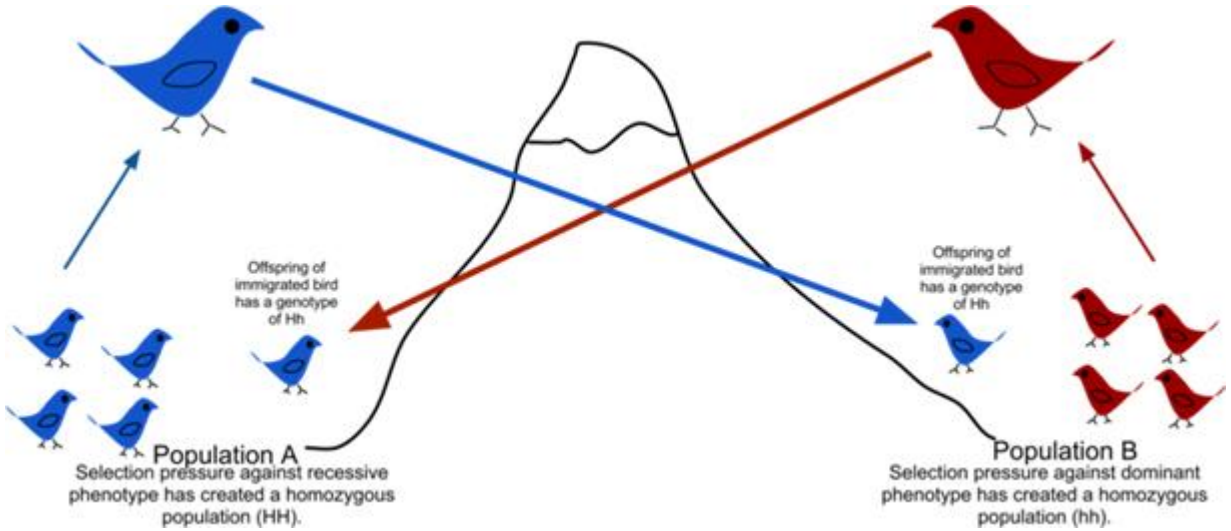
Conditions necessary: Multiplication; Heritable Variation; Competition

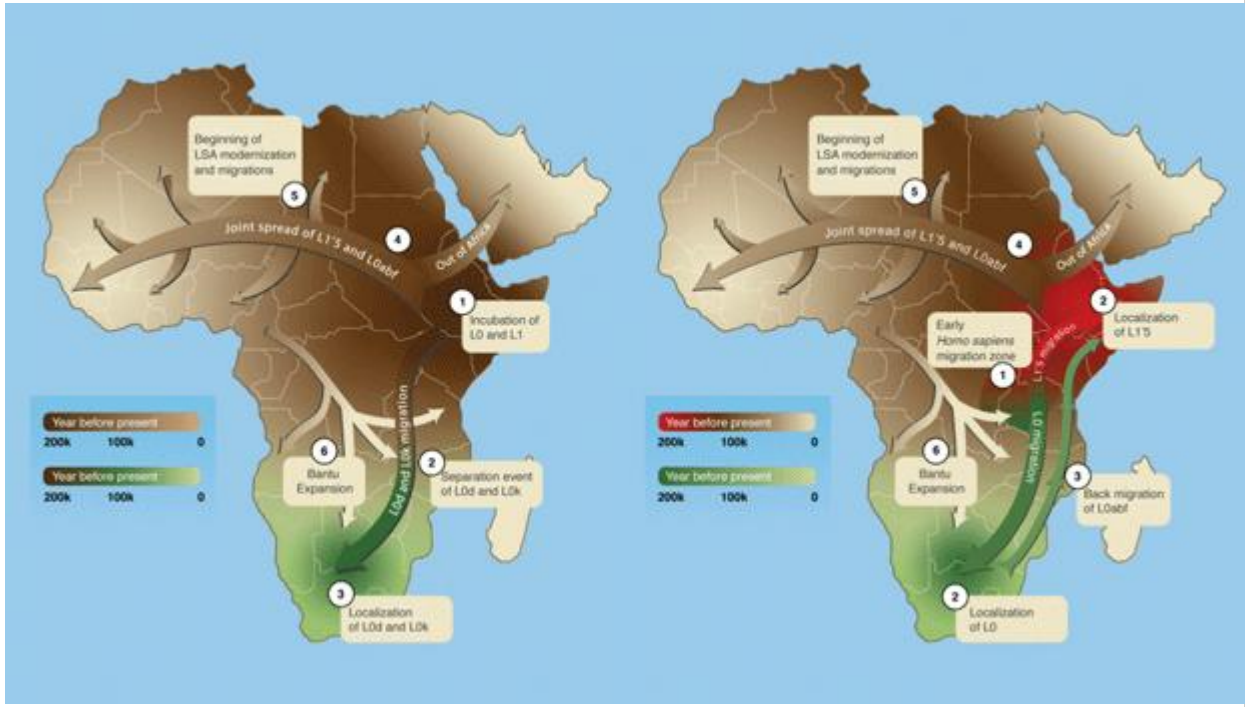


How and why does evolution occur?

Gene Flow [Migration]:

Gene Flow [Migration] is an "exchange of genes that occurs when a given population experiences a sudden expansion caused by in-migration of outsiders from another population of the species" (Mielke 2006)

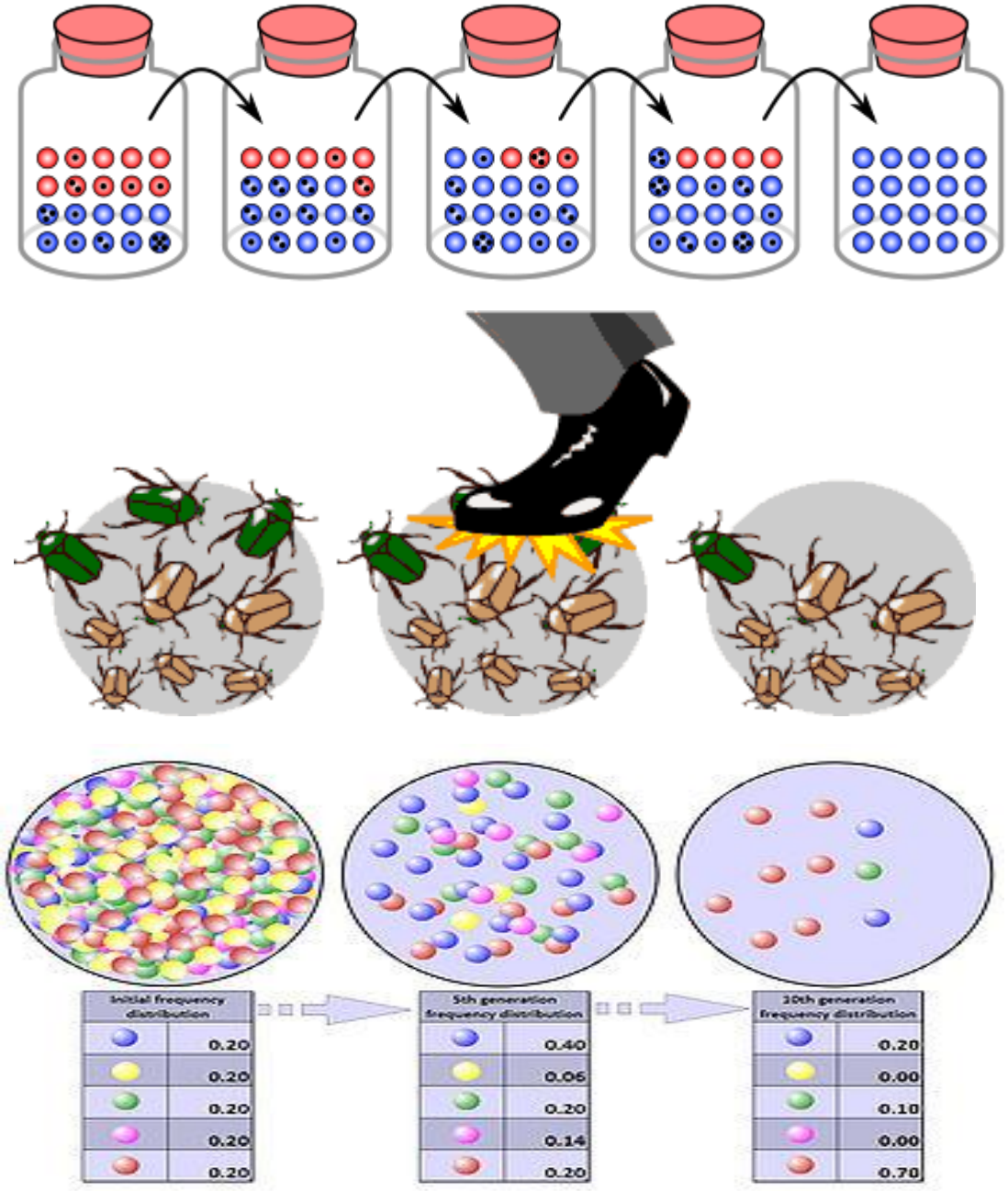




How and why does evolution occur?

Genetic Drift:

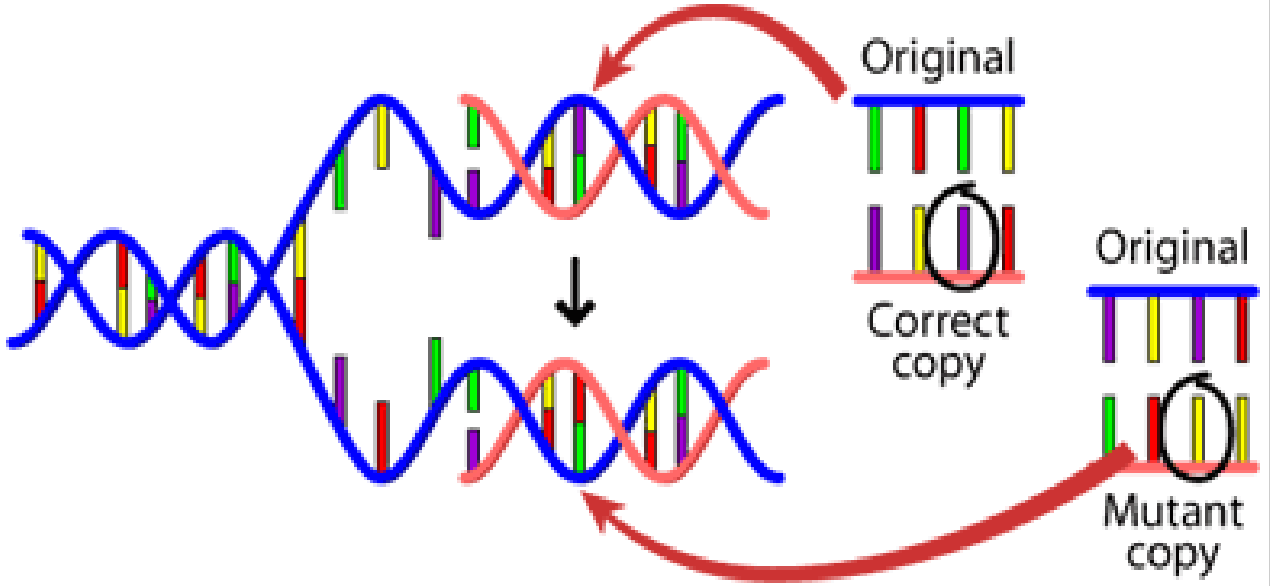
Genetic Drift: “Random changes in gene frequencies from one generation to the next caused by a sudden reduction in population size as a result of disaster disease or the out-migration of a small subgroup from a larger population” (Mielke 2006)



How and why does evolution occur?

Mutation:

Mutations are permanent alteration of the nucleotide sequence of the genome of an organism, virus, or extrachromosomal DNA or other genetic elements.

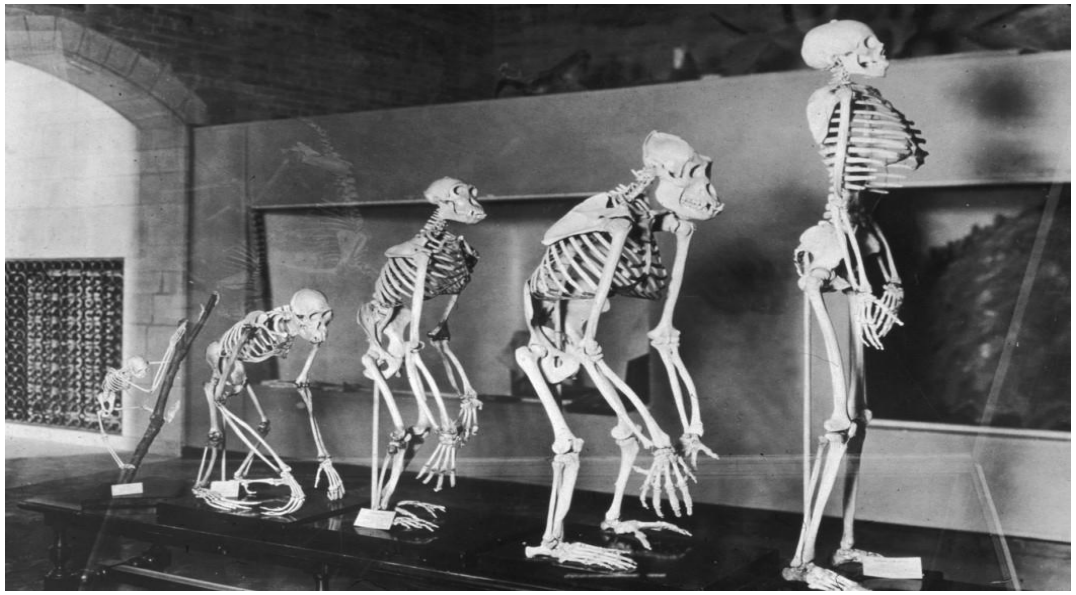


How and why does evolution occur?

Mutation:

In mutations, time and order of gene-activation is altered to reconfigure old genes in new ways.

.



How and why does evolution occur?

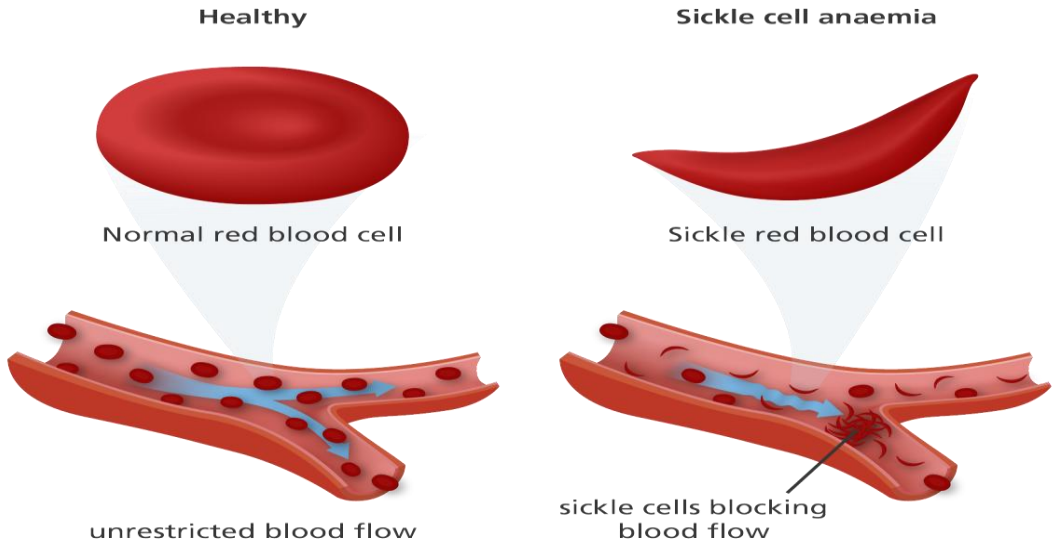
Types of Mutation

Point Mutation

- change of a single nitrogen base in a DNA sequence; maximum consequence - changes in single amino acid in a protein; minimal harm

Frame Shift Mutation

- Change of a single nitrogen base which is either deleted or has an extra one inserted into the middle of DNA sequence; causes the reading frame to shift



Insertions

Deletions

Substitutions

Translocations

Recombinations

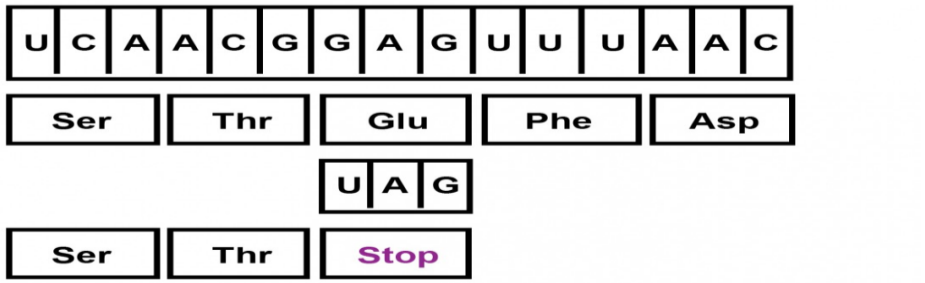
Non-Disjunction

How and why does evolution occur?

Types of Mutation

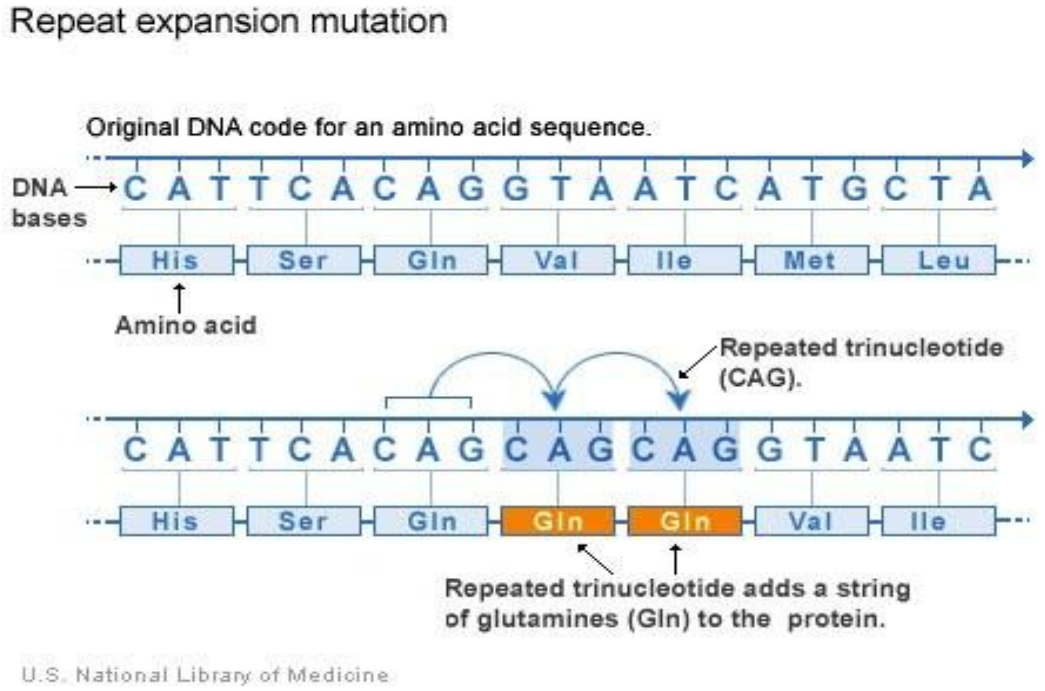
Nonsense mutation

- change in one DNA base pair in which the altered DNA sequence prematurely signals the cell to stop building a protein, which results in a shortened protein that may not function, or may function improperly



Repeat expansion

- Nucleotide repeats are short DNA sequences that are repeated a number of times in a row.



Duplication

- A duplication consists of a piece of DNA that is abnormally copied one or more times. This type of mutation may alter the function of the resulting protein.

How and why does evolution occur?

Types of Mutation

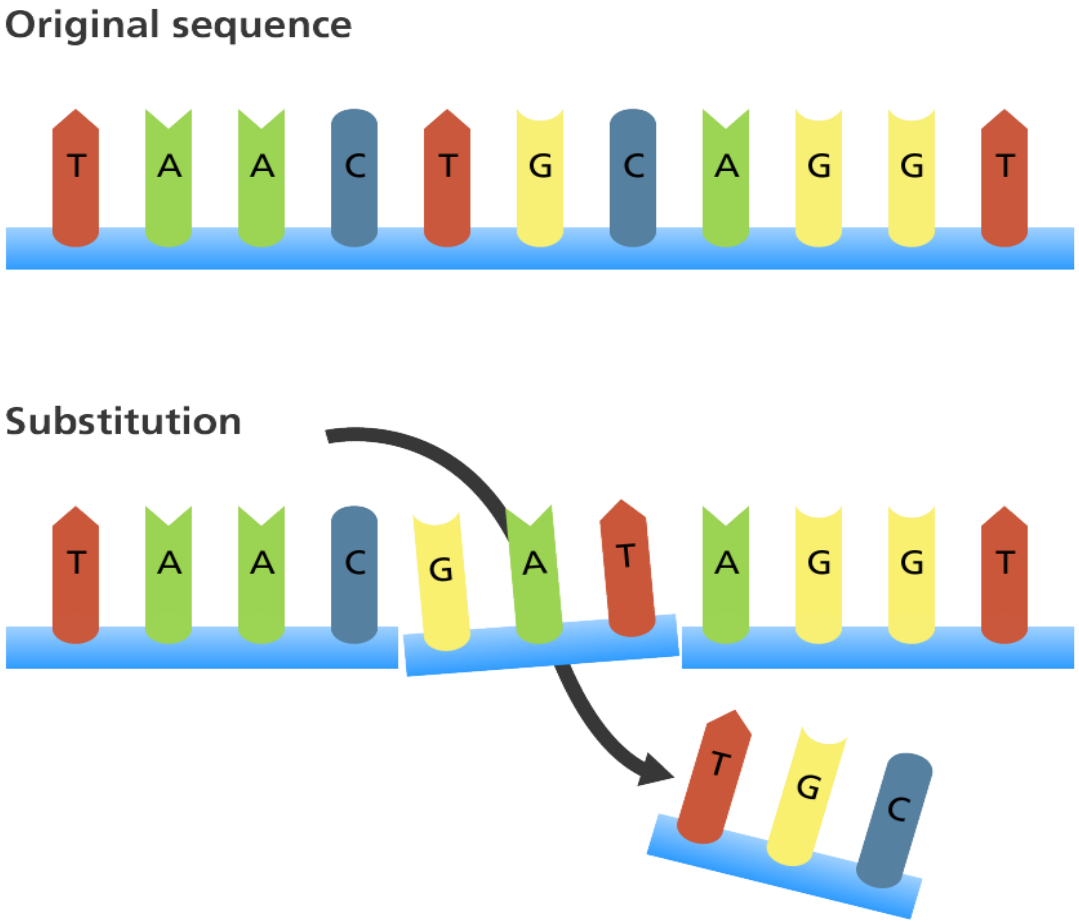
Insertions	• addition of one or more nucleotide base pairs into a DNA sequence
Deletions	• changes the number of DNA bases by removing a piece of DNA.
Substitutions	• An exchange of one base for another (i.e., a change in a single "chemical letter" such as switching an A to a G)
Translocations	• mutations in which chromosome segments, and the genes they contain, change positions.
Recombinations	• exchange of **genetic** material either between multiple chromosomes or between different regions of the same chromosome; can produce offspring with different characteristics than either parent.
Non-Disjunction	• failure of homologous chromosomes or sister chromatids to separate properly during cell division.

How and why does evolution occur?

Insertion

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

changes the number of DNA bases by removing a piece of DNA.

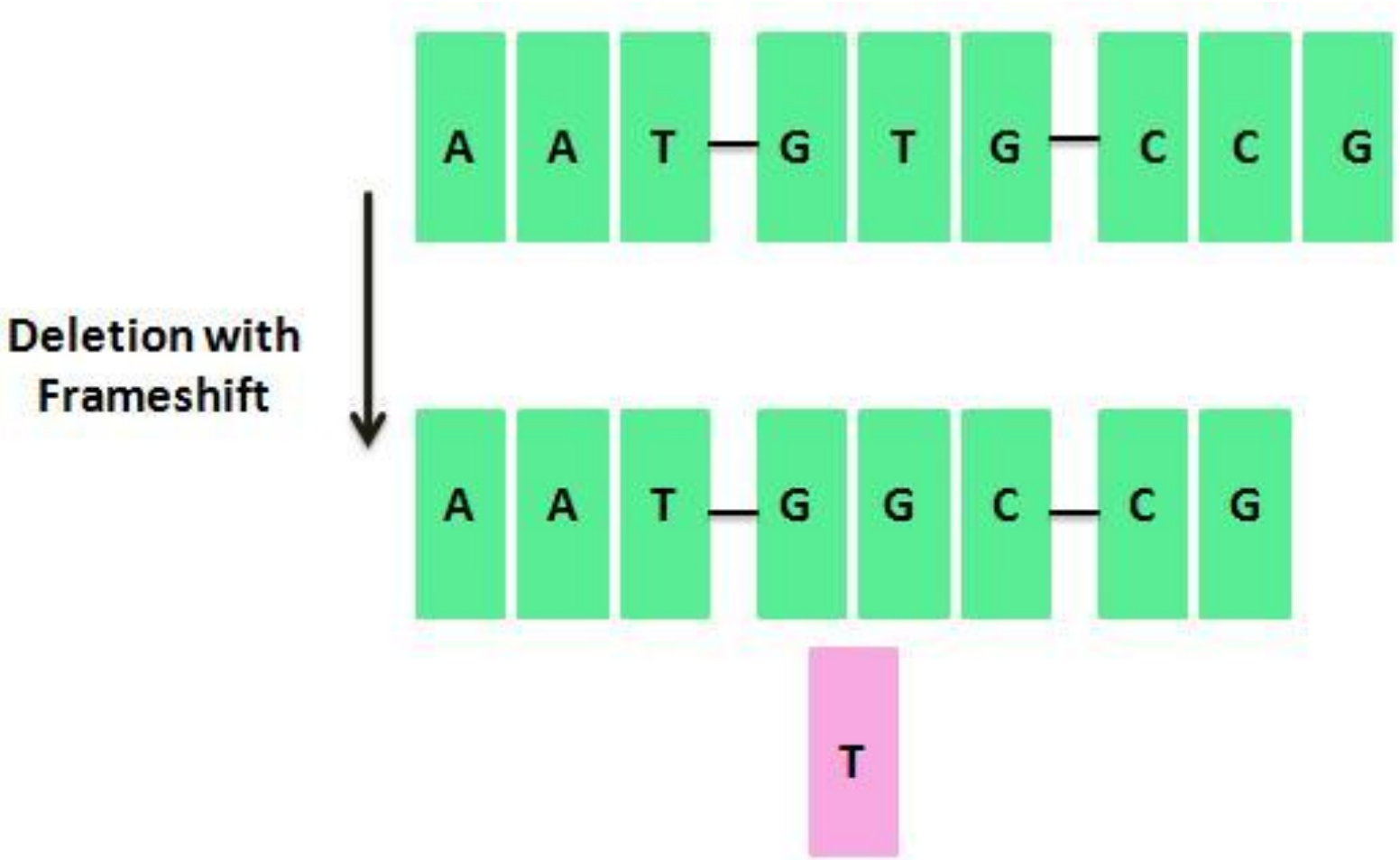


How and why does evolution occur?

Deletion

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

changes the number of DNA bases by removing a piece of DNA.

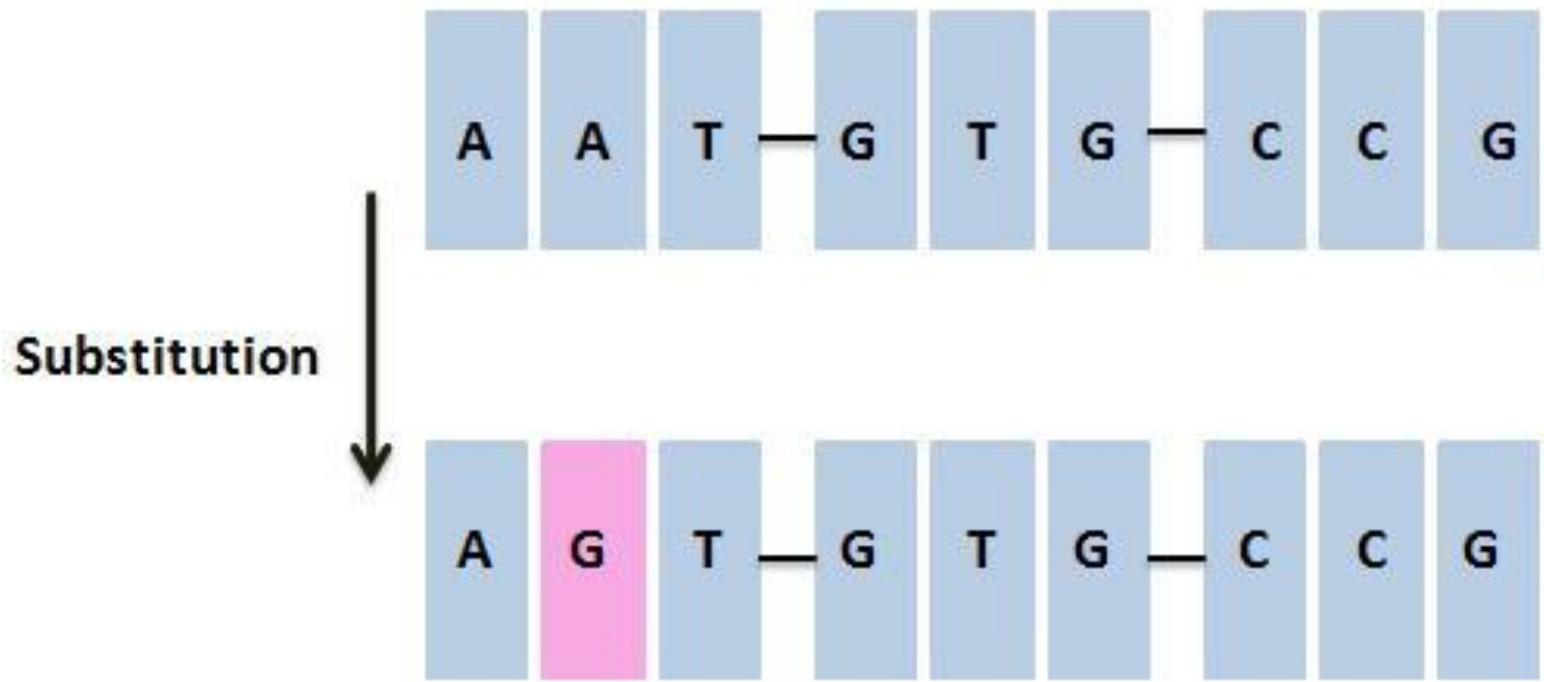


How and why does evolution occur?

Substitution

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

An exchange of one base for another (i.e., a change in a single "chemical letter" such as switching an A to a G)

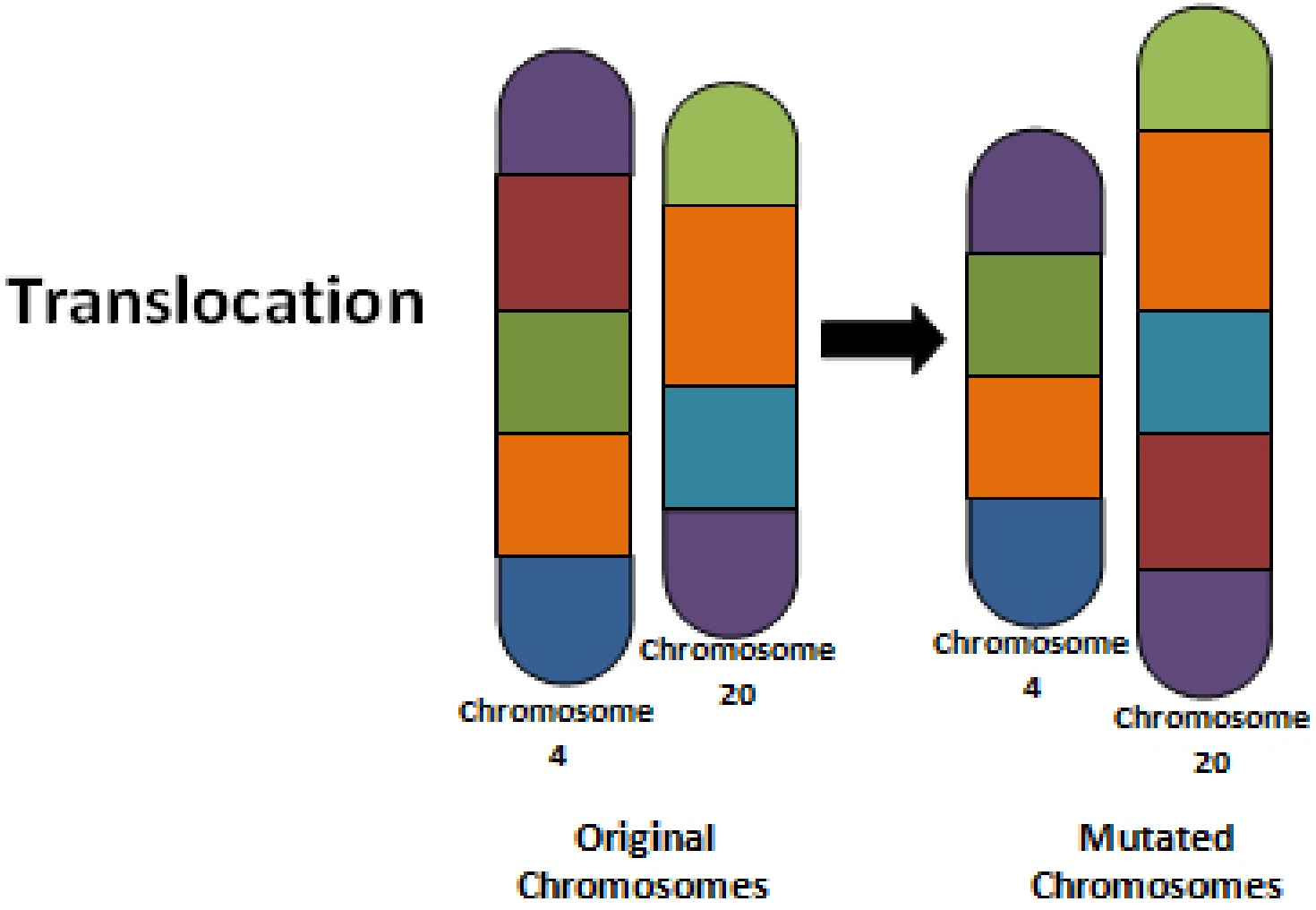


How and why does evolution occur?

Translocation

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

mutations in which chromosome segments, and the genes they contain, change positions.

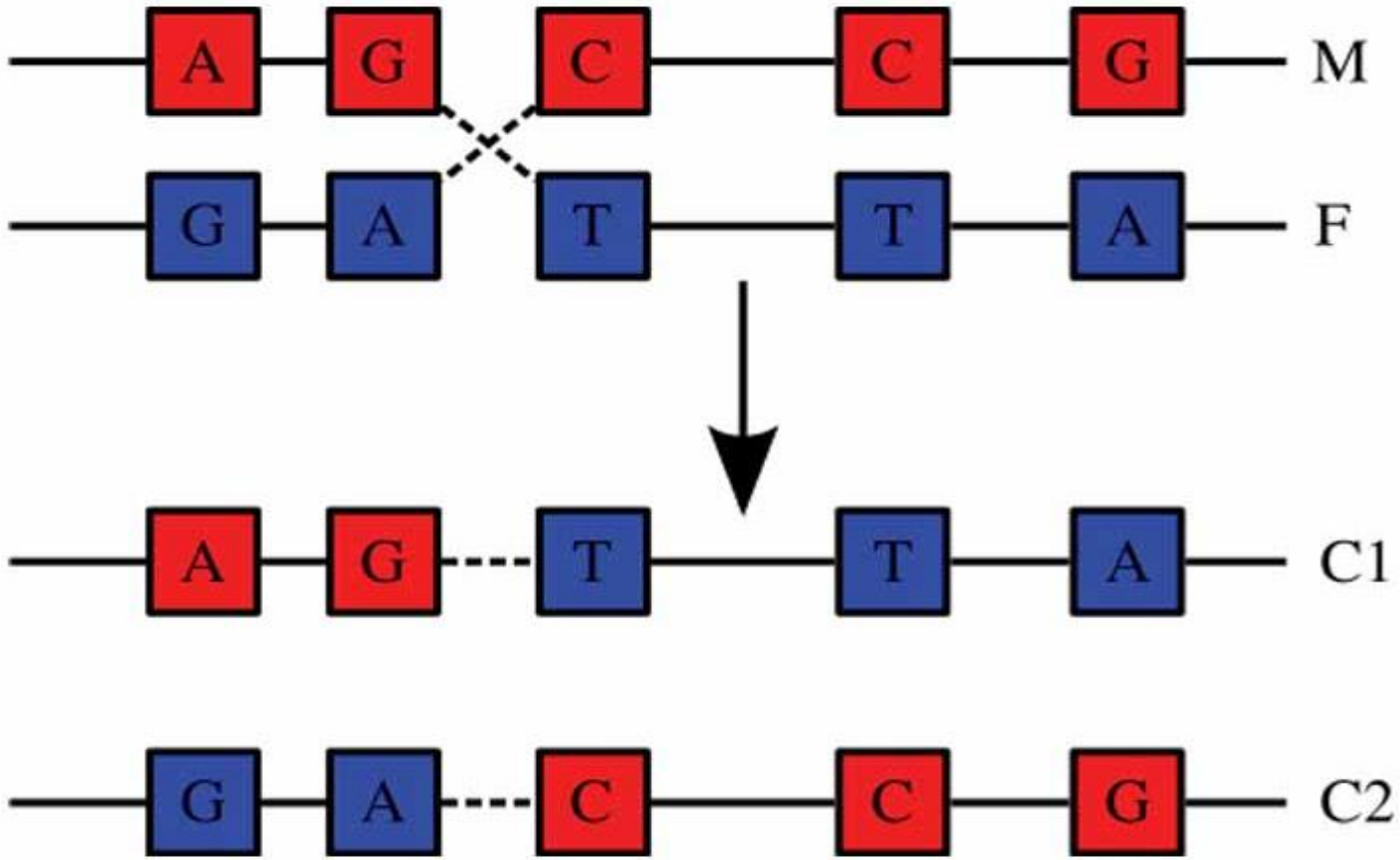


How and why does evolution occur?

Recombination

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

exchange of **genetic** material either between multiple chromosomes or between different regions of the same chromosome; can produce offspring with different characteristics than either parent.

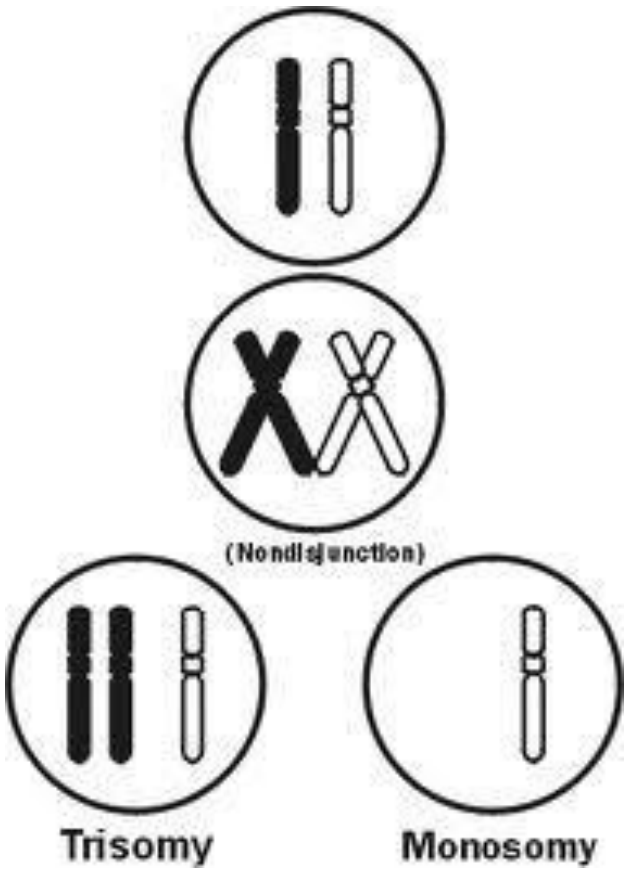


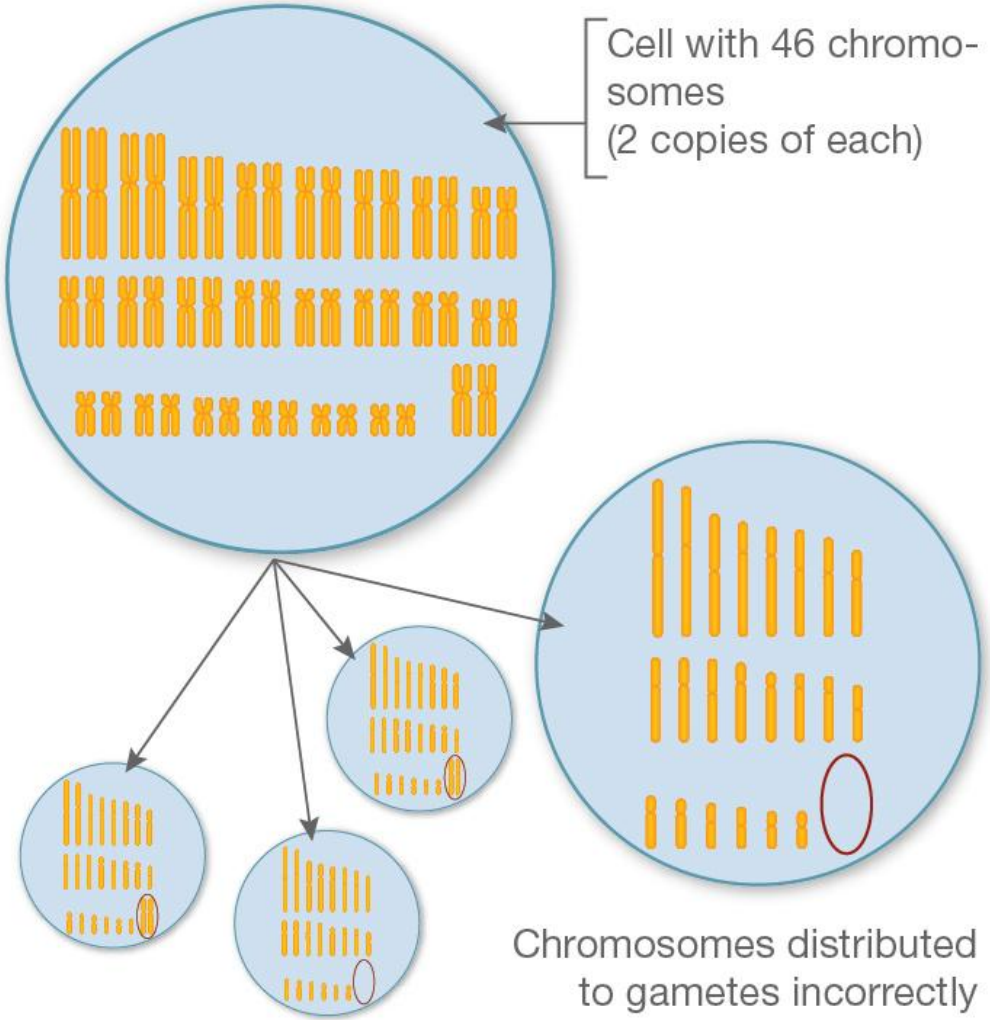
How and why does evolution occur?

Non-Disjunction

- Insertion
- Deletion
- Substitutions
- Translocations
- Recombinations
- Non-Disjunction

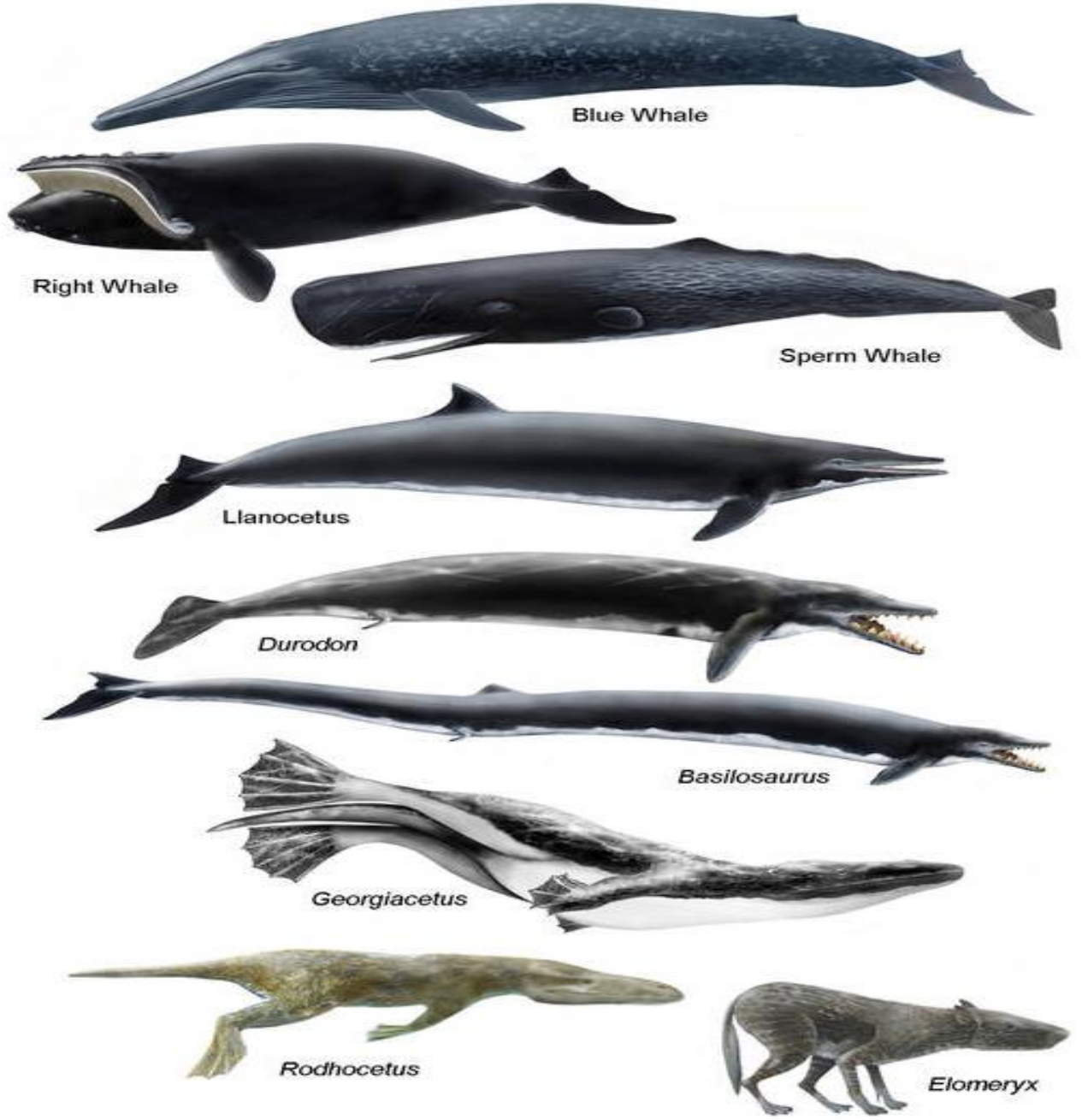
failure of homologous chromosomes or sister chromatids to separate properly during cell division.





Additional Video Resources

https://www.brightstorm.com/science/biology/mendelian-genetics/

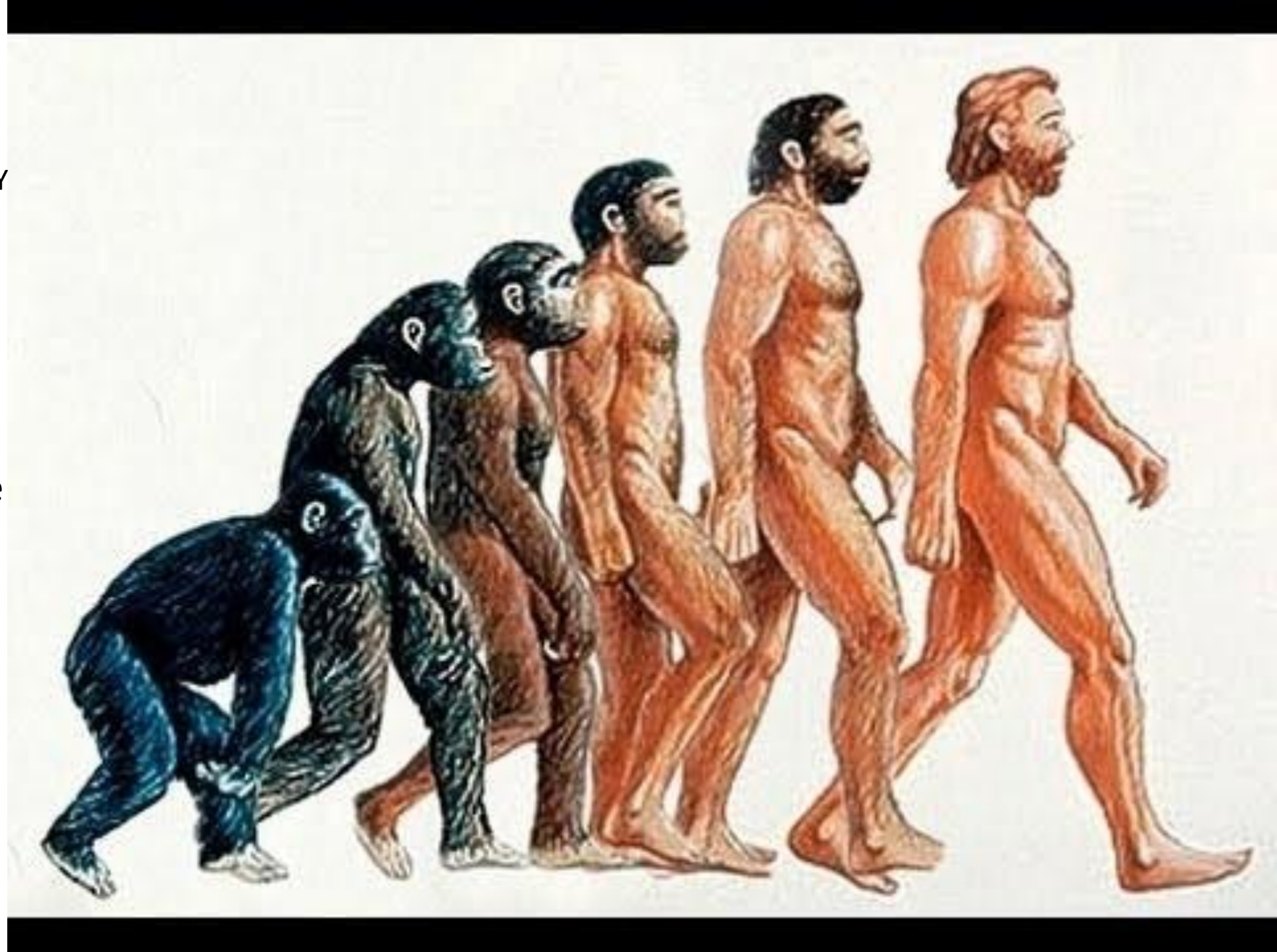


Evolution [Continued]
https://youtu.be/MsHEAnPX59Y

10:25-12:00 –
Cambrian explosion

17:35 –21:05 move from life in ocean to life on land

21:05-24:55 Mammals



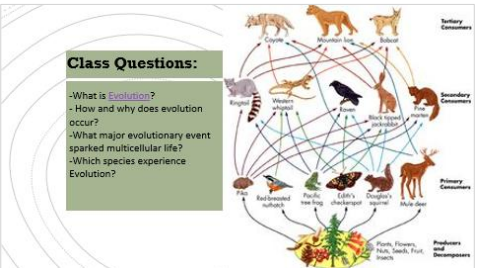
Evolution Research

https://youtu.be/NOHzY1fuOz4

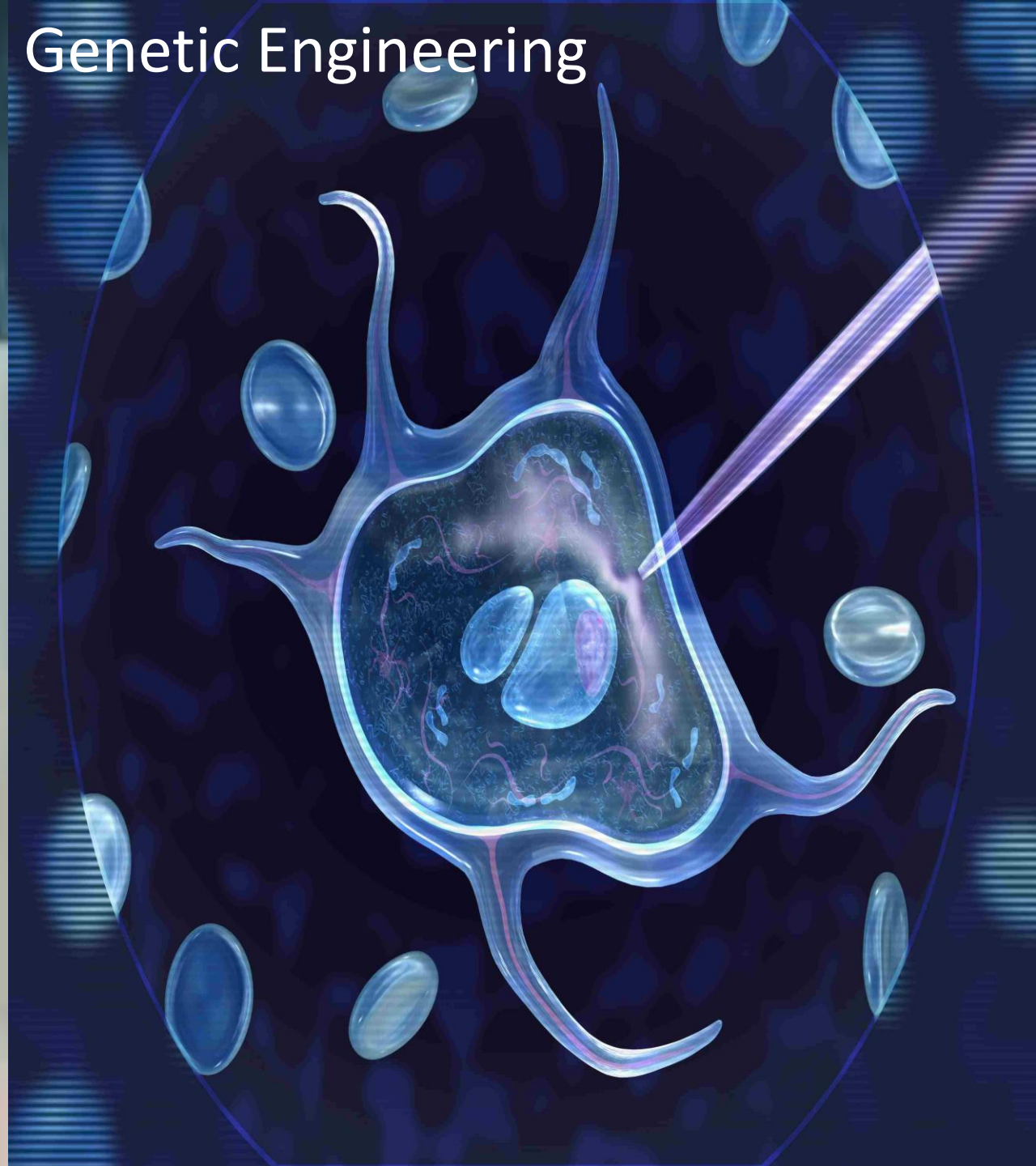
32 mins-mouse- DNA;
39 min- mutation – advantages of animals;
44 embryo studies- multi species; 233 - humans

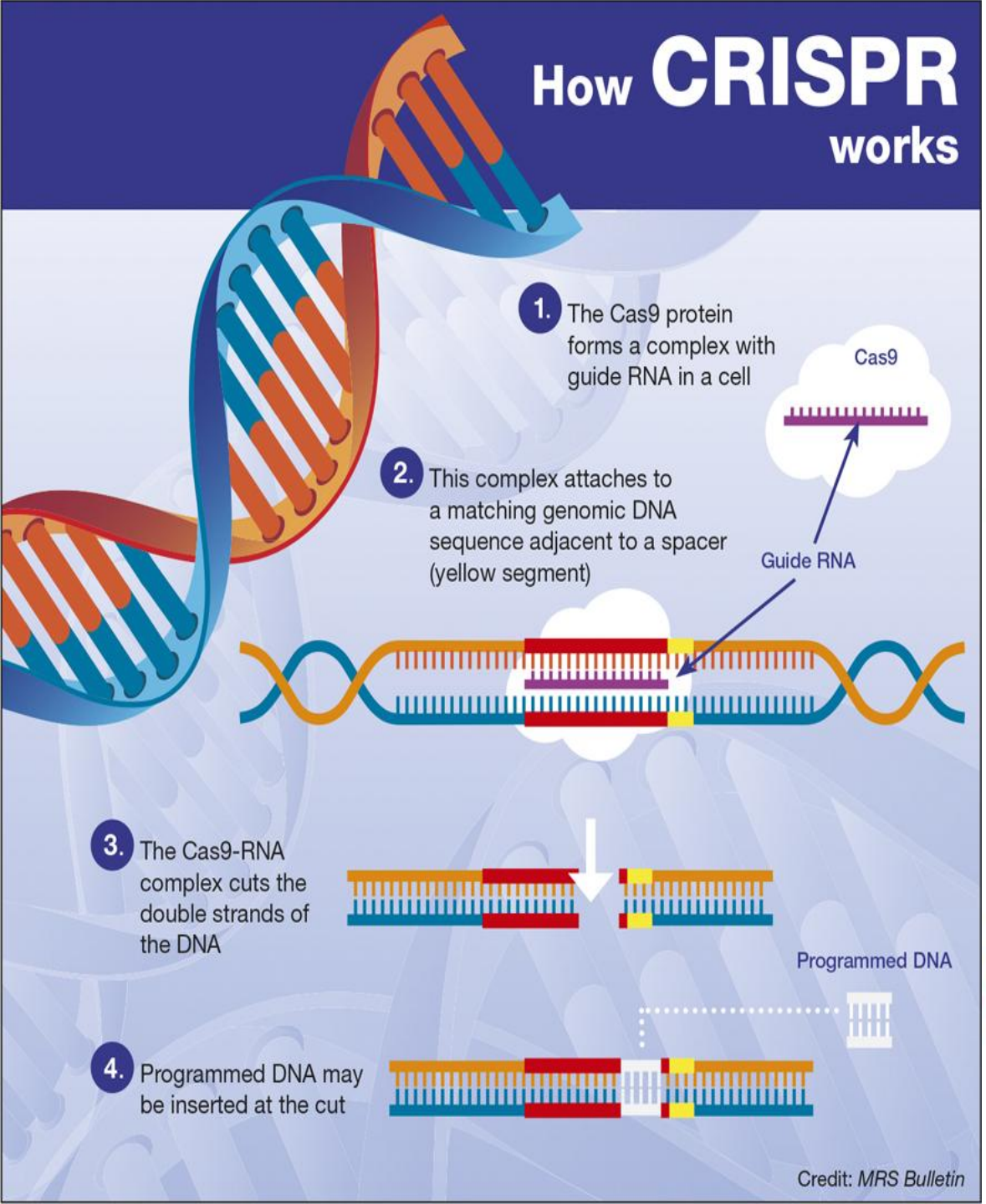
Evolution Introduction

https://youtu.be/hOfRN0KihOU



Genetic Engineering

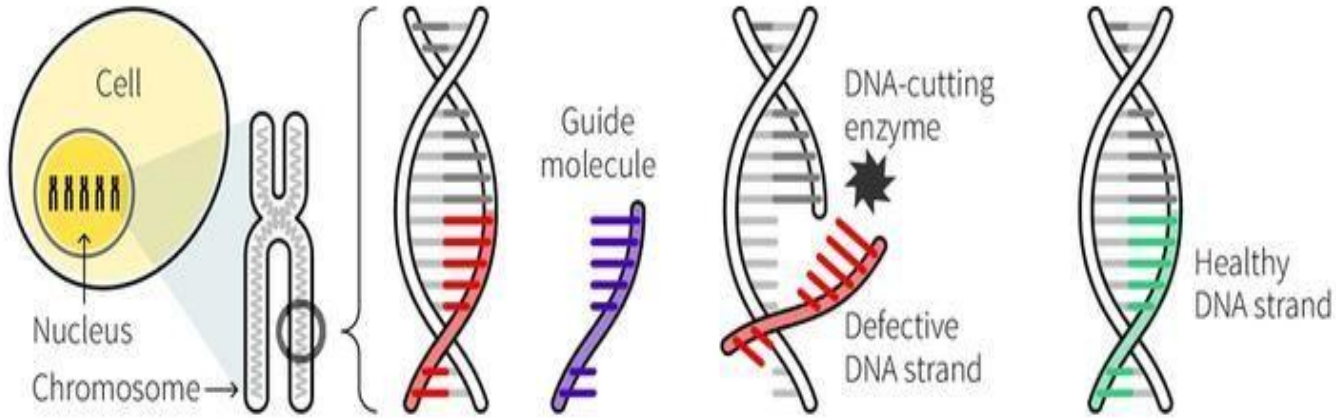




DNA editing

A DNA editing technique, called CRISPR/Cas9, works like a biological version of a word-processing programme's "find and replace" function.

HOW THE TECHNIQUE WORKS



A cell is transfected with an enzyme complex containing:

- Guide molecule
- Healthy DNA copy
- DNA-cutting enzyme

A specially designed synthetic guide molecule finds the target DNA strand.

An enzyme cuts off the target DNA strand.

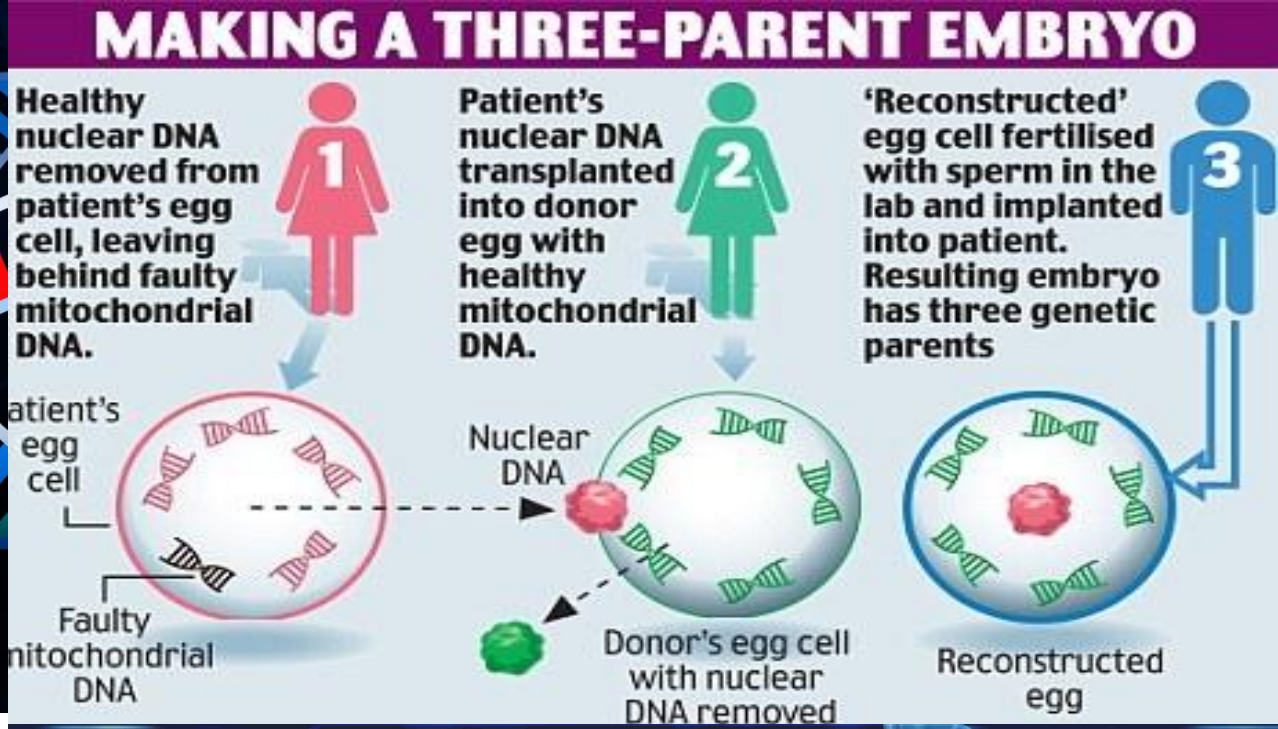
The defective DNA strand is replaced with a healthy copy.

Sources: Reuters; Nature; Massachusetts Institute of Technology

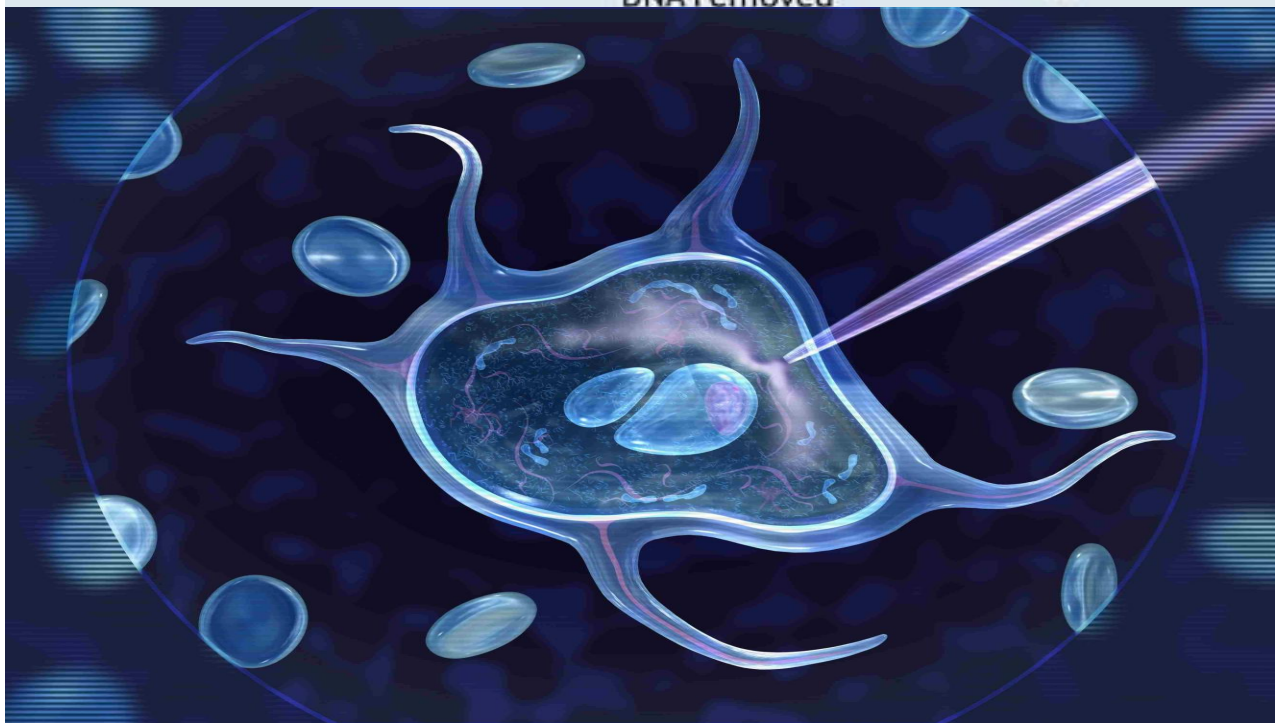
W. Foo, 24/04/2015

REUTERS


DESIGNER BABIES


MAKING A THREE-PARENT EMBRYO
Healthy nuclear DNA removed from patient's egg cell, leaving behind faulty mitochondrial DNA.
Patient's nuclear DNA transplanted into donor egg with healthy mitochondrial DNA.
'Reconstructed' egg cell fertilised with sperm in the lab and implanted into patient. Resulting embryo has three genetic parents
1
2
3
atient's egg cell
Faulty nitochondrial DNA
Nuclear DNA
Donor's egg cell with nuclear DNA removed
Reconstructed egg

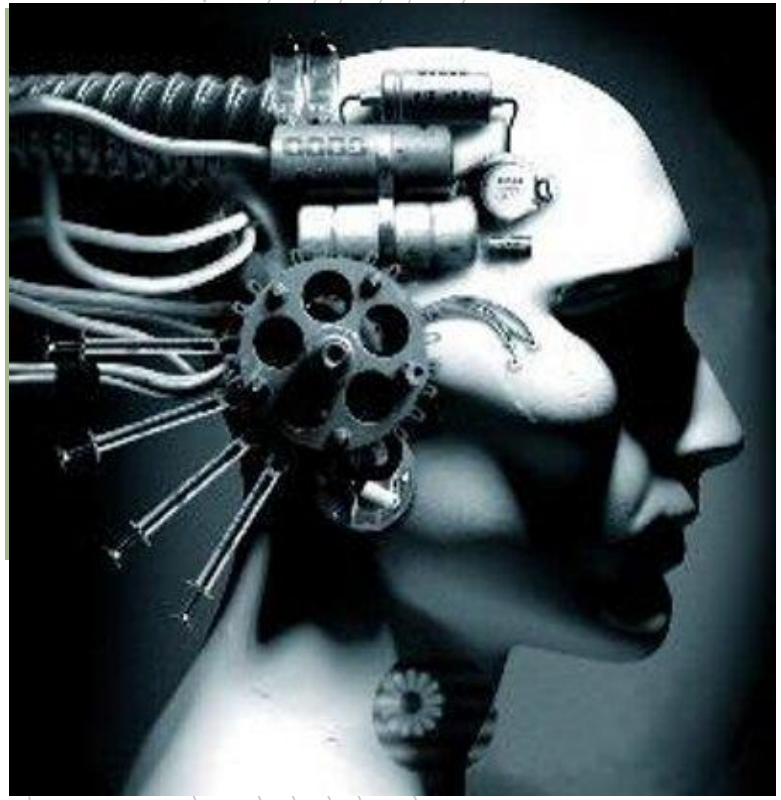

No baldness
High IQ
Low risk of Alzheimer's, breast cancer and strokes
Sprinter
Perfect pitch
20/20 vision
A
T
G
C
Shutterstock



Human Cloning

Cyborgs

The integration of genetics and technology; a being with both organic and biomechatronic body parts or using technological adaptations.



http://www.explainthatstuff.com/timeline.html

Evolution - Major Historical Events

- Only watch 10:25-12:00 [Cambrian Explosion, >2 mins] 17:35-21:05 [Move from ocean to life on land >4 mins]; 21:05-24:55 Mammals [>4 mins]
- https://www.youtube.com/watch?v=MsHEAnPX59Y&feature=youtu.be

1:25:00-1:52:00 [27 minutes]

https://www.youtube.com/watch?v=NOHzY1fuOz4&feature=youtu.be