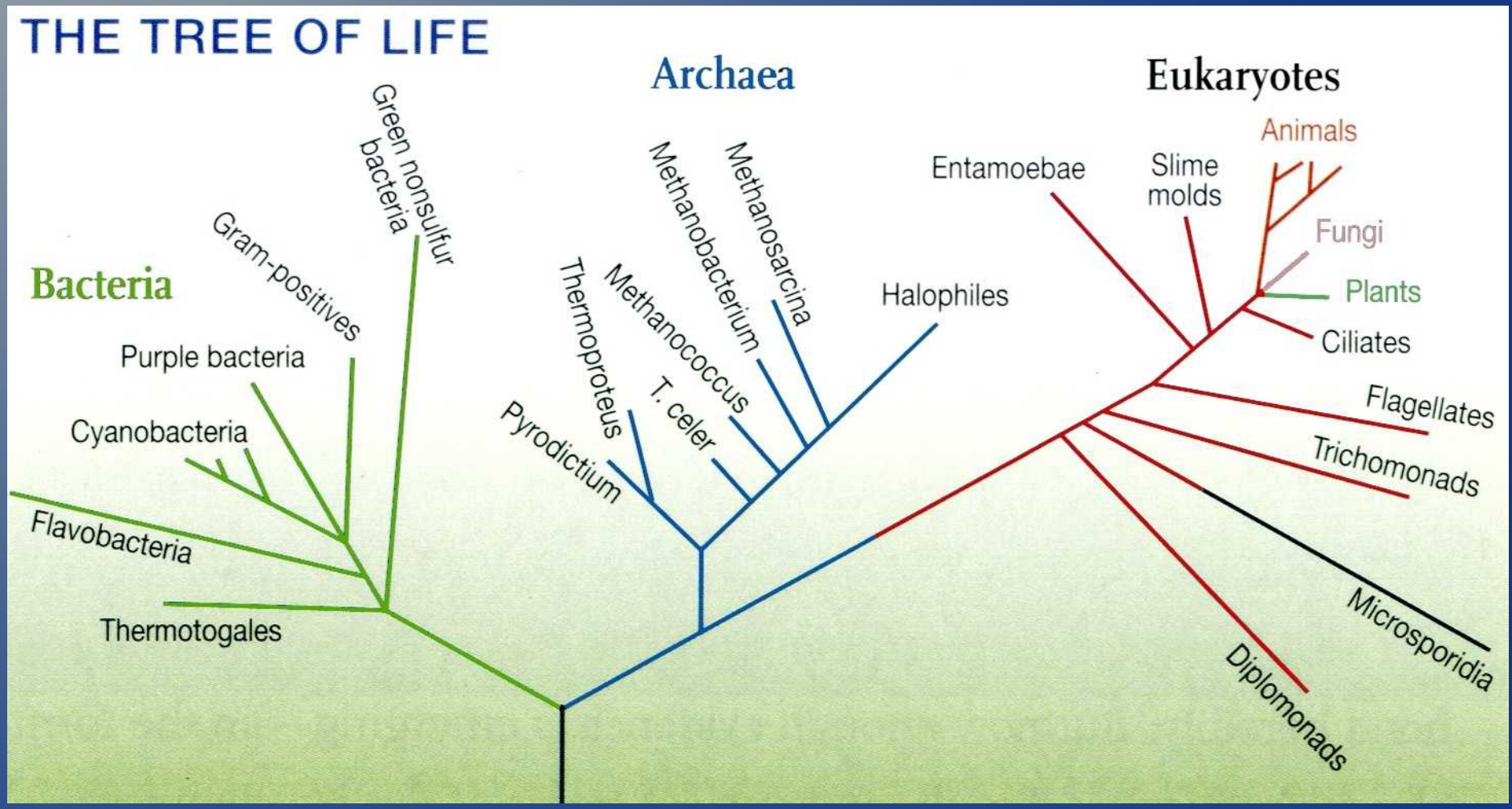
Mini-Lectures of Biology

For school students

Part II

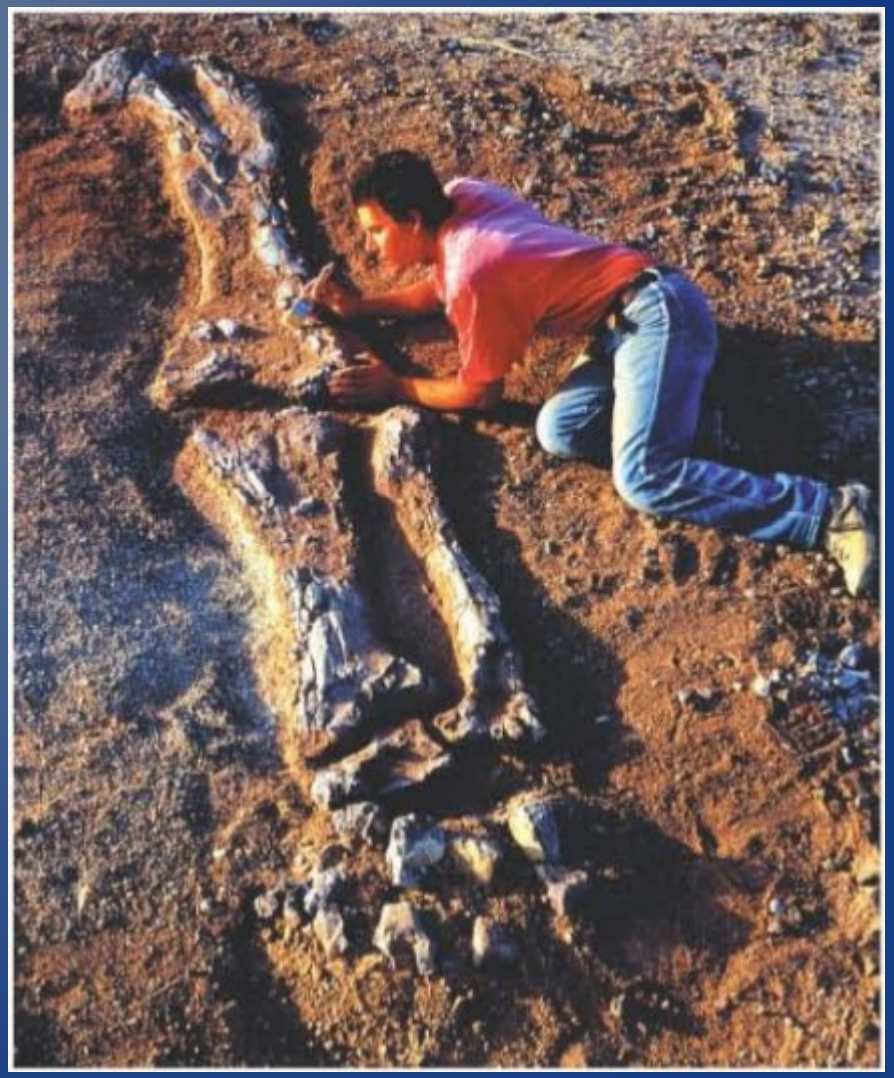
By
Ankit Agrawal

Organizing the diversity of life



History of life

Digging into the past: Paleontologist Paul Sereno, of the University of Chicago. gingerly excavates the leg bones of a dinosaur fossil in Niger



Charles Darwin and Natural Selection

- Three key observations about life
  - Life in their environments
  - Unity of life
  - Diversity of life


Darwin in 1840, after his return from the voyage
HMS Beagle in port
The Galápagos Islands
Pinta
Genovesa
Marchena
Santiago
Daphne Islands
Pinzón
Fernandina
Isabela
Santa Cruz
Santa Fe
San Cristobal
Florenza
Española
0 40 km
0 40 miles
PACIFIC OCEAN
NORTH AMERICA
GREAT BRITAIN
EUROPE
ATLANTIC OCEAN
AFRICA
Equator
SOUTH AMERICA
PACIFIC OCEAN
Andes
Cape of Good Hope
AUSTRALIA
PACIFIC OCEAN
Tasmania
New Zealand
Cape Horn
Tierra del Fuego

Darwin in 1840, after his return from the voyage

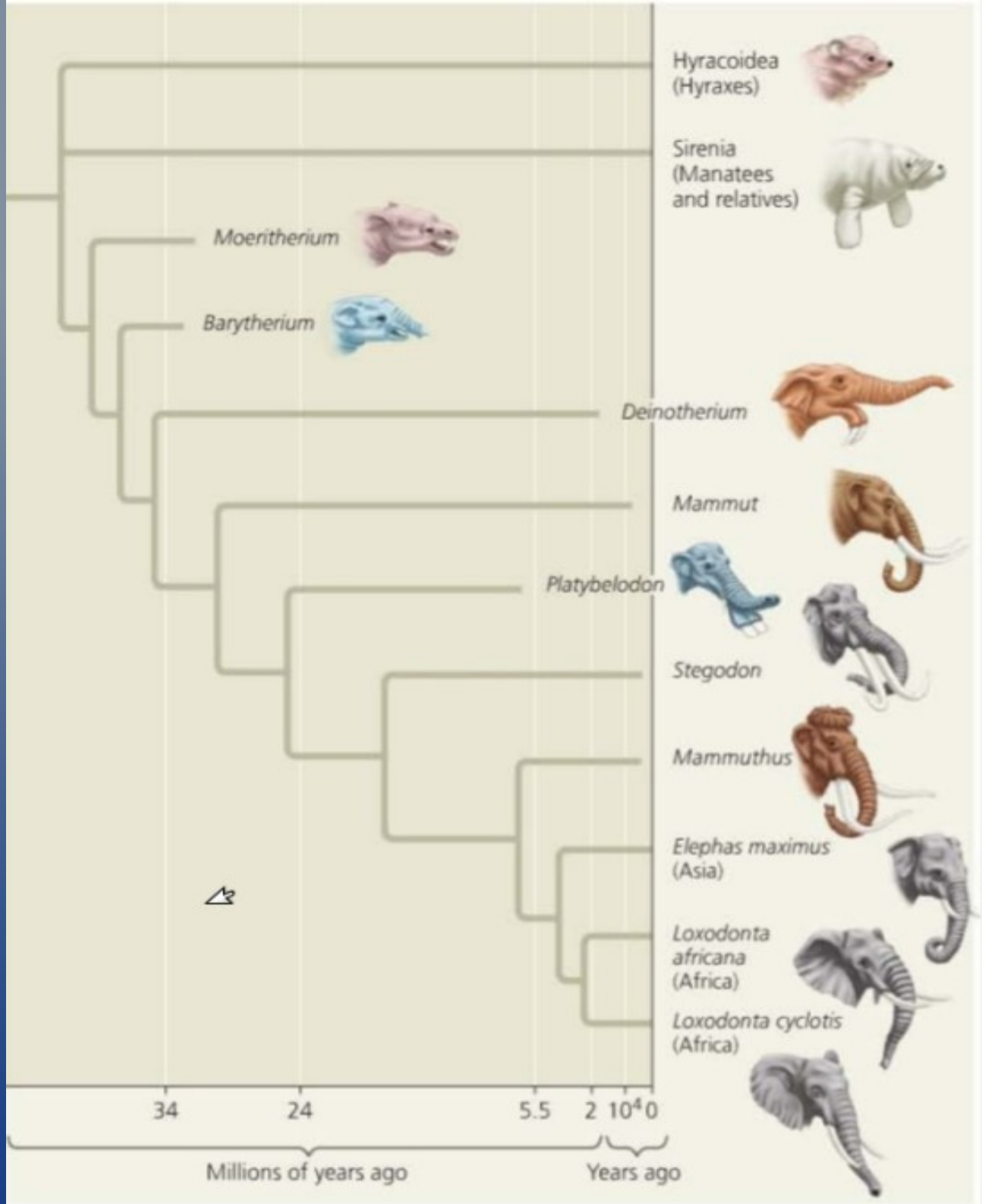
(a) Cactus-eater. The long, sharp beak of the cactus ground finch (*Geospiza scandens*) helps it tear and eat cactus flowers and pulp.

(c) Seed-eater. The large ground finch (*Geospiza magnirostris*) has a large beak adapted for cracking seeds that fall from plants to the ground.

(b) Insect-eater. The green warbler finch (*Certhidea olivacea*) uses its narrow, pointed beak to grasp insects.

Charles Darwin and Natural Selection

- Three key observations about life
  - Life in their environments
  - Unity of life
  - Diversity of life
- Darwin developed two main ideas
  - Descent with modification explains life's unity and diversity
  - Natural selection brings about match between organism and their environment

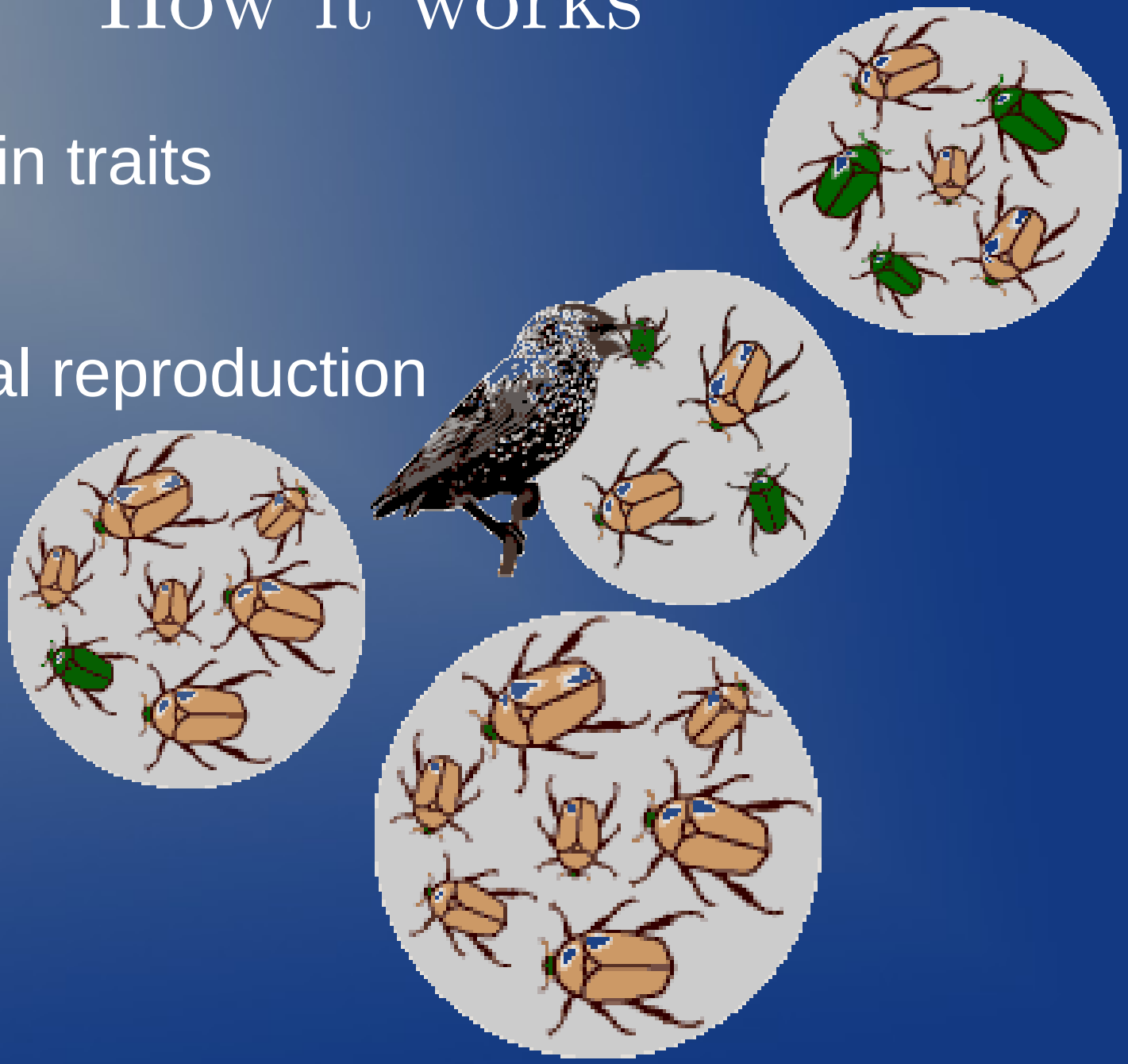

Hyracoidea
(Hyraxes)
Sirenia
(Manatees
and relatives)
Moeritherium
Barytherium
Deinotherium
Mammut
Platybelodon
Stegodon
Mammuthus
Elephas maximus
(Asia)
Loxodonta
africana
(Africa)
Loxodonta cyclotis
(Africa)
34
24
5.5
2
10^4
0
Millions of years ago
Years ago

Natural Selection

- Individuals that have certain heritable characteristics survive and reproduce at a higher rate than other individuals
- Over time, natural selection can increase the match between organism and their environments
- If an environment changes, or if individuals move to a new environment, natural selection may result in adaptation to these new conditions, sometimes giving rise to new species in the process

How it works

1. Variation in traits
2. Differential reproduction
3. Heredity
4. End

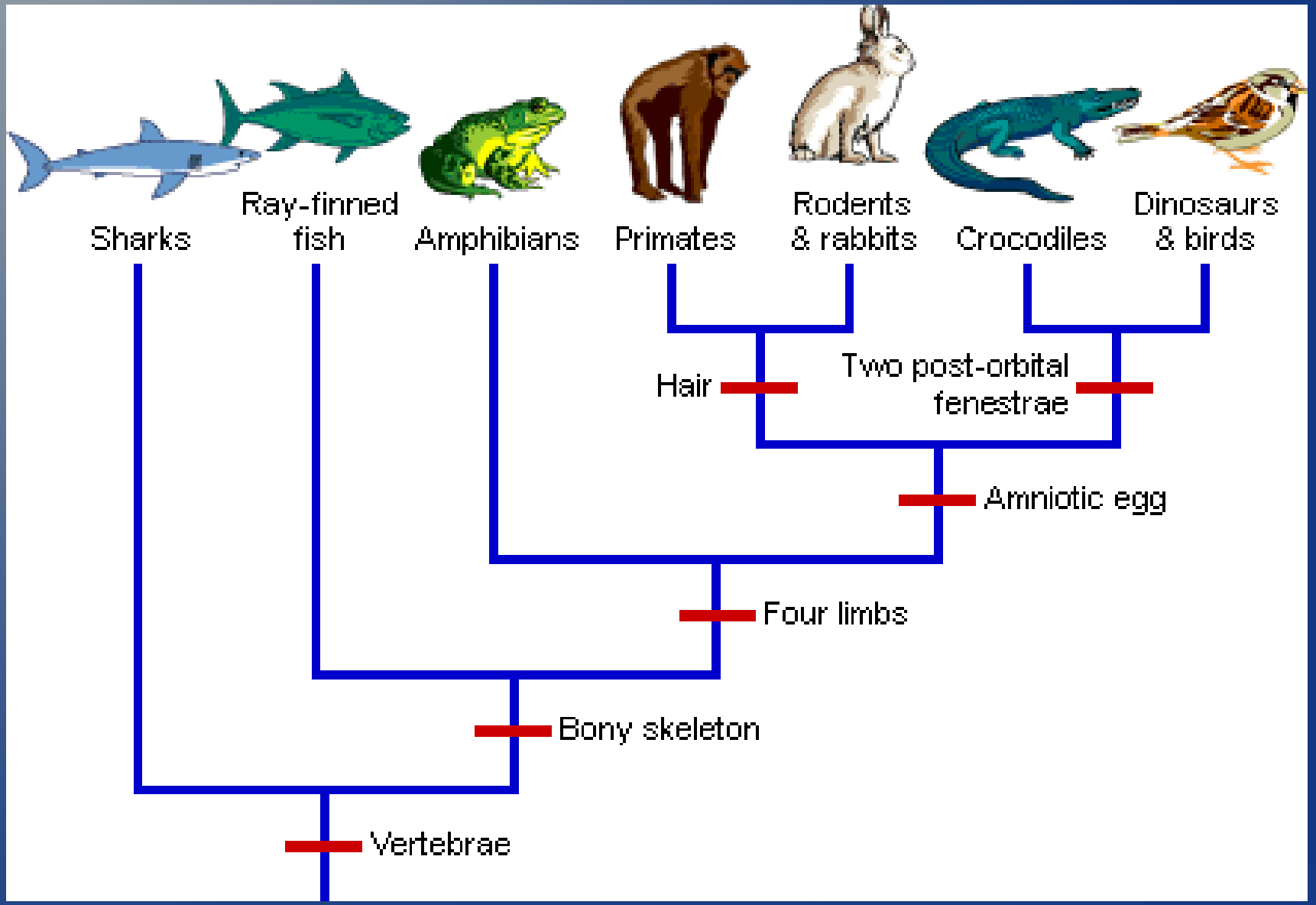


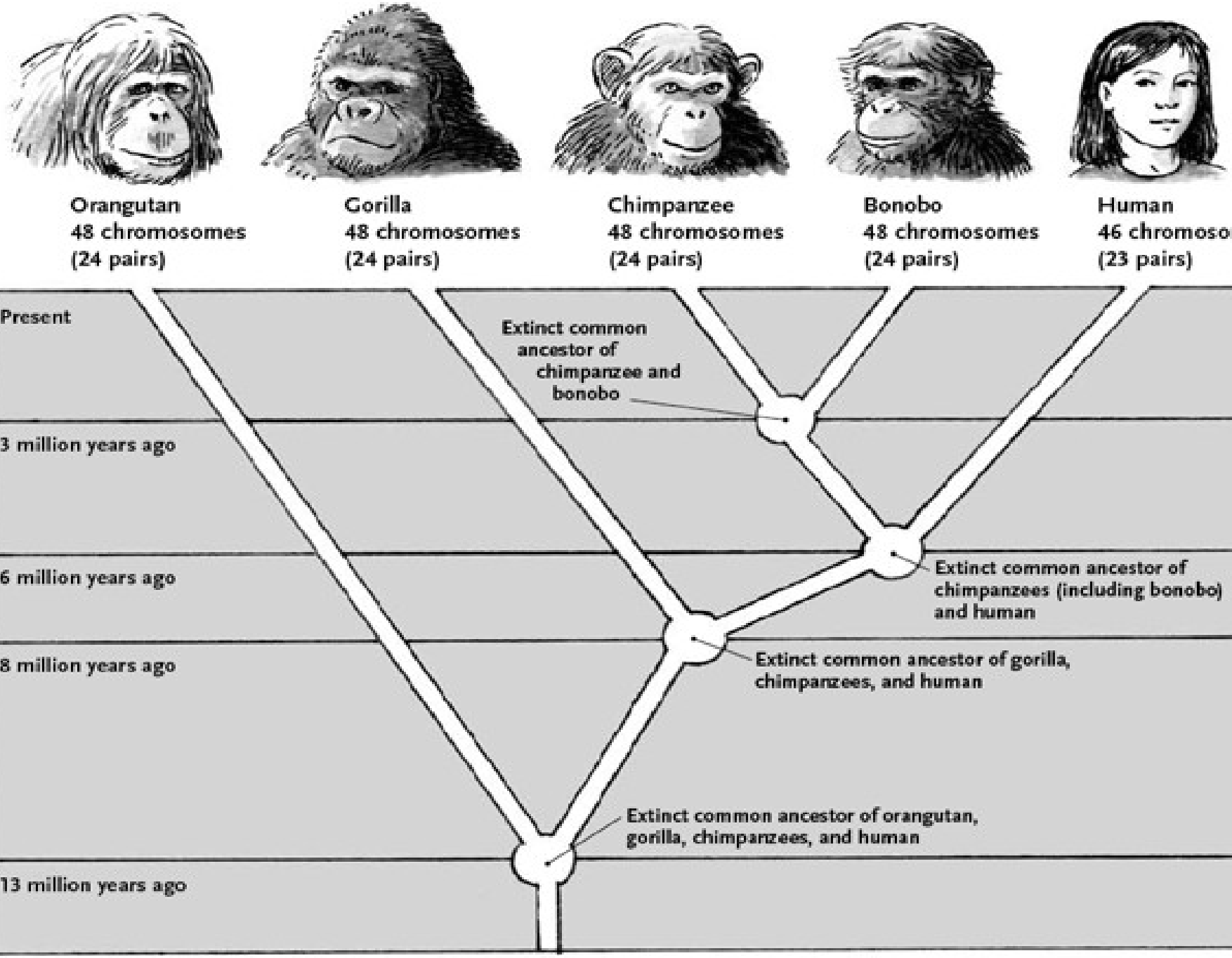
Evolution only occurs when there is a change in gene frequency within a population over time

- Beetles on a diet

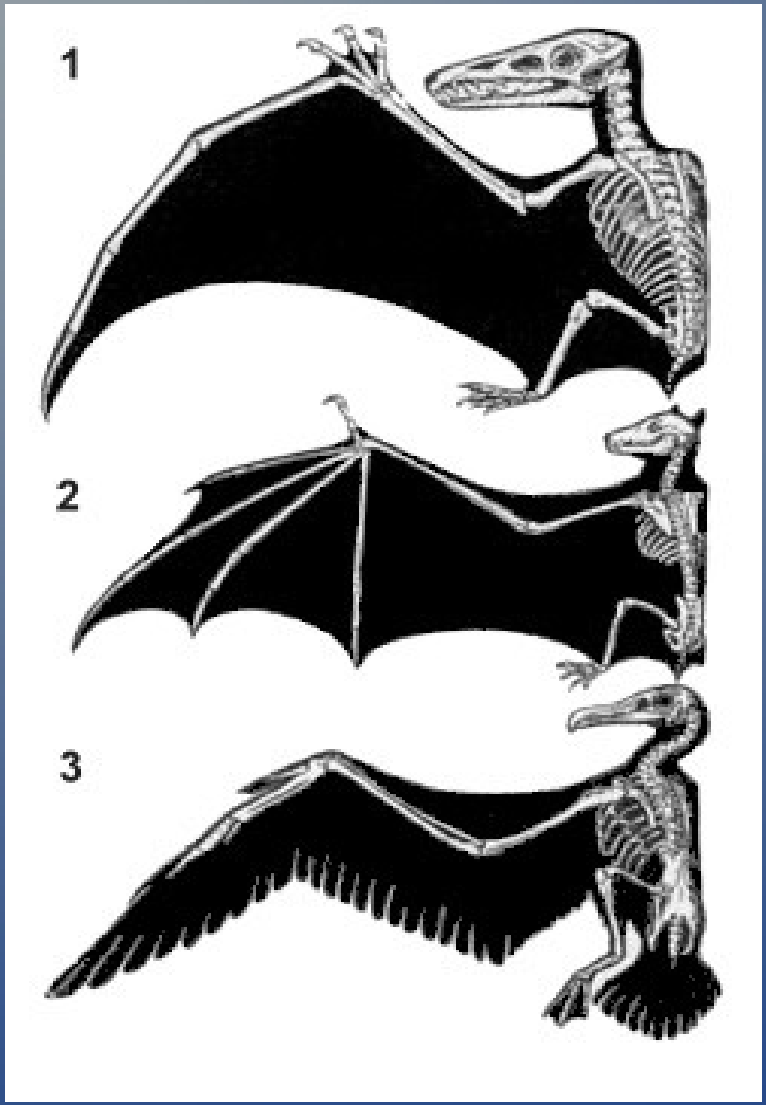
- Beetles of a different color

Speciation


Sharks
Ray-finned fish
Amphibians
Primates
Rodents & rabbits
Crocodiles
Dinosaurs & birds
Hair
Two post-orbital fenestrae
Amniotic egg
Four limbs
Bony skeleton
Vertebrae


Orangutan
48 chromosomes
(24 pairs)
Gorilla
48 chromosomes
(24 pairs)
Chimpanzee
48 chromosomes
(24 pairs)
Bonobo
48 chromosomes
(24 pairs)
Human
46 chromosomes
(23 pairs)
Present
3 million years ago
6 million years ago
8 million years ago
13 million years ago
Extinct common ancestor of chimpanzee and bonobo
Extinct common ancestor of chimpanzees (including bonobo) and human
Extinct common ancestor of gorilla, chimpanzees, and human
Extinct common ancestor of orangutan, gorilla, chimpanzees, and human

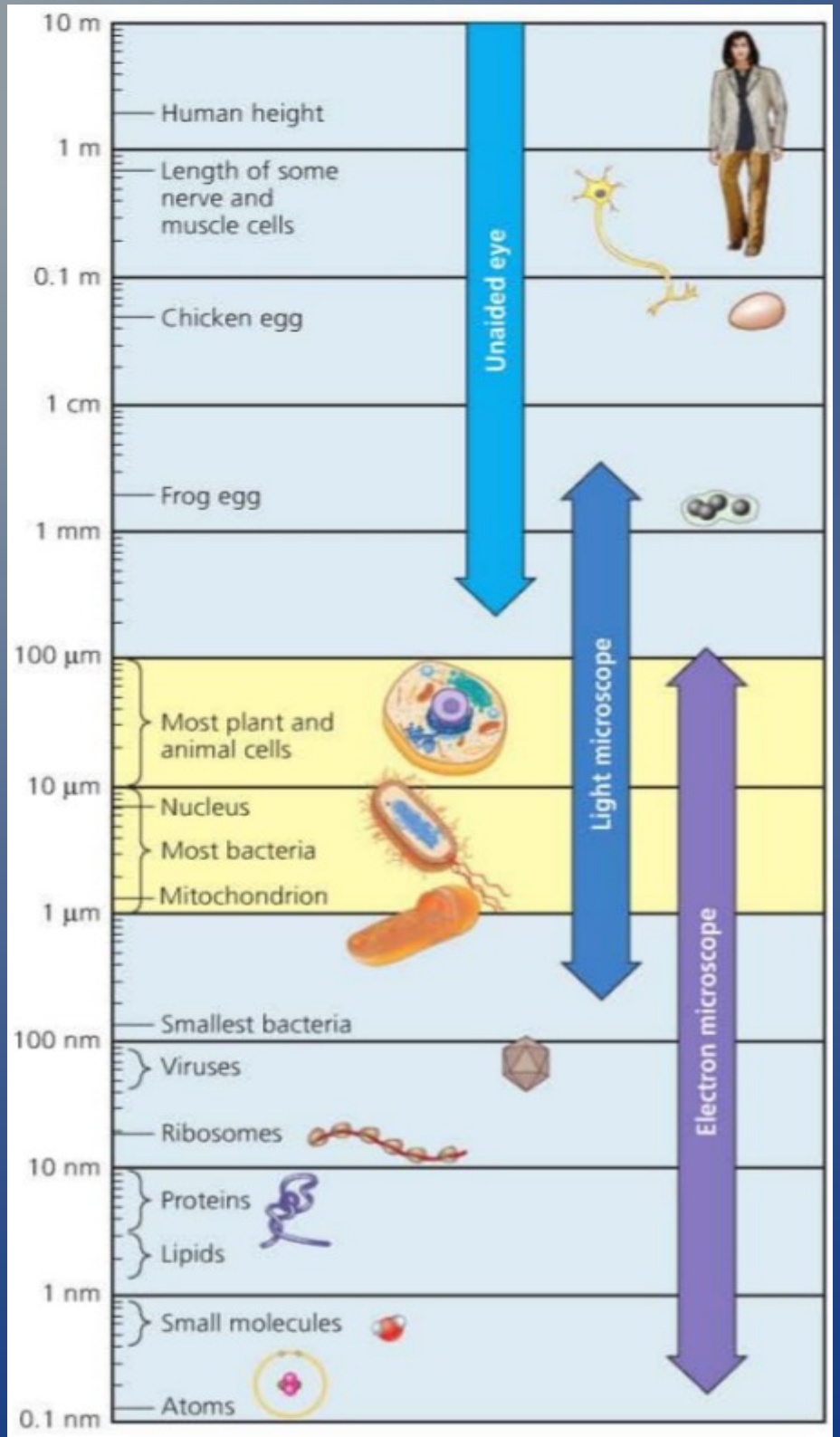
Types of Evolution



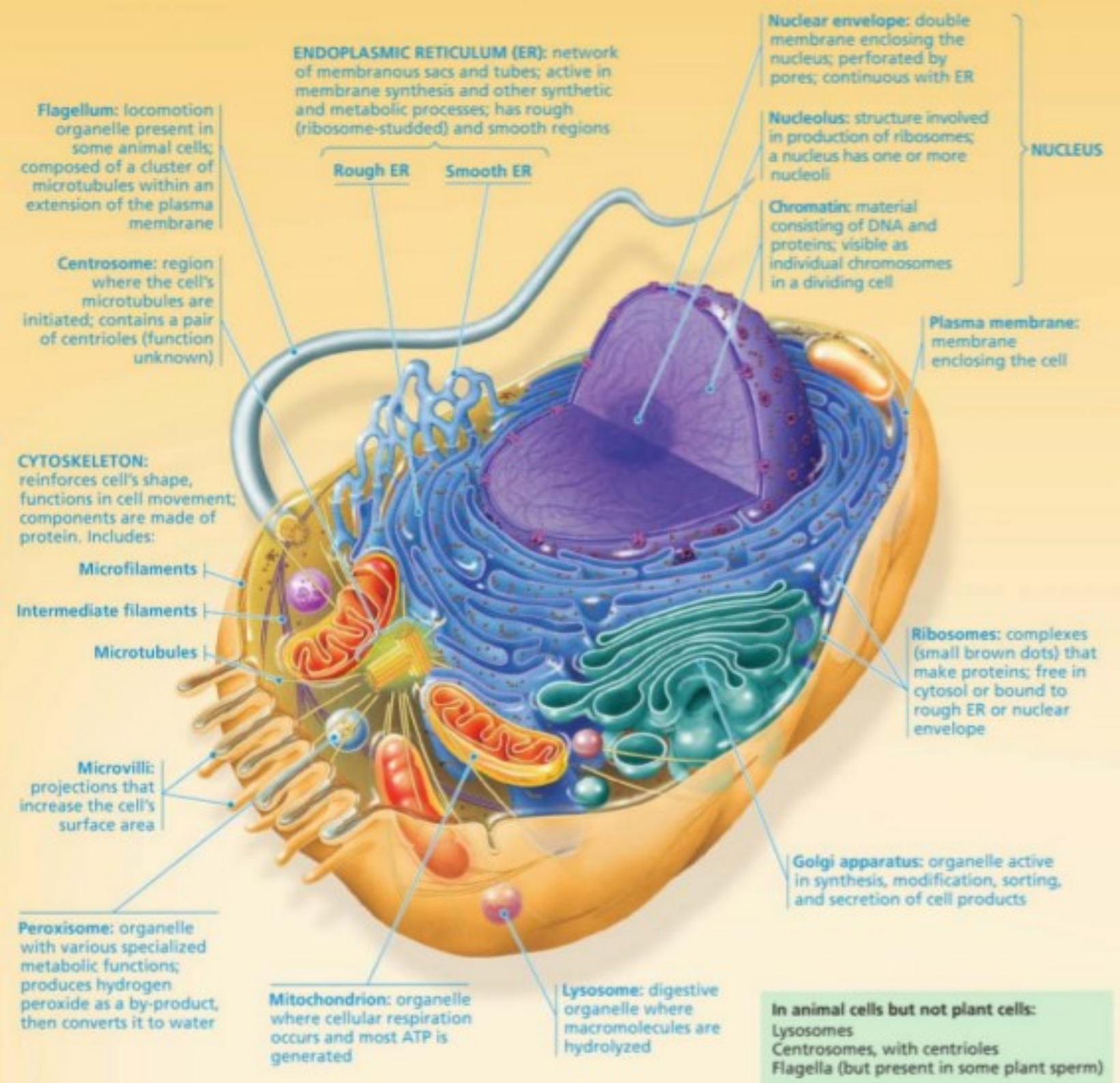
(1) Pterosaur
(2) Bat
(3) Bird

- Divergent
- Convergent
- Parallel

The Cell

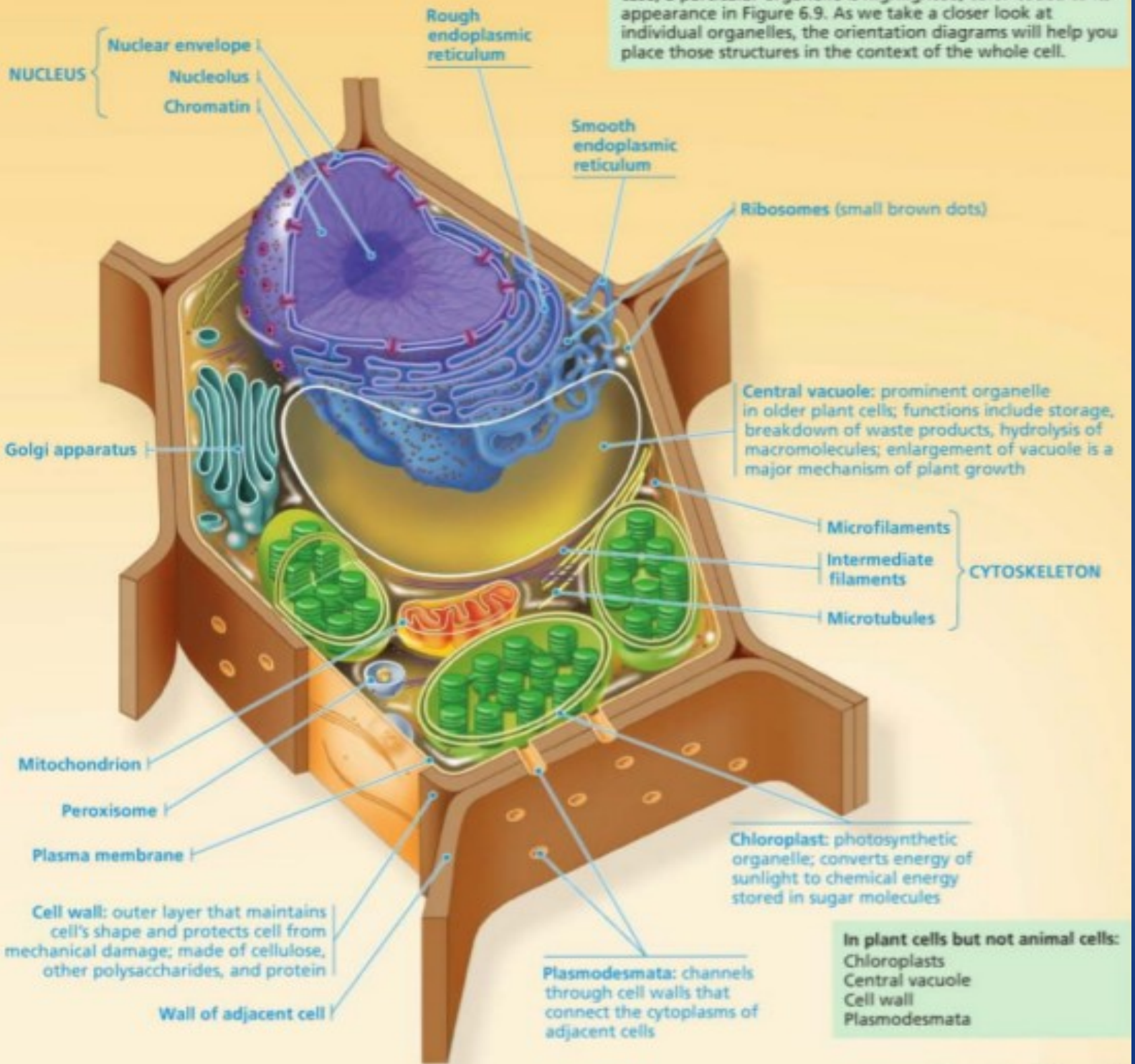

10 m
Human height
1 m
Length of some nerve and muscle cells
0.1 m
Chicken egg
1 cm
Frog egg
1 mm
100 µm
Most plant and animal cells
10 µm
Nucleus
Most bacteria
Mitochondrion
1 µm
Smallest bacteria
100 nm
Viruses
Ribosomes
10 nm
Proteins
Lipids
1 nm
Small molecules
Atoms
0.1 nm
Unaided eye
Light microscope
Electron microscope

ANIMAL CELL


ENDOPLASMIC RETICULUM (ER): network of membranous sacs and tubes; active in membrane synthesis and other synthetic and metabolic processes; has rough (ribosome-studded) and smooth regions
Rough ER
Smooth ER
Flagellum: locomotion organelle present in some animal cells; composed of a cluster of microtubules within an extension of the plasma membrane
Centrosome: region where the cell's microtubules are initiated; contains a pair of centrioles (function unknown)
CYTOSKELETON: reinforces cell's shape, functions in cell movement; components are made of protein. Includes:
Microfilaments
Intermediate filaments
Microtubules
Microvilli: projections that increase the cell's surface area
Peroxisome: organelle with various specialized metabolic functions; produces hydrogen peroxide as a by-product, then converts it to water
Mitochondrion: organelle where cellular respiration occurs and most ATP is generated
Lysosome: digestive organelle where macromolecules are hydrolyzed
Nuclear envelope: double membrane enclosing the nucleus; perforated by pores; continuous with ER
Nucleolus: structure involved in production of ribosomes; a nucleus has one or more nucleoli
Chromatin: material consisting of DNA and proteins; visible as individual chromosomes in a dividing cell
NUCLEUS
Plasma membrane: membrane enclosing the cell
Ribosomes: complexes (small brown dots) that make proteins; free in cytosol or bound to rough ER or nuclear envelope
Golgi apparatus: organelle active in synthesis, modification, sorting, and secretion of cell products
In animal cells but not plant cells:
Lysosomes
Centrosomes, with centrioles
Flagella (but present in some plant sperm)

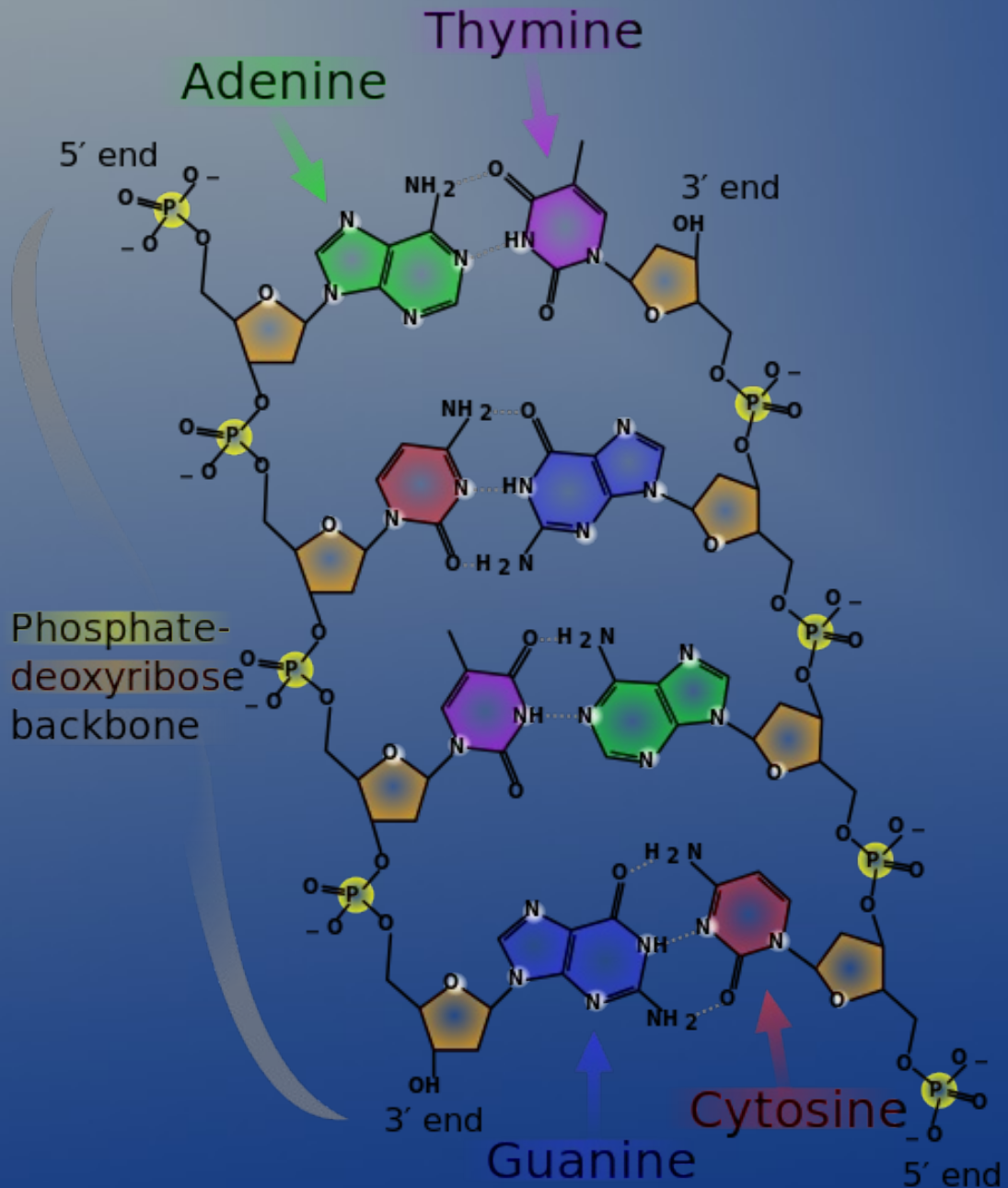
PLANT CELL

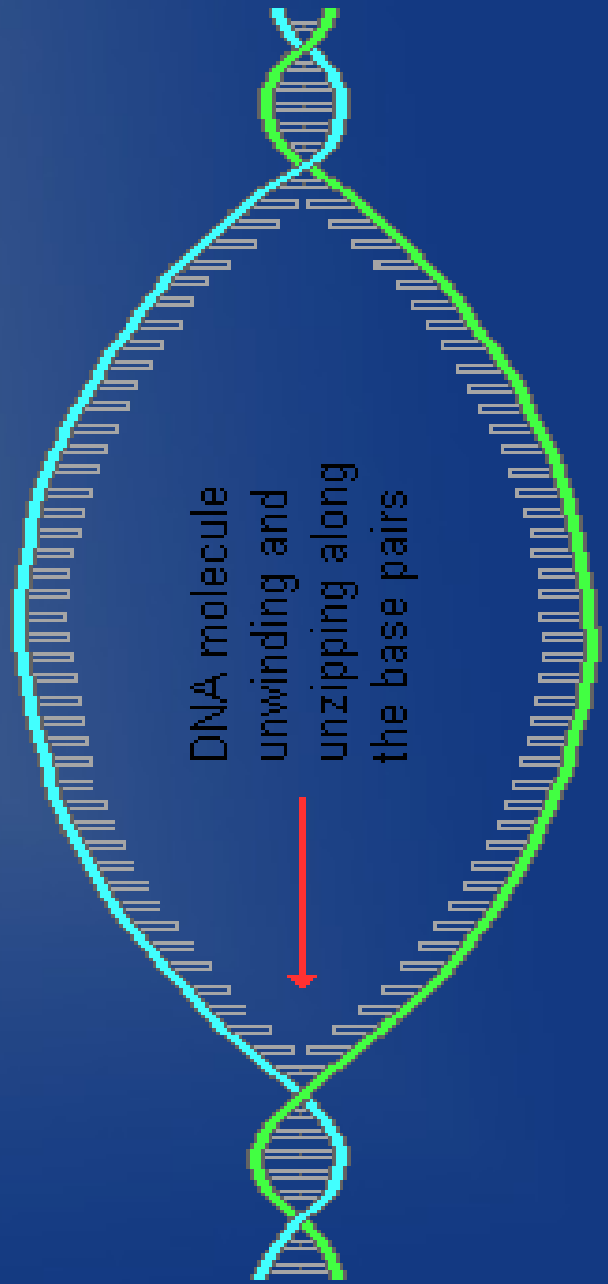
If you preview the rest of the chapter now, you'll see Figure 6.9 repeated in miniature as orientation diagrams. In each case, a particular organelle is highlighted, color-coded to its appearance in Figure 6.9. As we take a closer look at individual organelles, the orientation diagrams will help you place those structures in the context of the whole cell.

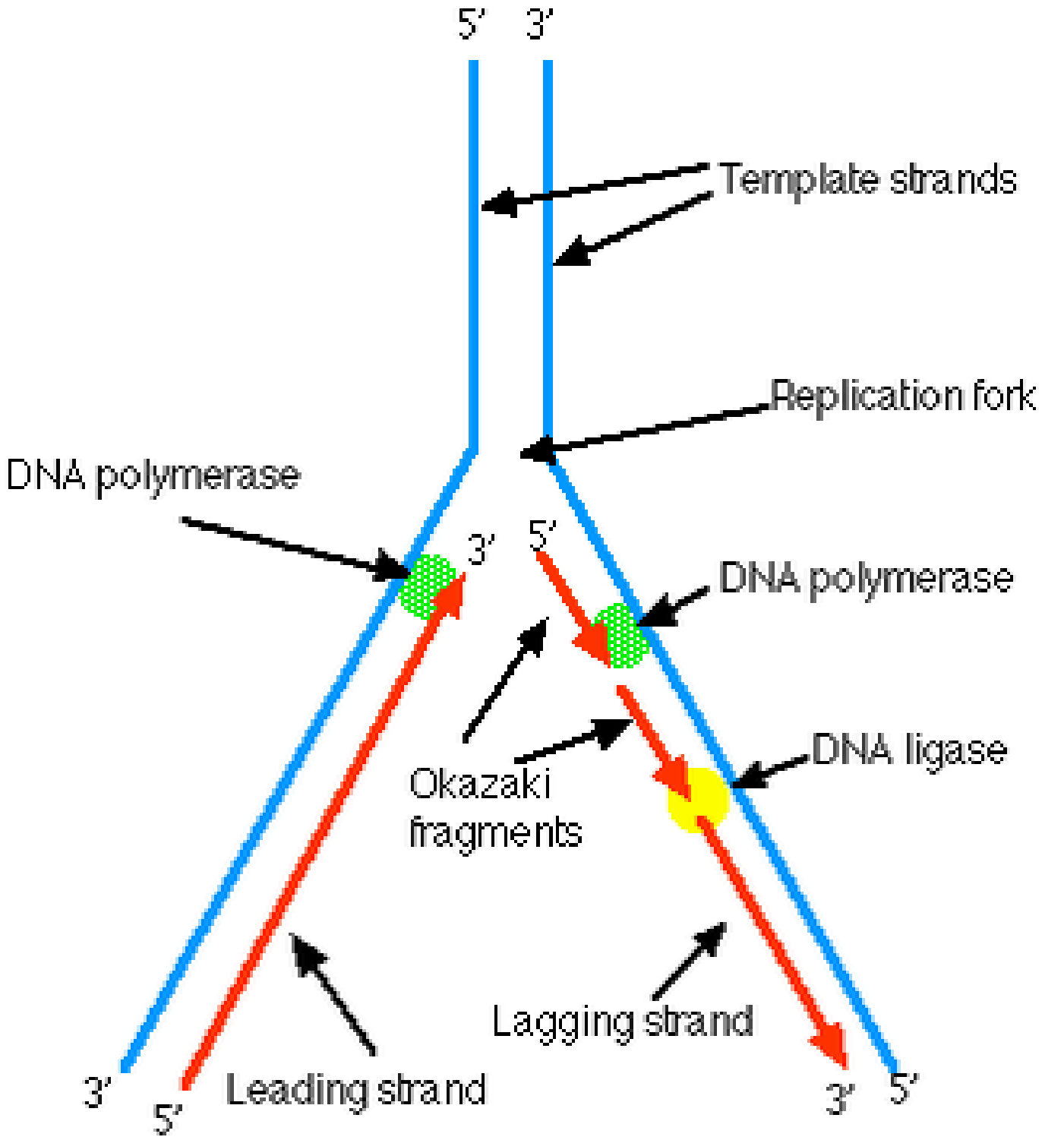


In plant cells but not animal cells:
Chloroplasts
Central vacuole
Cell wall
Plasmodesmata

Molecular Biology: Replication

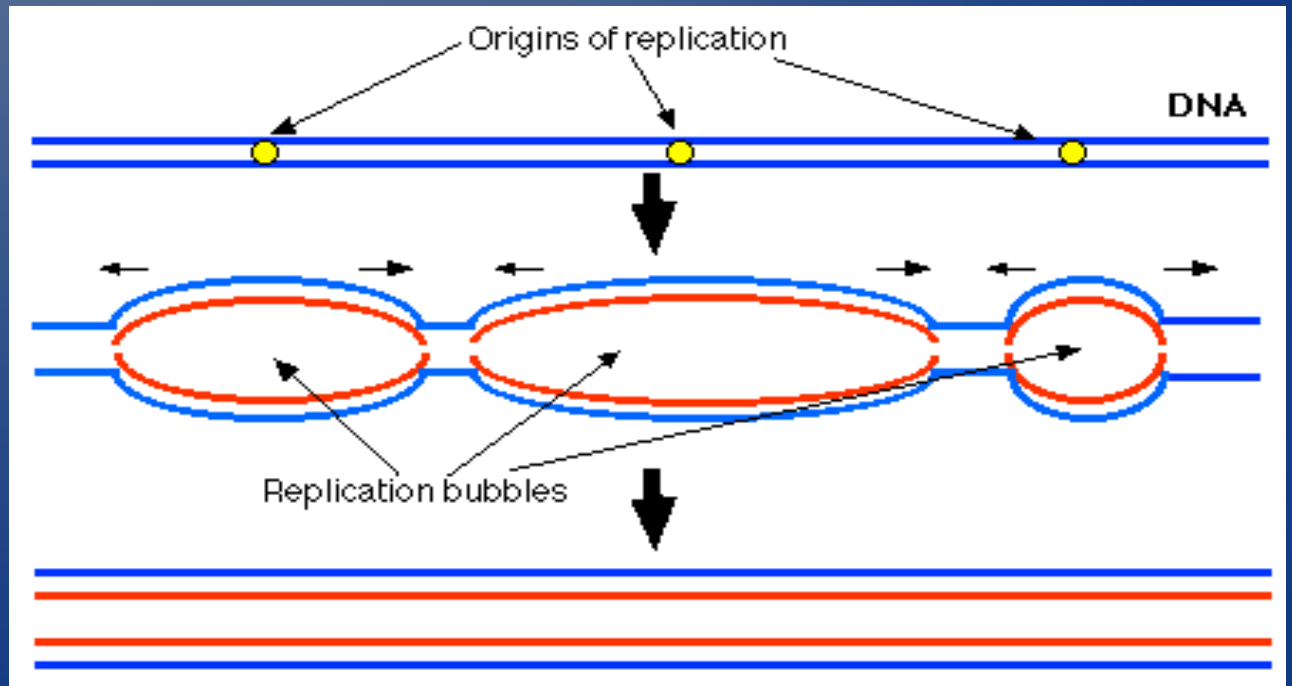




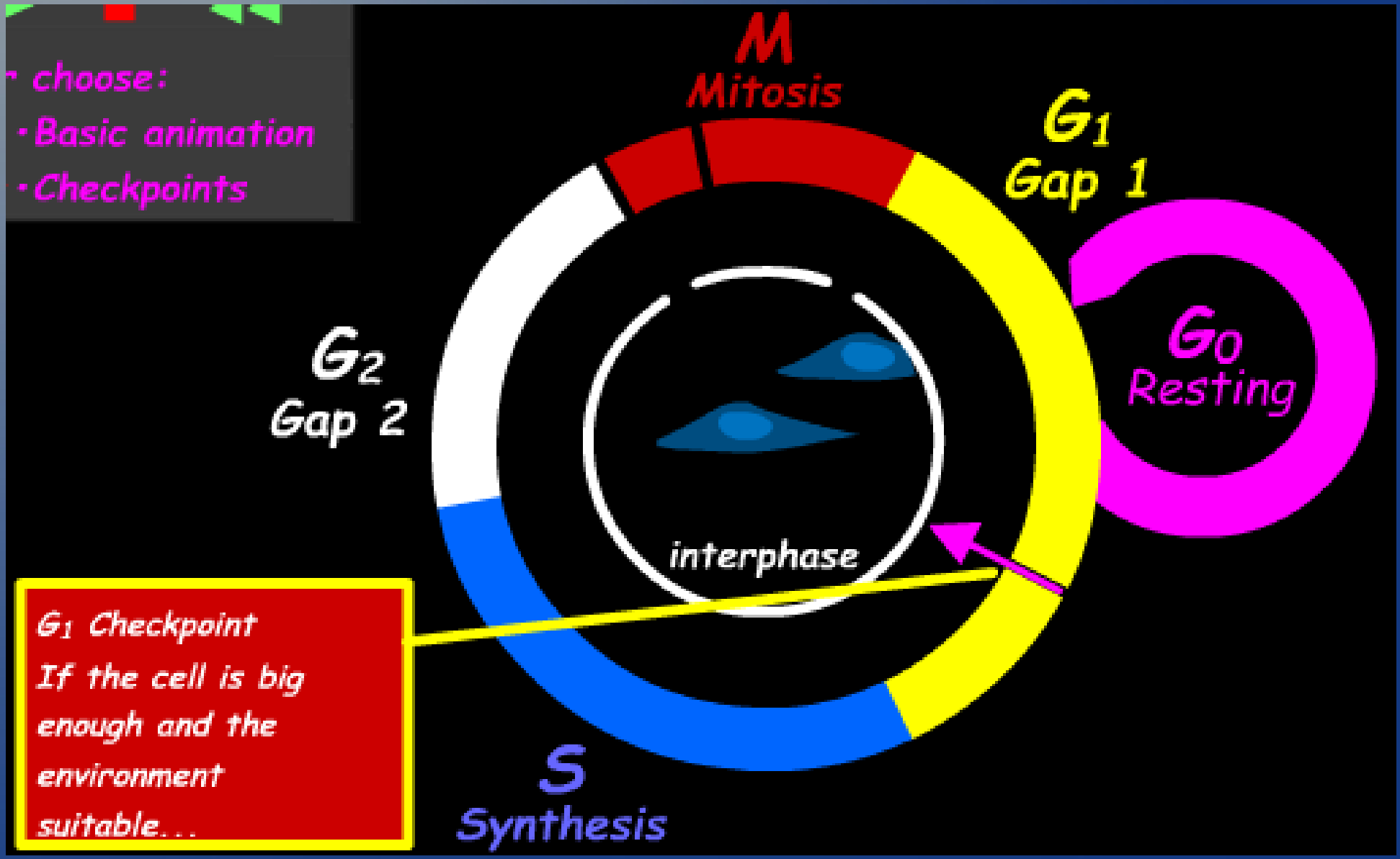

5′
3′
Template strands
Replication fork
DNA polymerase
3′
5′
DNA polymerase
Okazaki
fragments
DNA ligase
Lagging strand
Leading strand
3′
5′
3′
5′

Speed of Replication

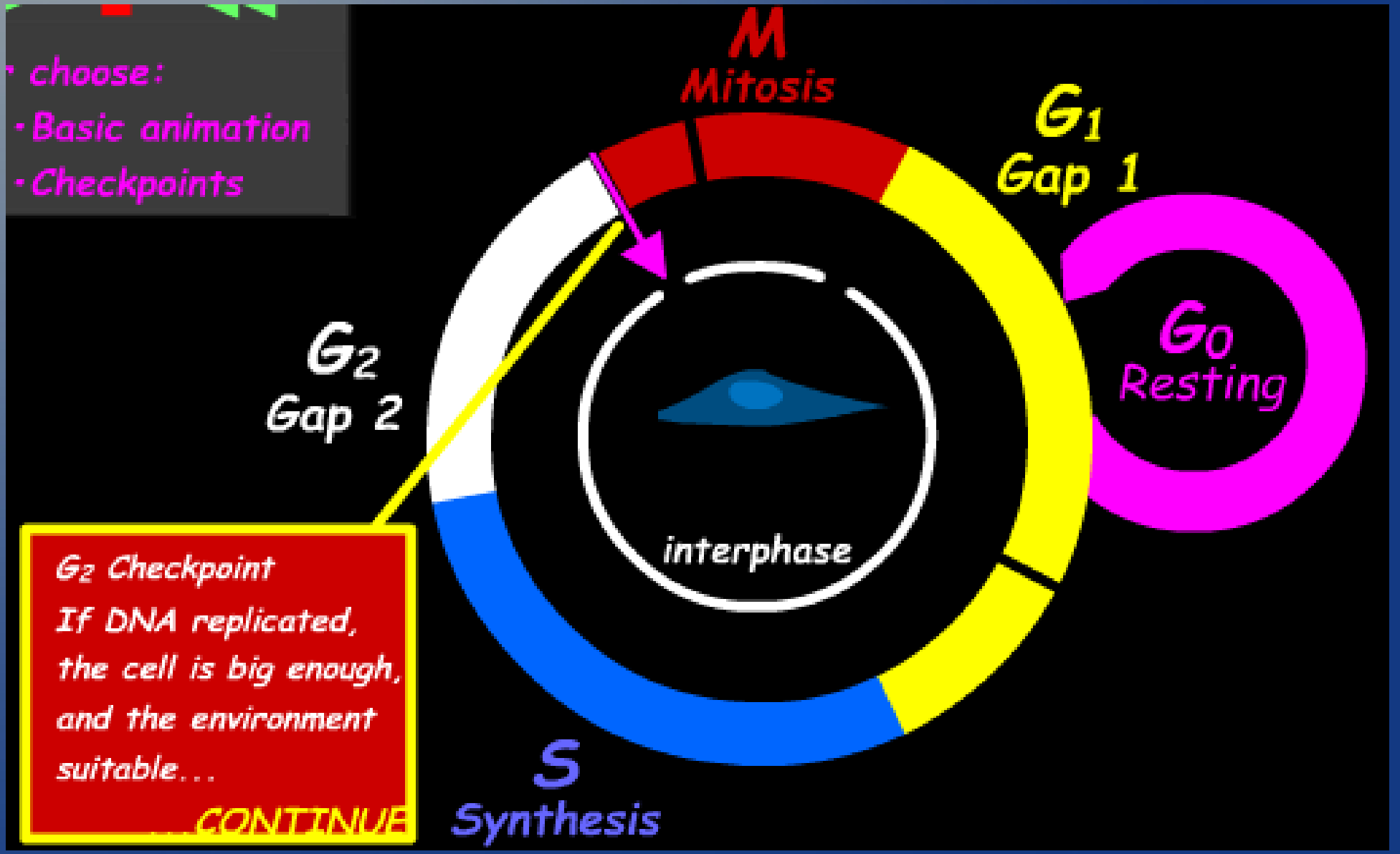
- E. coli. genome contains 4.7×10^6 nucleotide pairs. Replication proceeds at about 1000 nucleotides / second (40 minutes)
- The average human chromosome contains 150×10^6 nucelotide pairs which are copied at about 50 base pairs / second. The process would take a month.



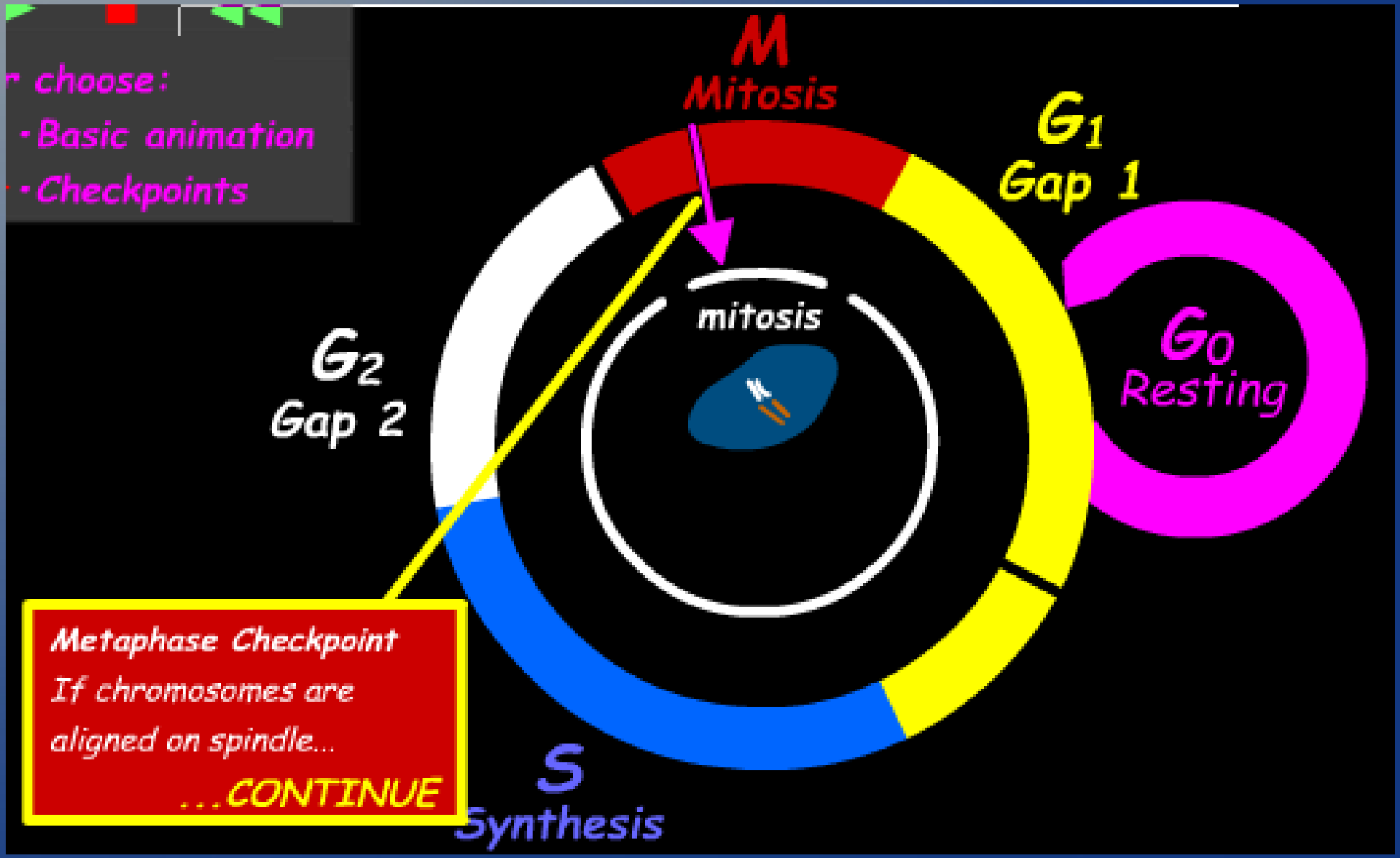
Cell Cycle


choose:
Basic animation
Checkpoints
M
Mitosis
G1
Gap 1
G0
Resting
G2
Gap 2
interphase
S
Synthesis
G1 Checkpoint
If the cell is big enough and the environment suitable...

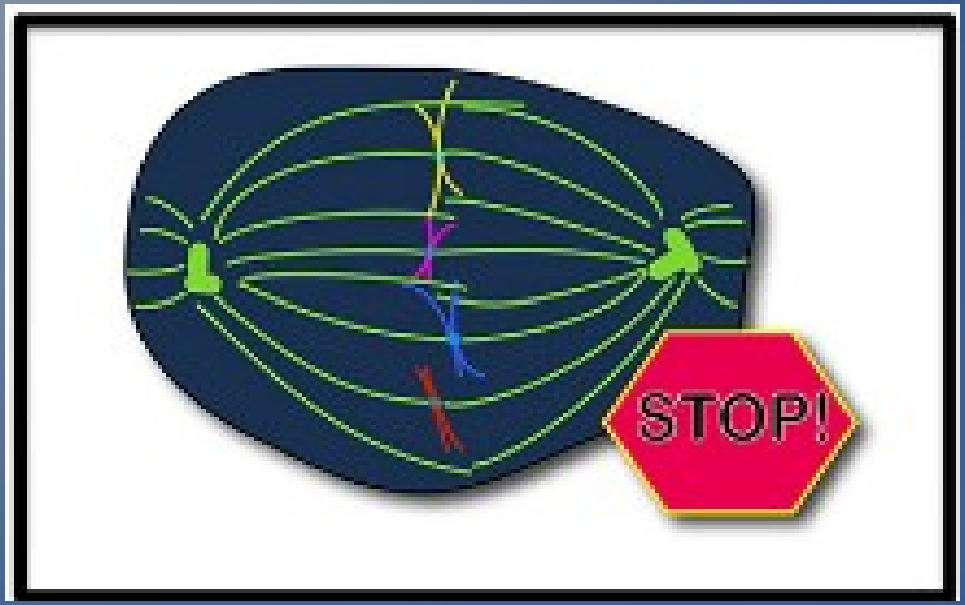
Cell Cycle


choose:
Basic animation
Checkpoints
M
Mitosis
G1
Gap 1
G0
Resting
G2
Gap 2
interphase
S
Synthesis
G2 Checkpoint
If DNA replicated,
the cell is big enough,
and the environment
suitable...
CONTINUE

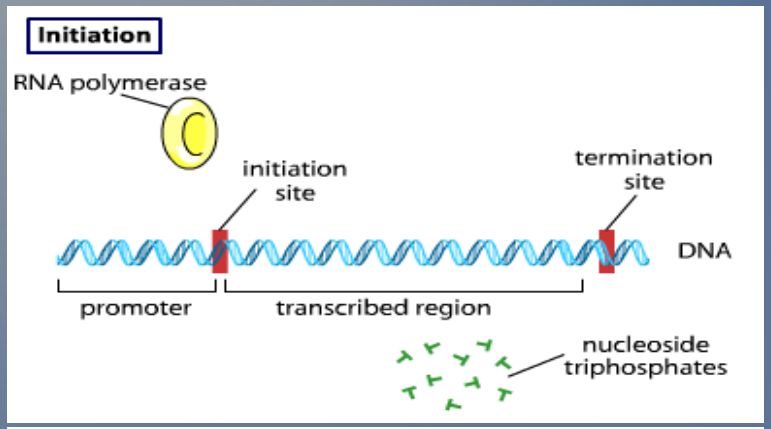
Cell Cycle

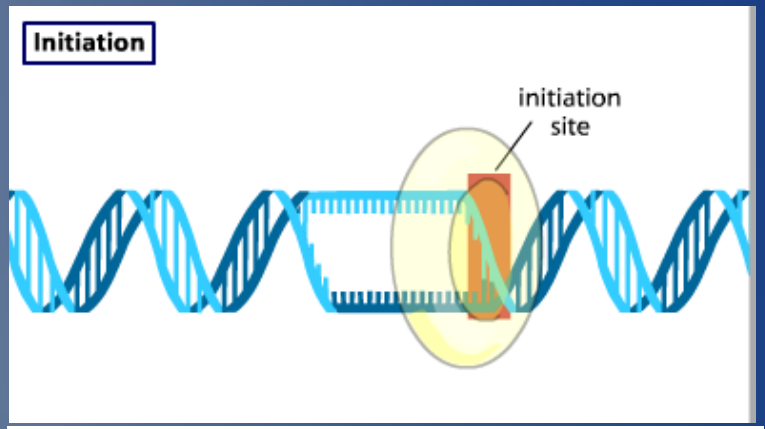

choose:
- Basic animation
- Checkpoints
M
Mitosis
G1
Gap 1
mitosis
G2
Gap 2
G0
Resting
Metaphase Checkpoint
If chromosomes are
aligned on spindle...
...CONTINUE
S
Synthesis

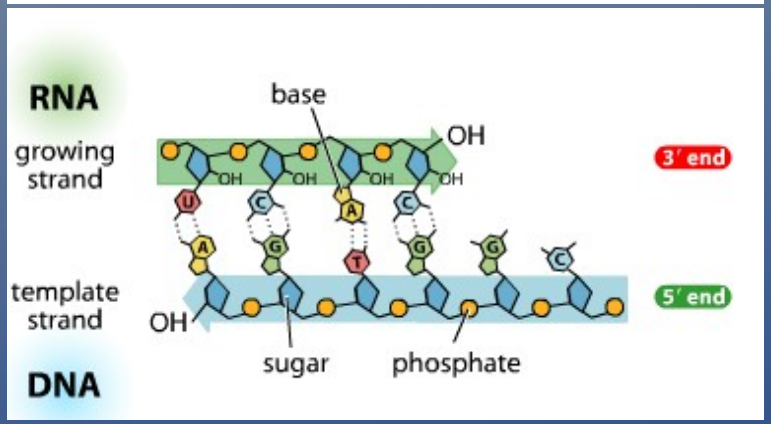
Cell Cycle

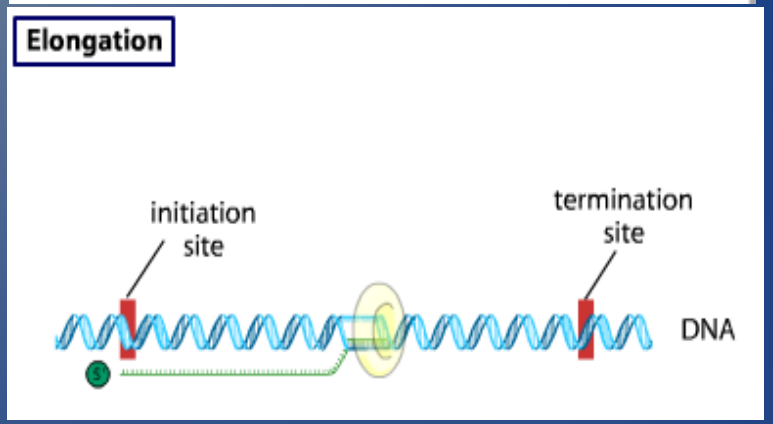


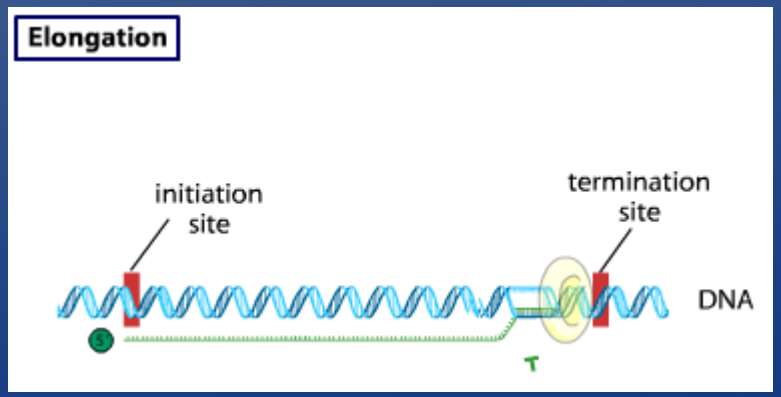
Transcription



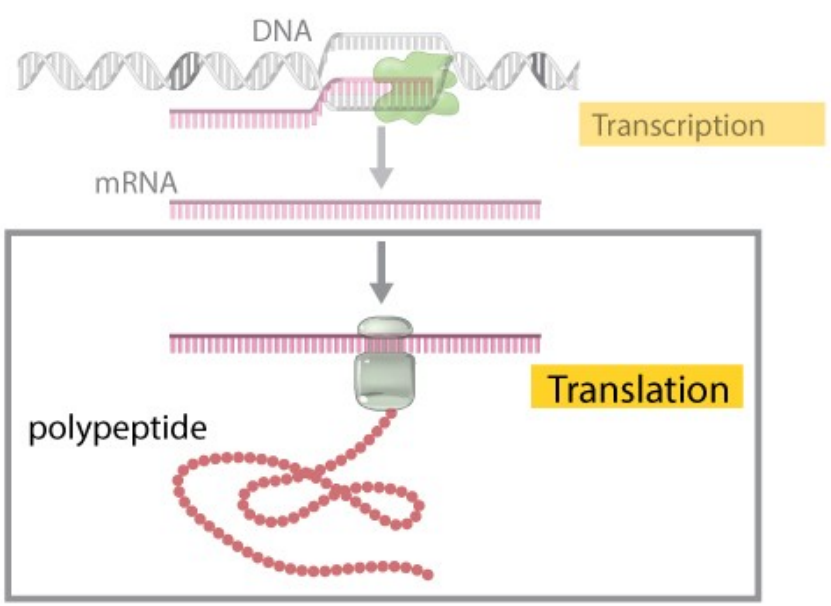


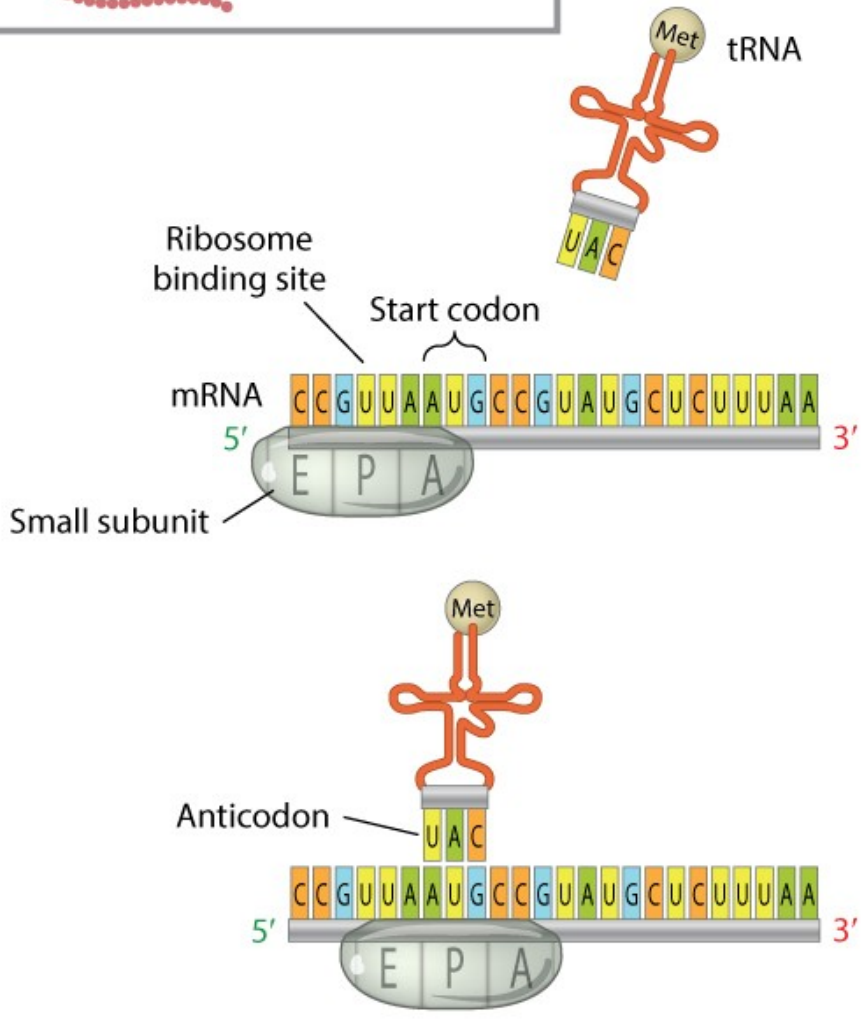


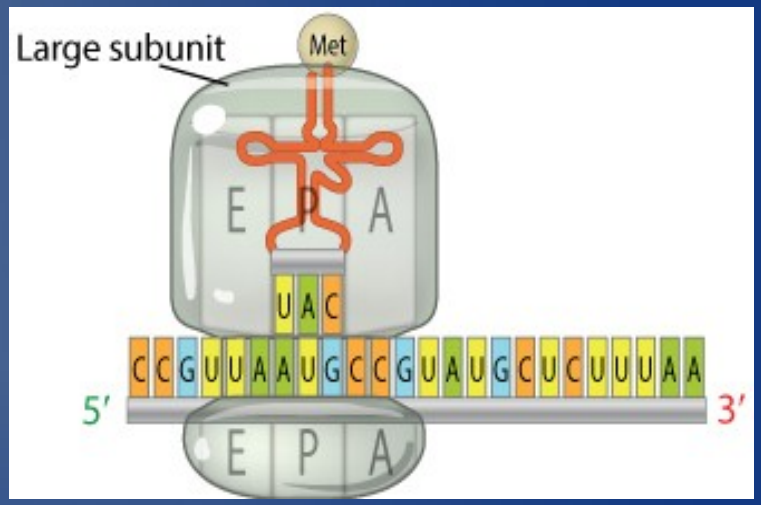




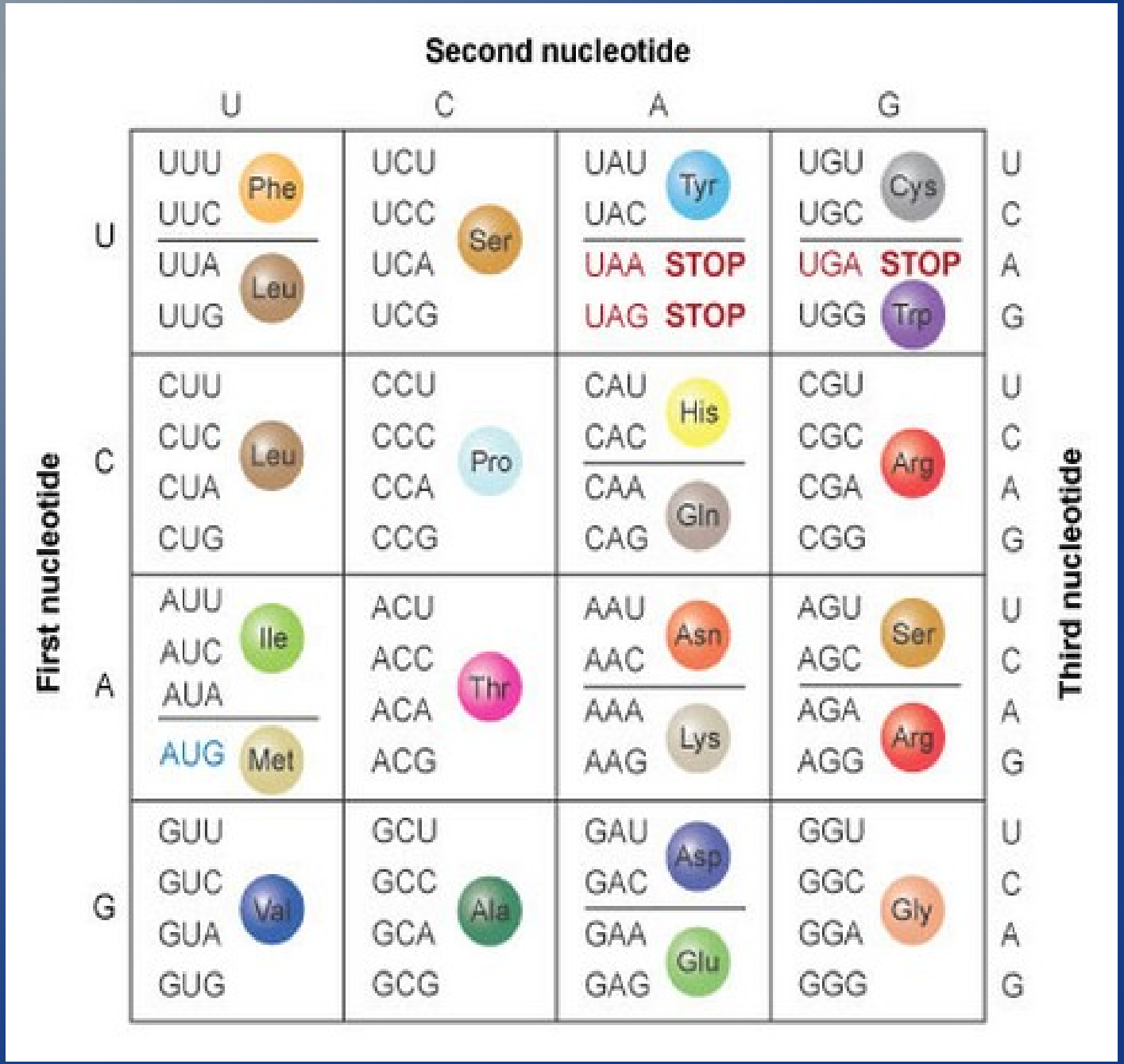
Translation





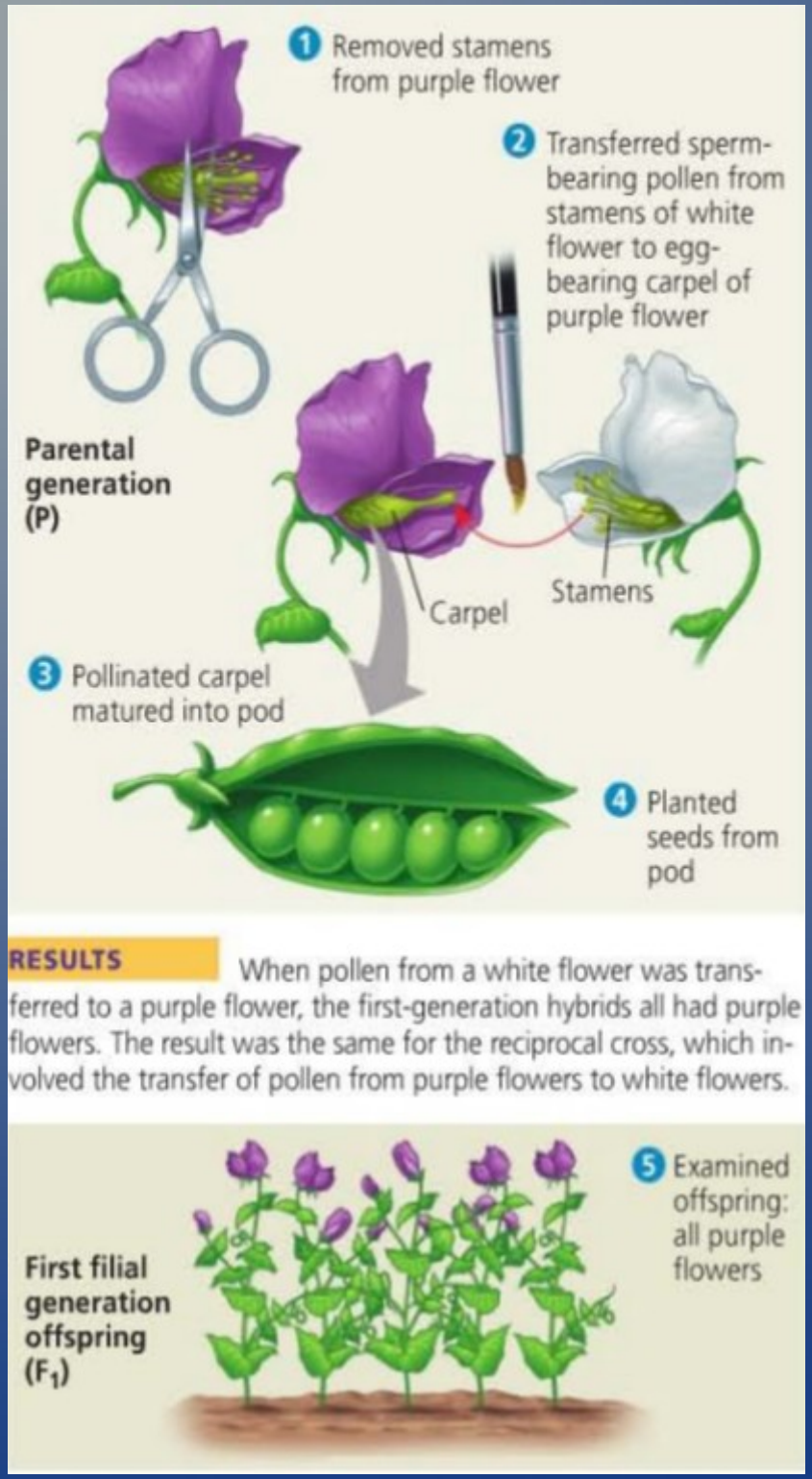


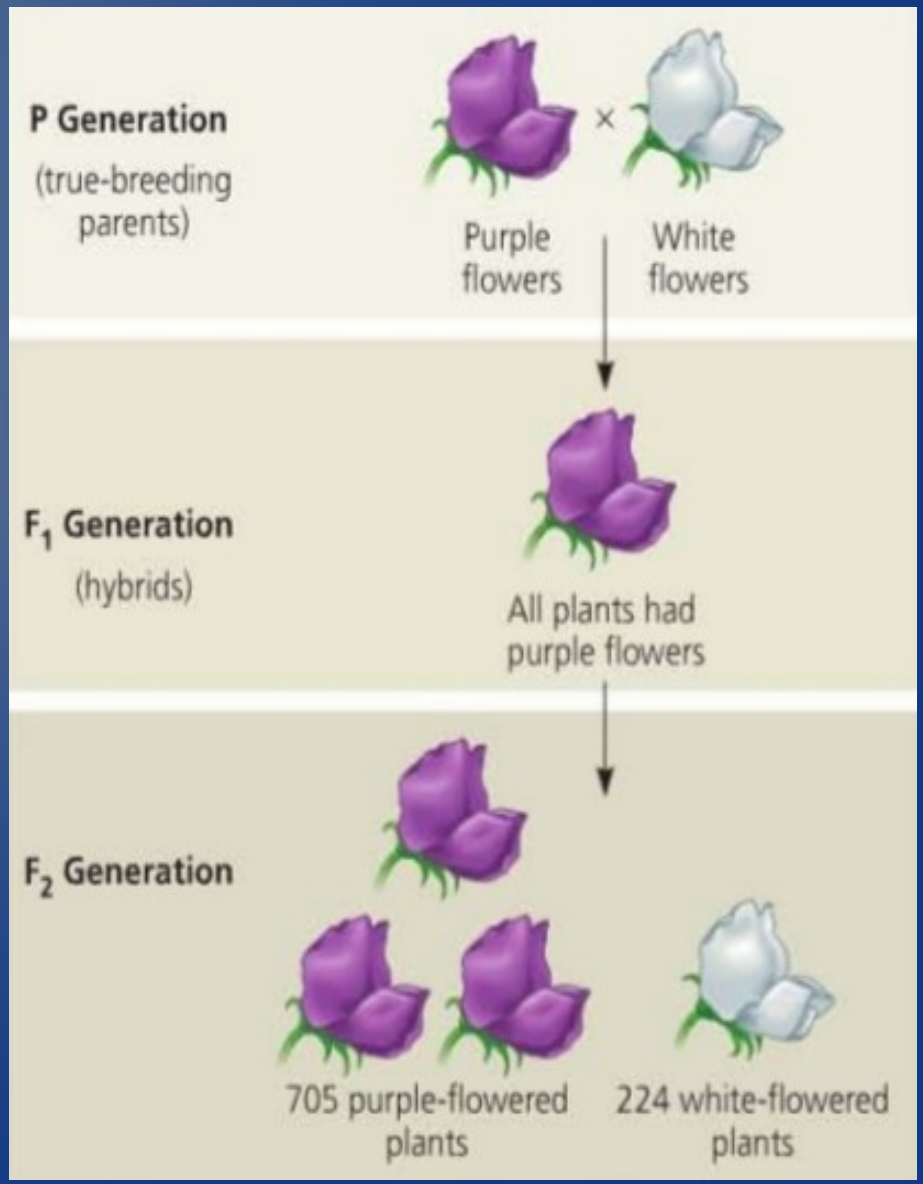
Genetic Code



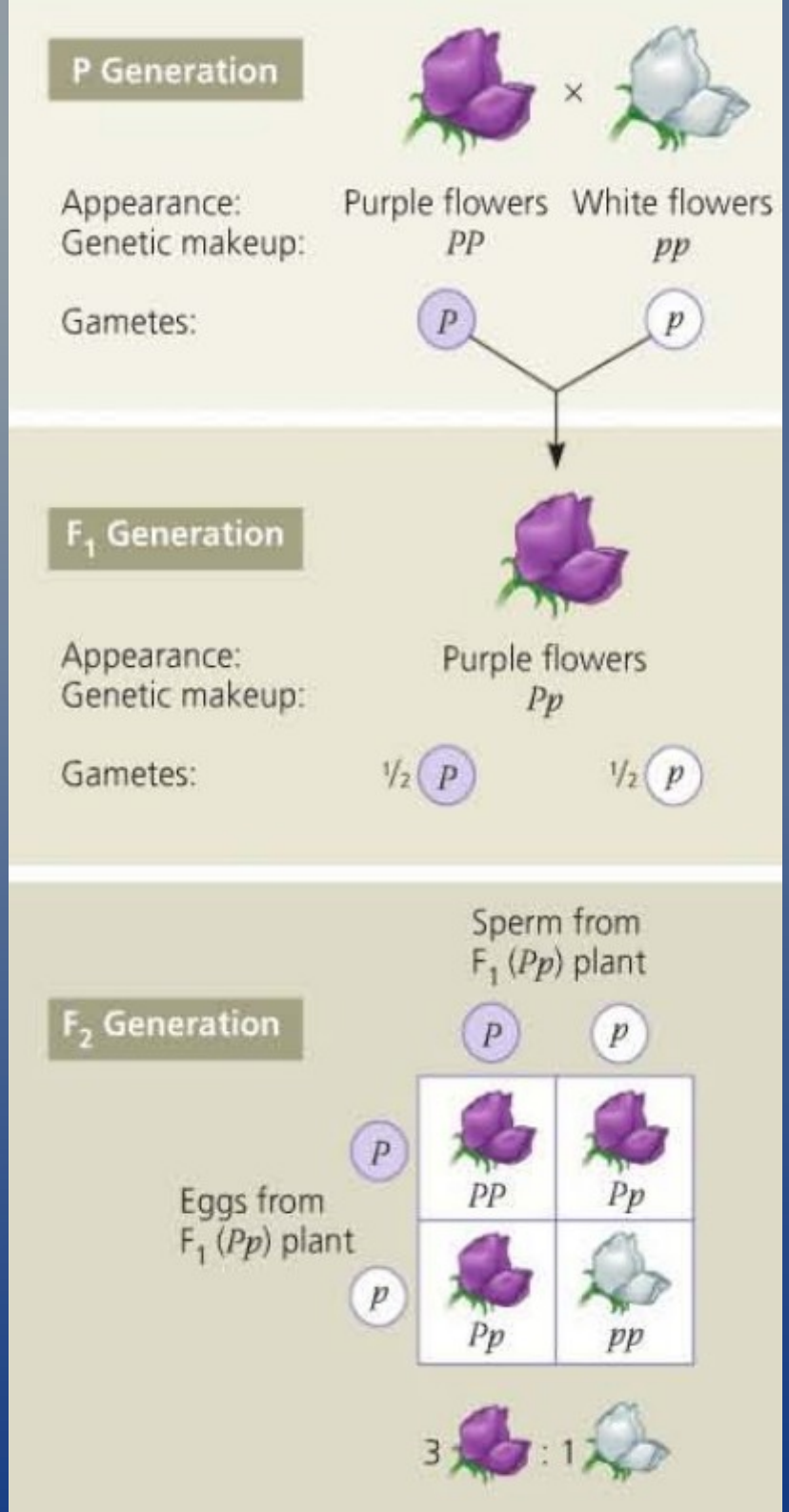
Genetics

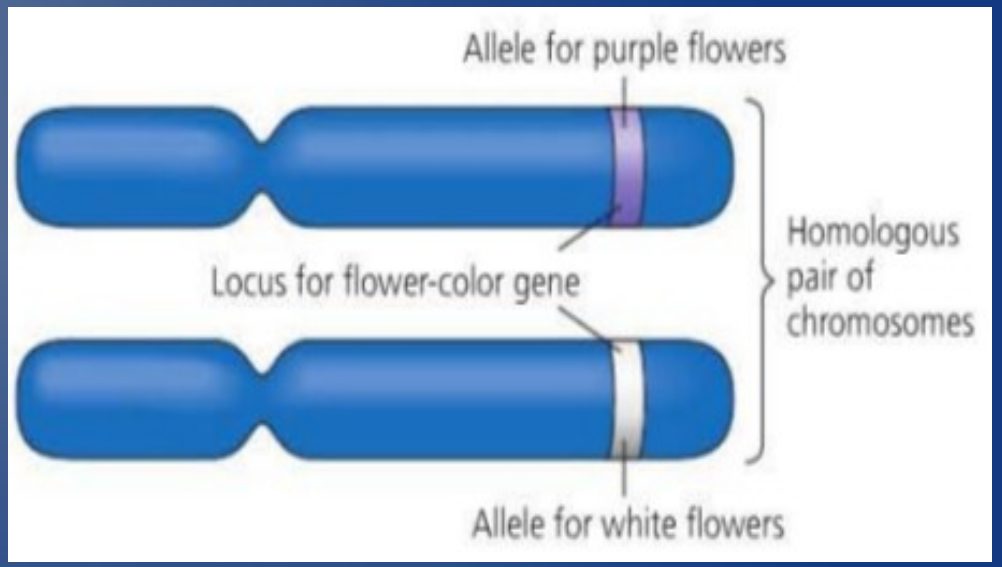
Mendel's Experimental, Quantiative approach



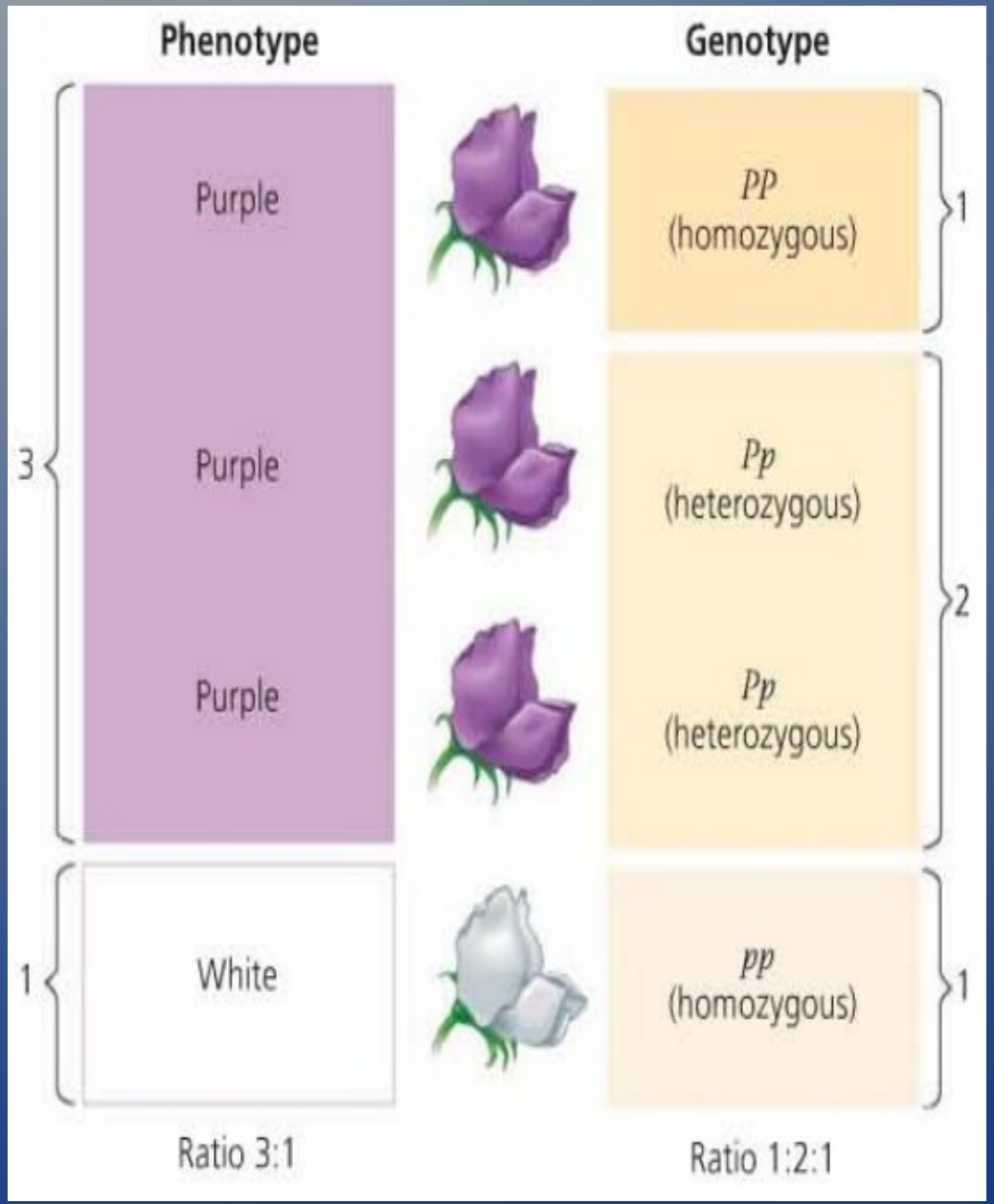


Law of Segregation

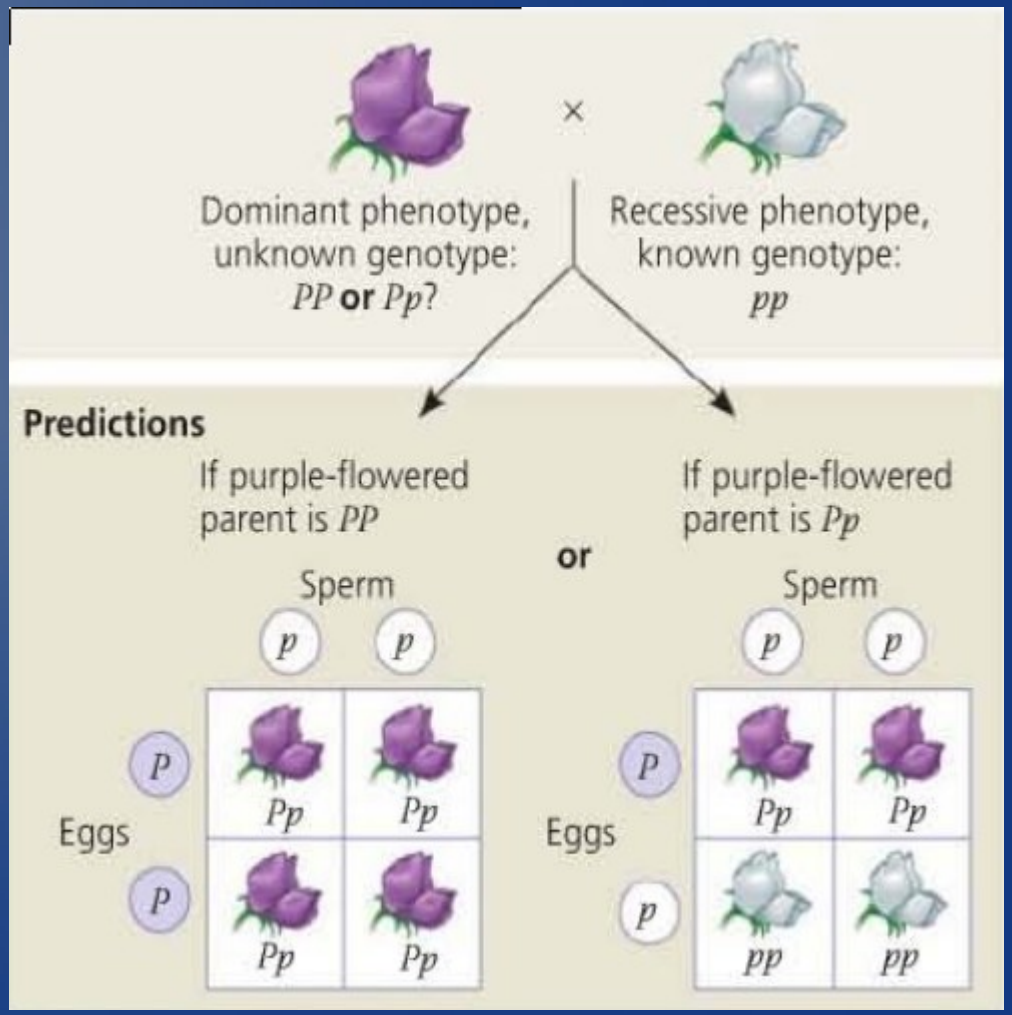




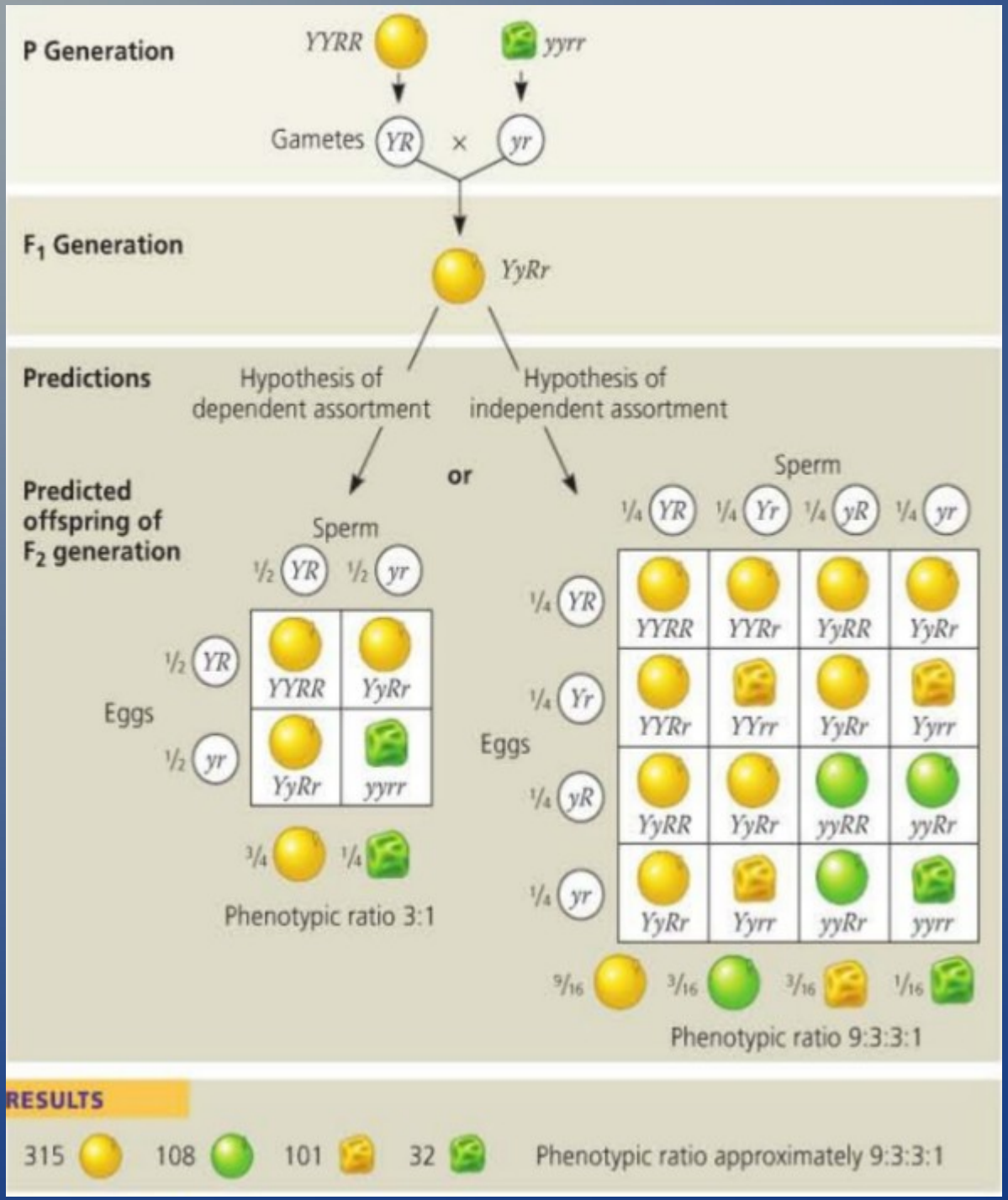
Genotype vs Phenotype

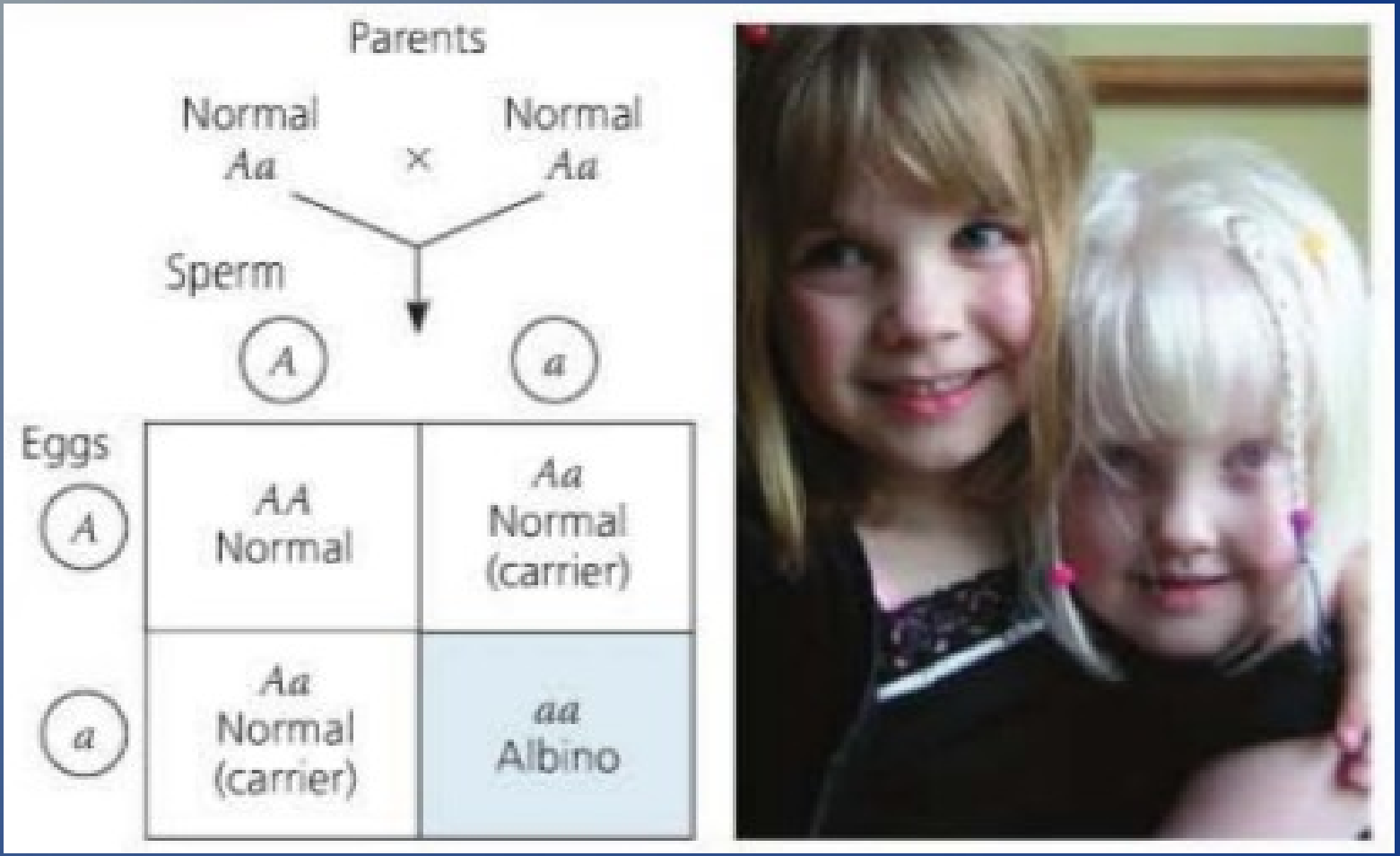


Testcross



Law of independent Assortment




Parents
Normal
Aa
×
Normal
Aa
Sperm
A
a
Eggs
A
a
AA
Normal
Aa
Normal
(carrier)
Aa
Normal
(carrier)
aa
Albino

Thank You