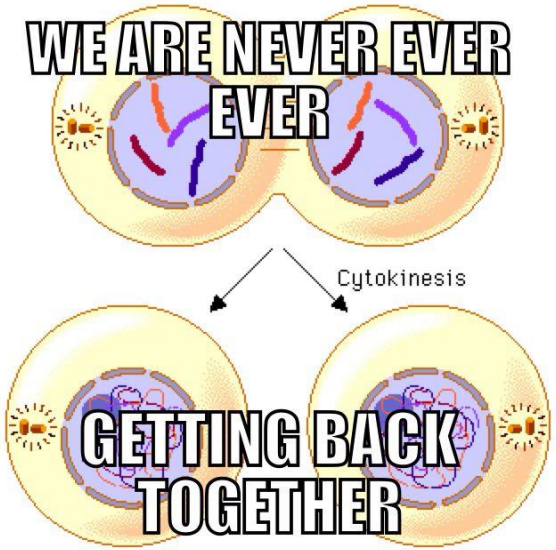
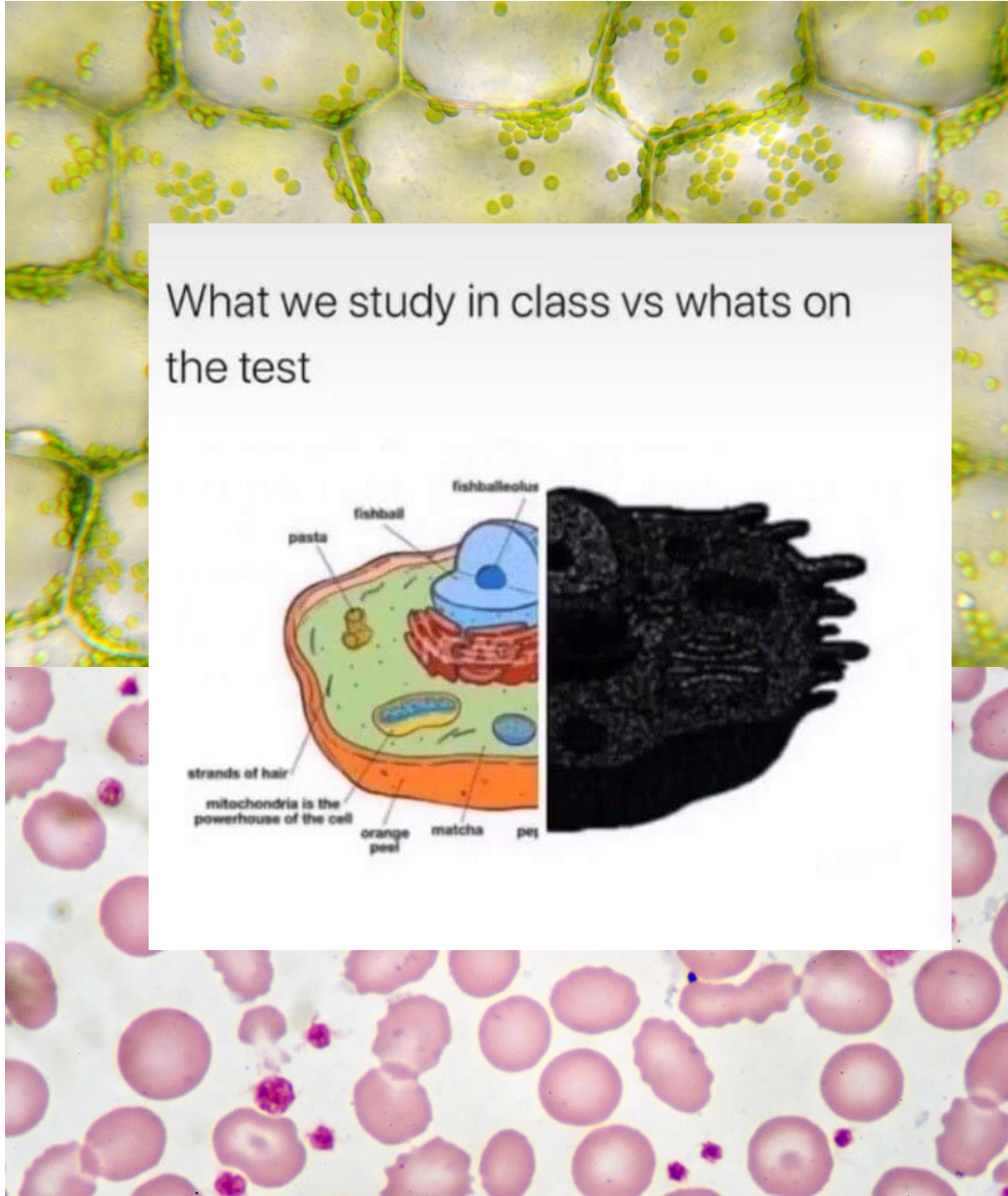
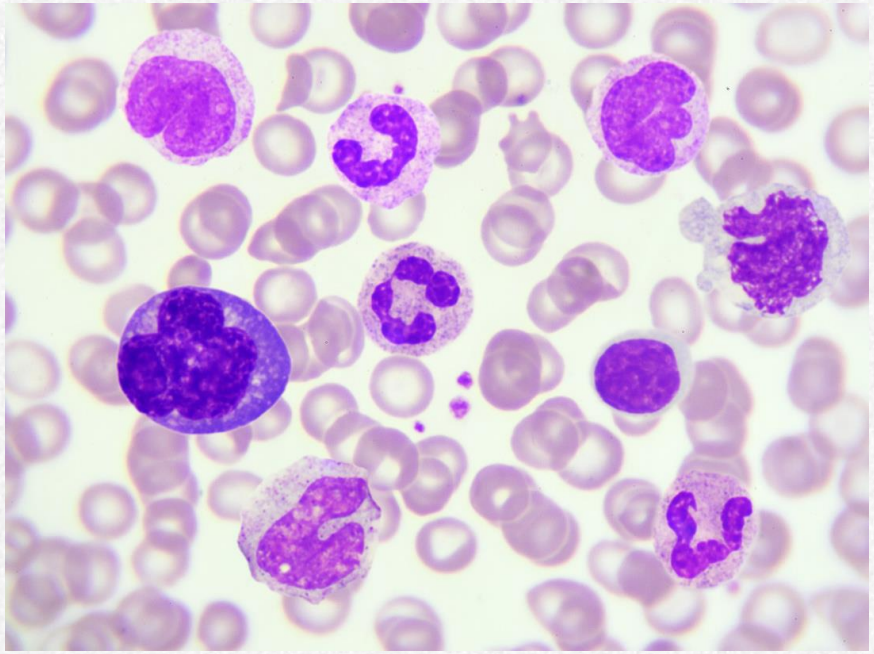
Chapter 3 and 4: Cell Structure and Function

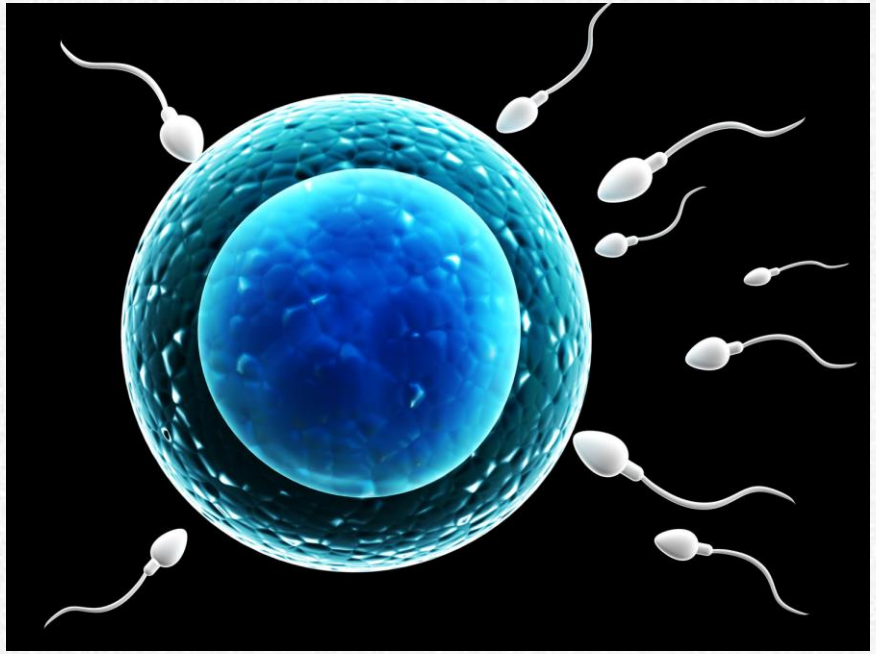




Introduction to Cell Structure

Cells are the fundamental units of life, serving as the **building blocks** for all living organisms. They perform vital functions, including **energy production, metabolism, and reproduction, ensuring the survival and proper functioning of biological systems.**



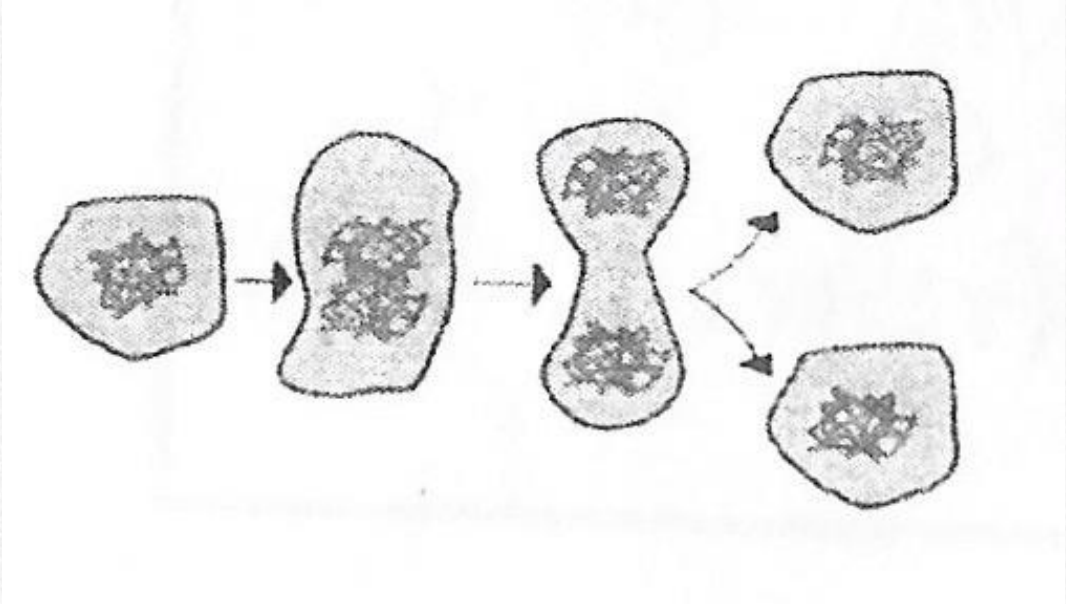


Cell Theory

All organisms are composed of **1 or more cells**

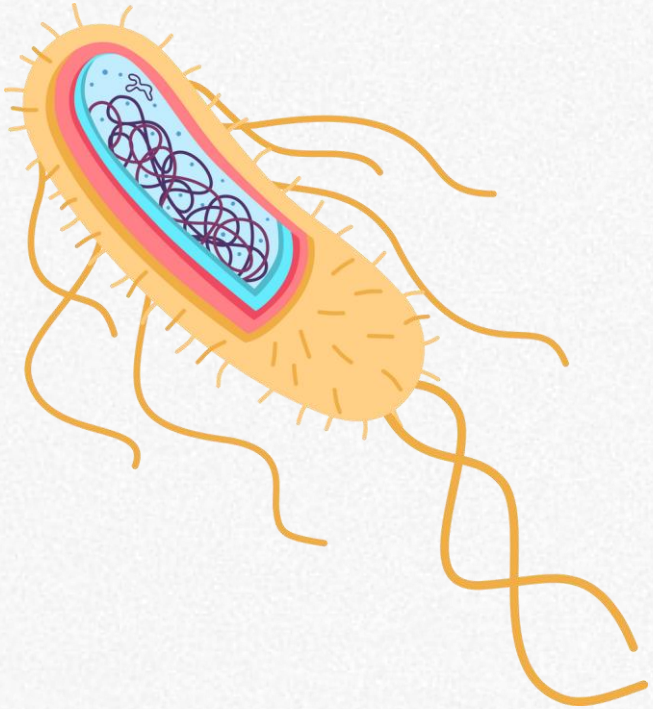
Cells are the **basic living unit** of structure and function in organisms

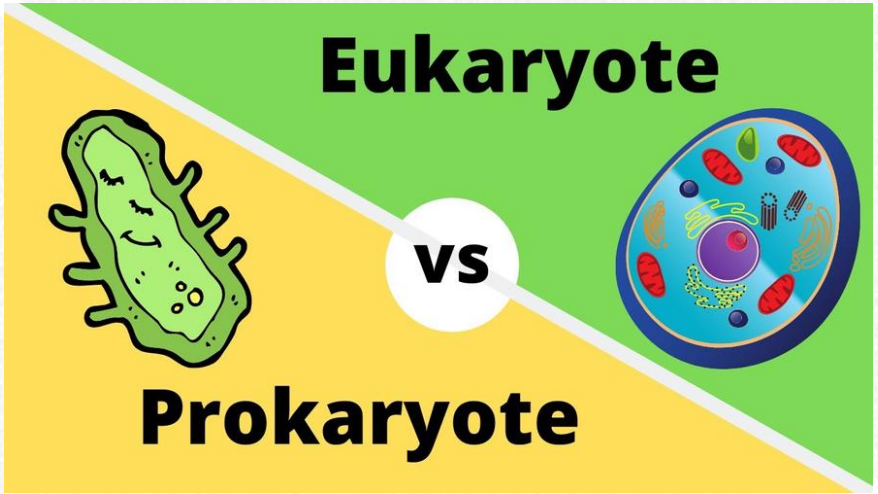
All cells **come from other cells**



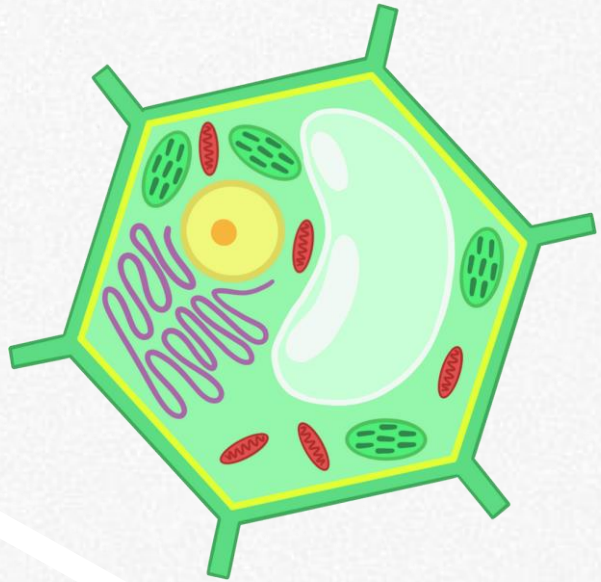
Complex; multicellular

Ex. Bacteria





Ex. Plant Cell



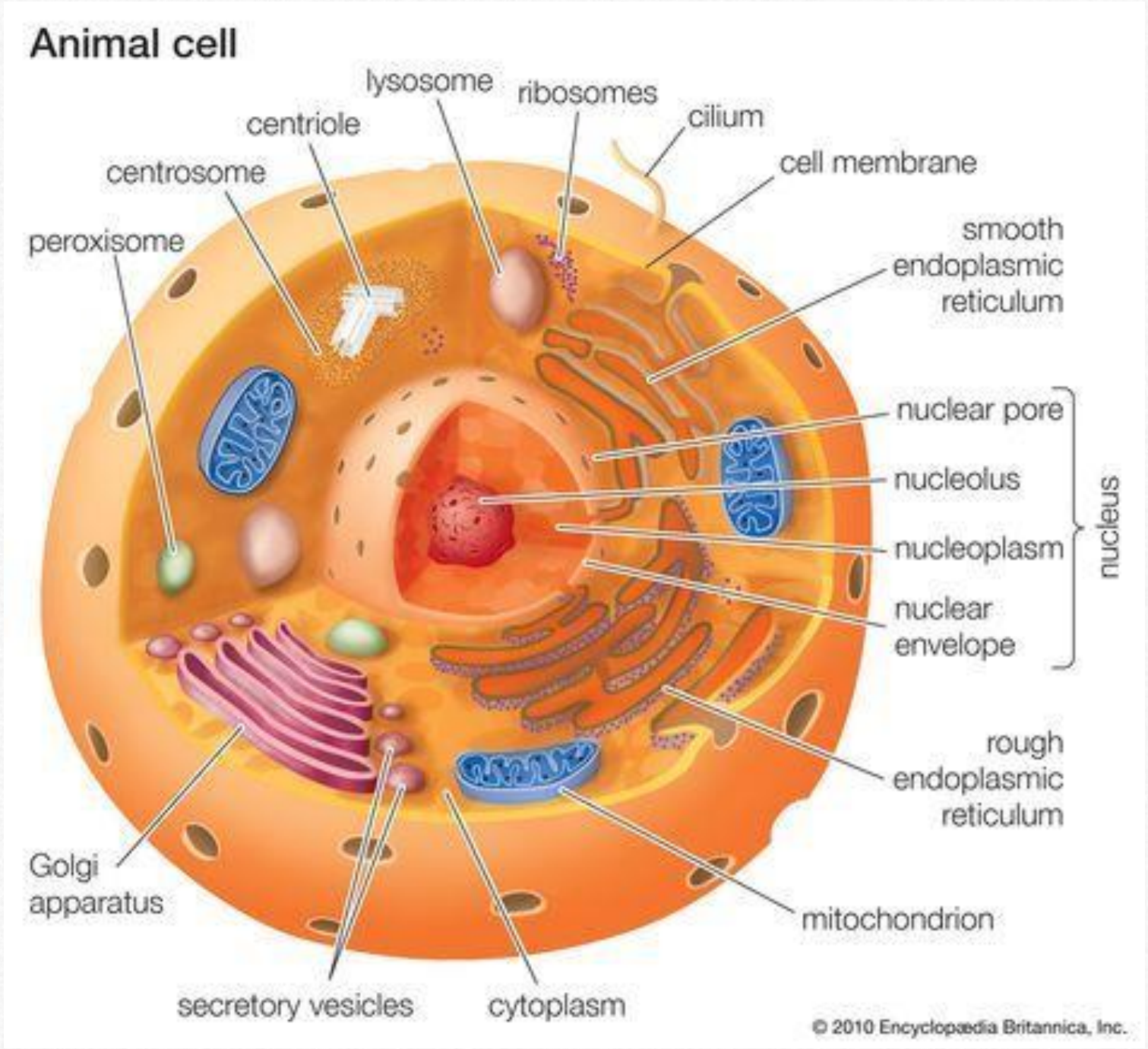
Simple; single-celled

Eukaryotic Cells

- Have a **nucleus**
- Could be a **plant or animal cell, fungi or protists**

Specific to Plant and Animal Cells:

- Cells surrounded by a **plasma membrane**
- Contain various **organelles** with their own specific jobs in the cell


Animal cell
lysosome
ribosomes
cilium
centriole
cell membrane
centrosome
peroxisome
smooth endoplasmic reticulum
nuclear pore
nucleolus
nucleoplasm
nuclear envelope
nucleus
rough endoplasmic reticulum
Golgi apparatus
mitochondrion
secretory vesicles
cytoplasm
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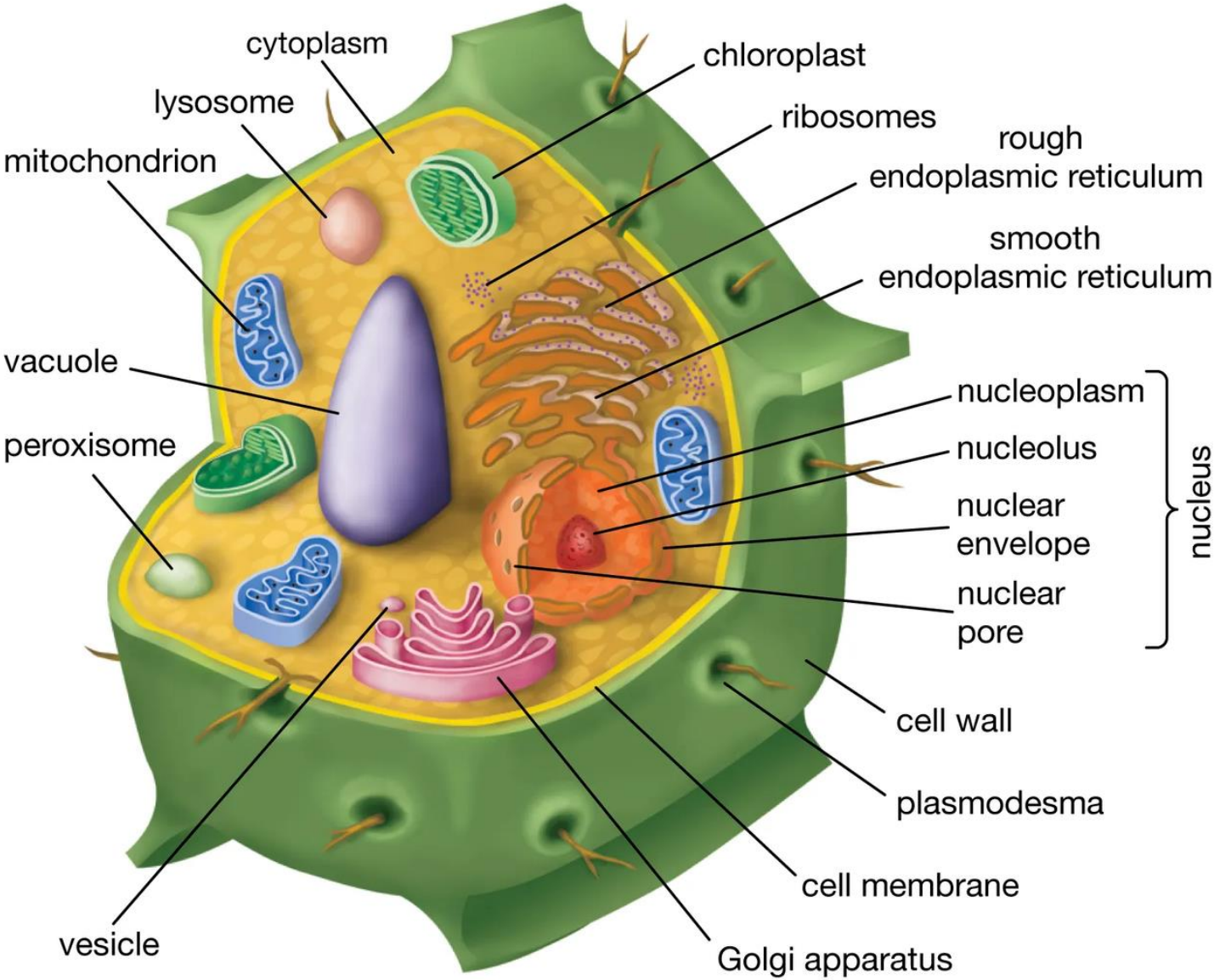
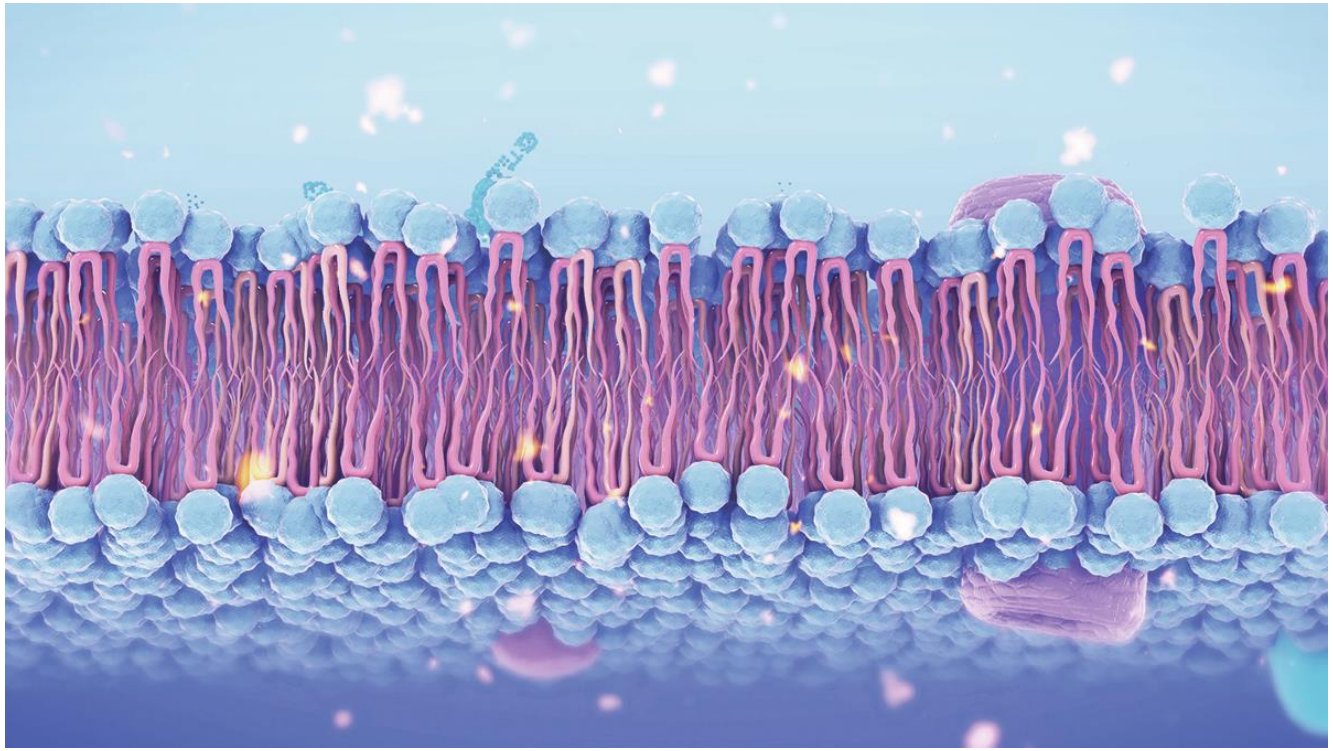
Plant cell



The Plasma Membrane

The plasma membrane is **differentially (selectively) permeable**. Some substances can freely move across the membrane, and some cannot. There are two methods of transport across the membrane.



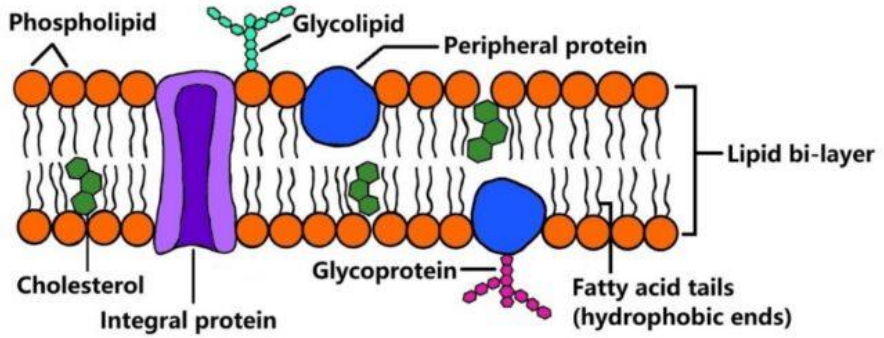
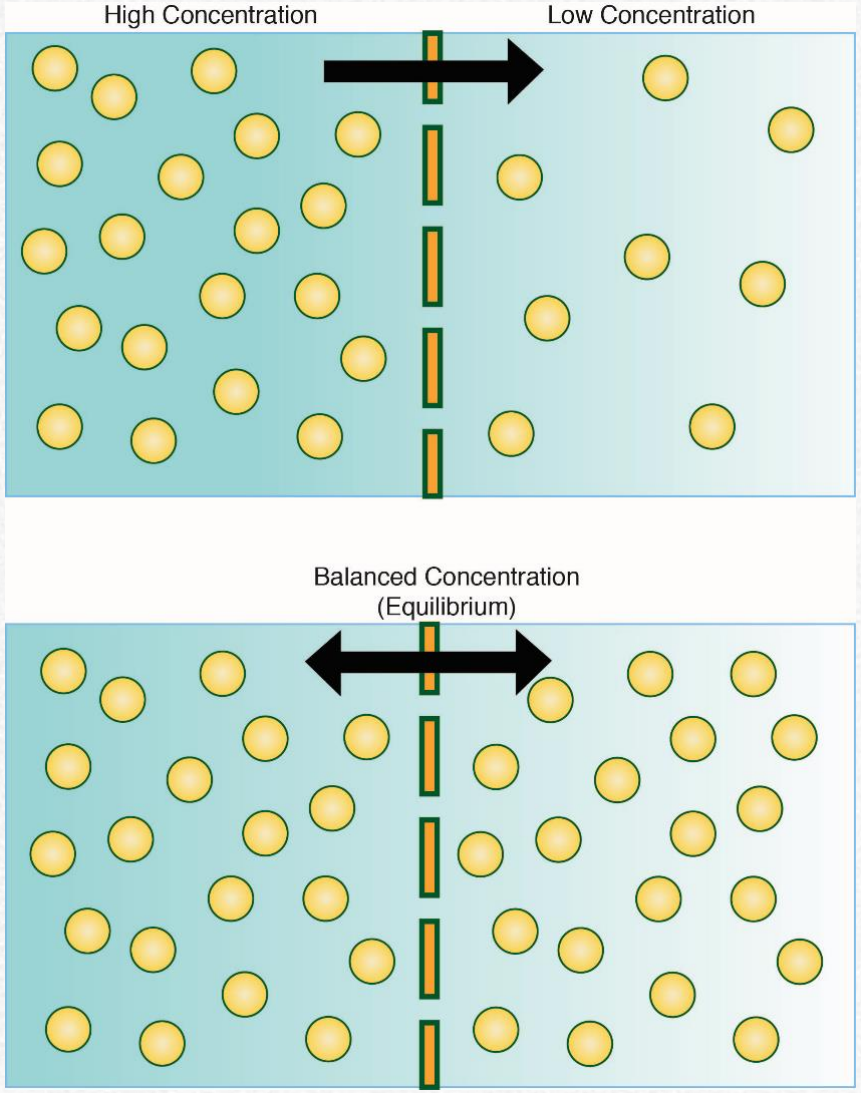


Fig: Components of cell membrane

1. Passive Transport

Passive Transport: Transport across a membrane that does not require carrier proteins/chemical energy. Movement occurs via diffusion, osmosis or facilitated transport.

Examples: Water, gaseous organic molecules



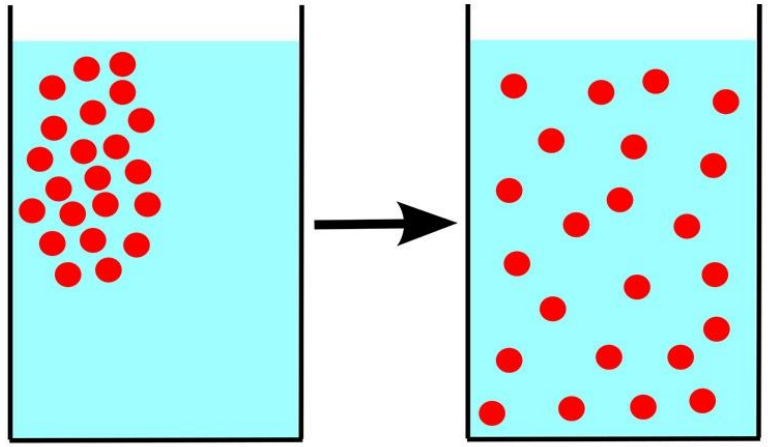
Diffusion vs. Osmosis

BOTH are Passive transport of molecules across a membrane

Diffusion

Movement of molecules from high concentration to low concentration

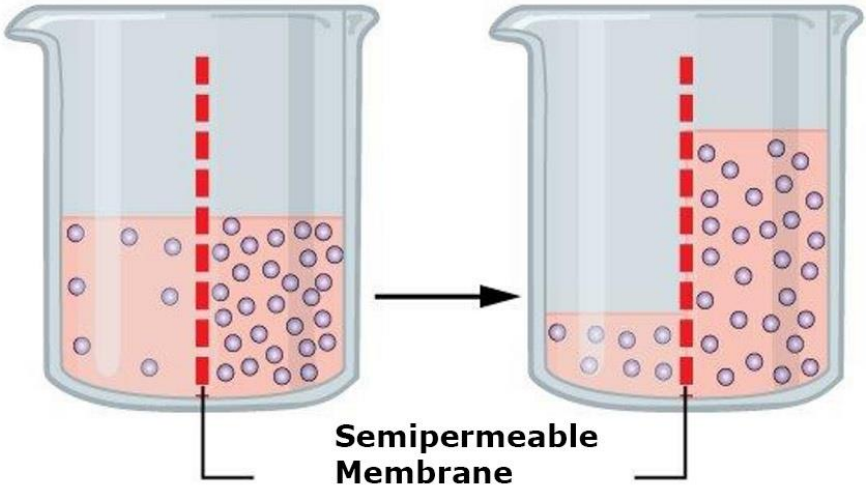
Both solute and solvent move



Osmosis

Movement of solvent (water) across a semipermeable membrane from high to low solvent concentration

Only solvent moves



Diffusion vs. Osmosis

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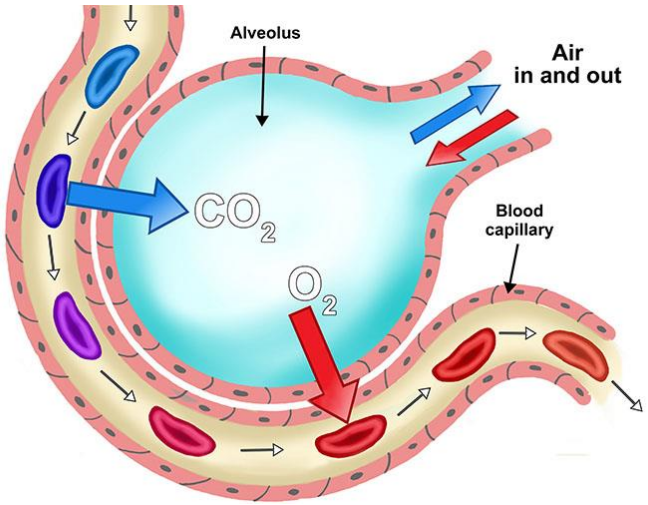
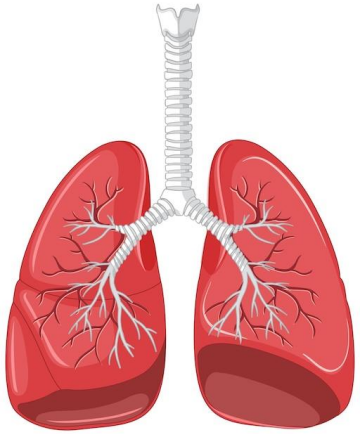
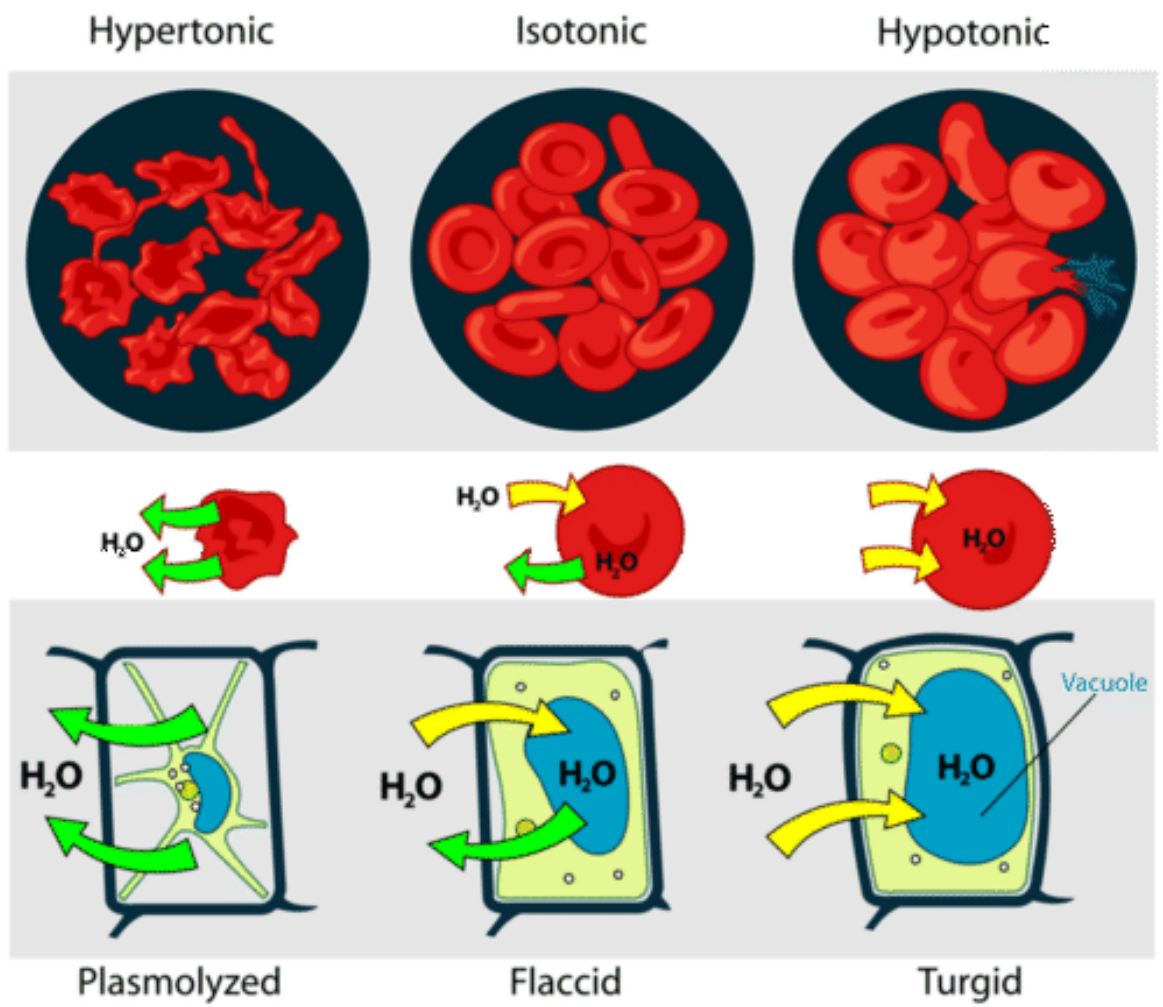


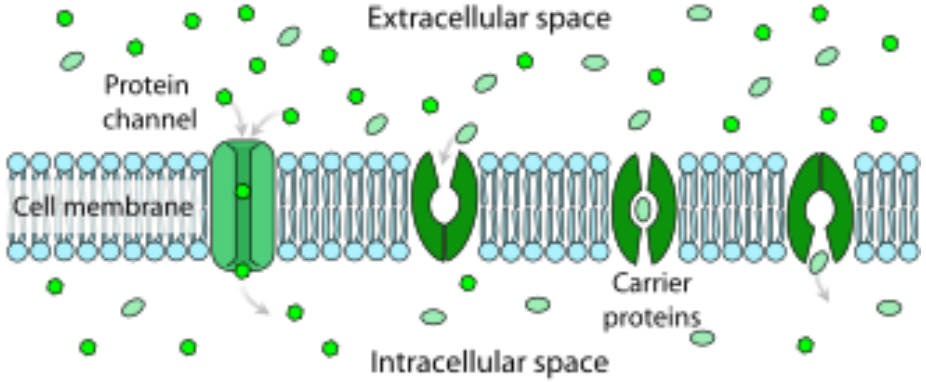


Oxygen (O_2) diffuses into the capillaries of the lungs because there **is higher concentration of O_2 [O_2] in the alveoli (air sacs) than in the capillaries**.

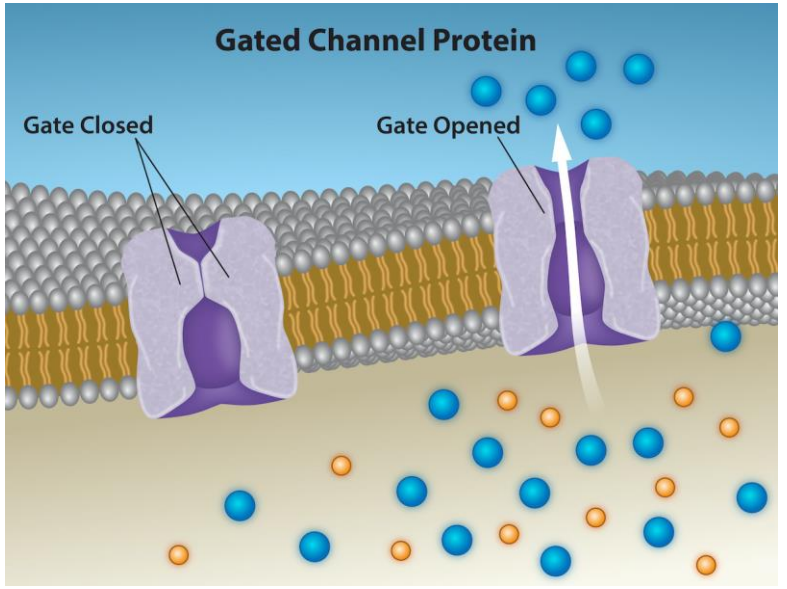


Facilitated Transport

Biologically useful molecules enter and exit the cell at a rapid rate **because of channel and carrier proteins in the membrane**.



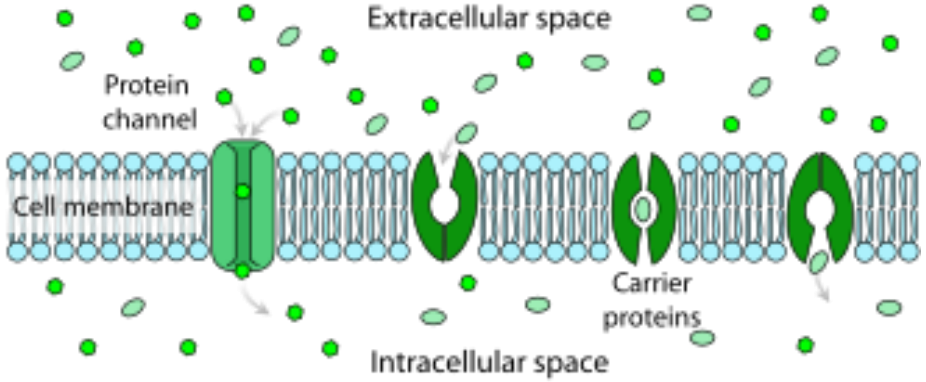
Carrier proteins: specific proteins that bind/pair to a specific molecule, which then allows that molecule to enter or exit the cell automatically

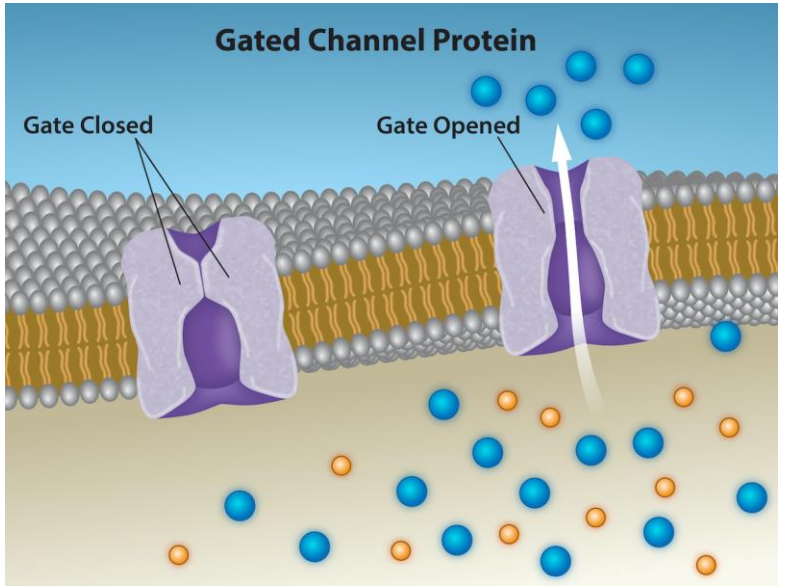


Carrier proteins can be used for several types of transport across a cell

Facilitated Transport

Facilitated Transport explains the passage of molecules like glucose and amino acids across the plasma membrane (even though they are not lipid soluble)

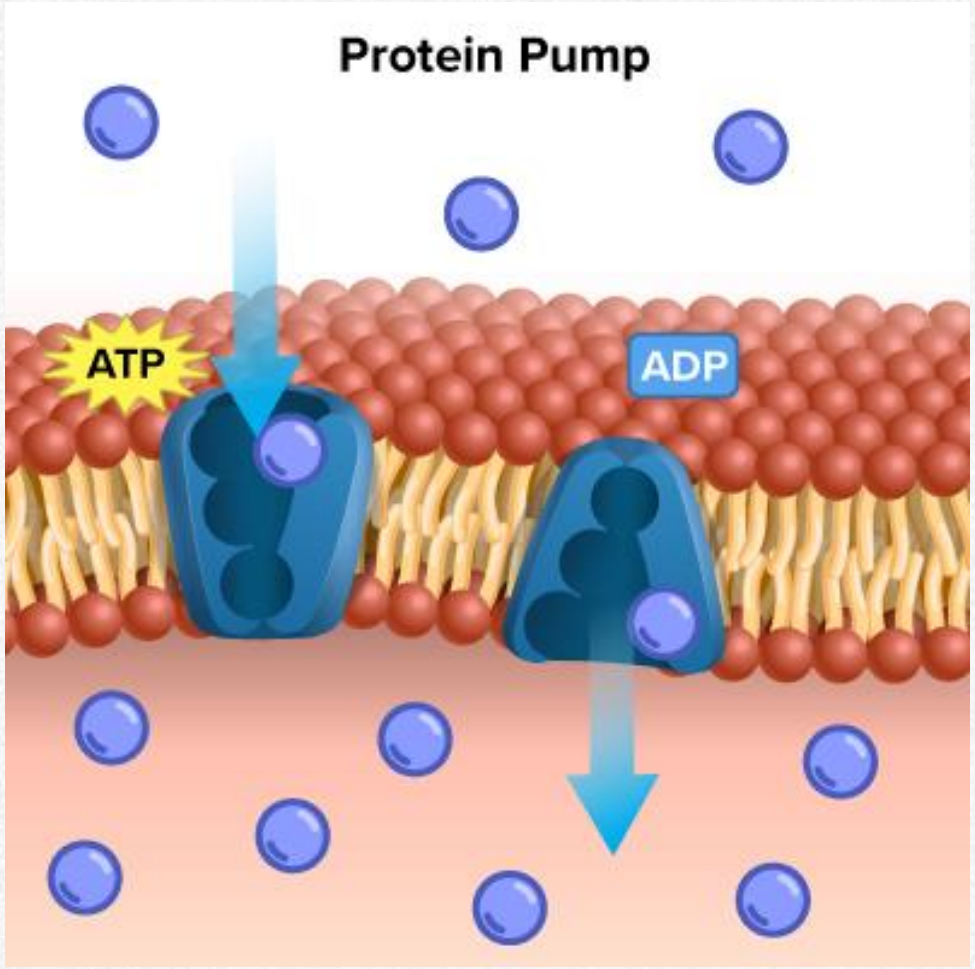




2. Active Transport

Active Transport: Transport across a membrane **requiring a carrier protein and chemical energy (ATP).** Examples: Sodium/Potassium Pump

Exocytosis/endocytosis can also occur, but energy is still required.

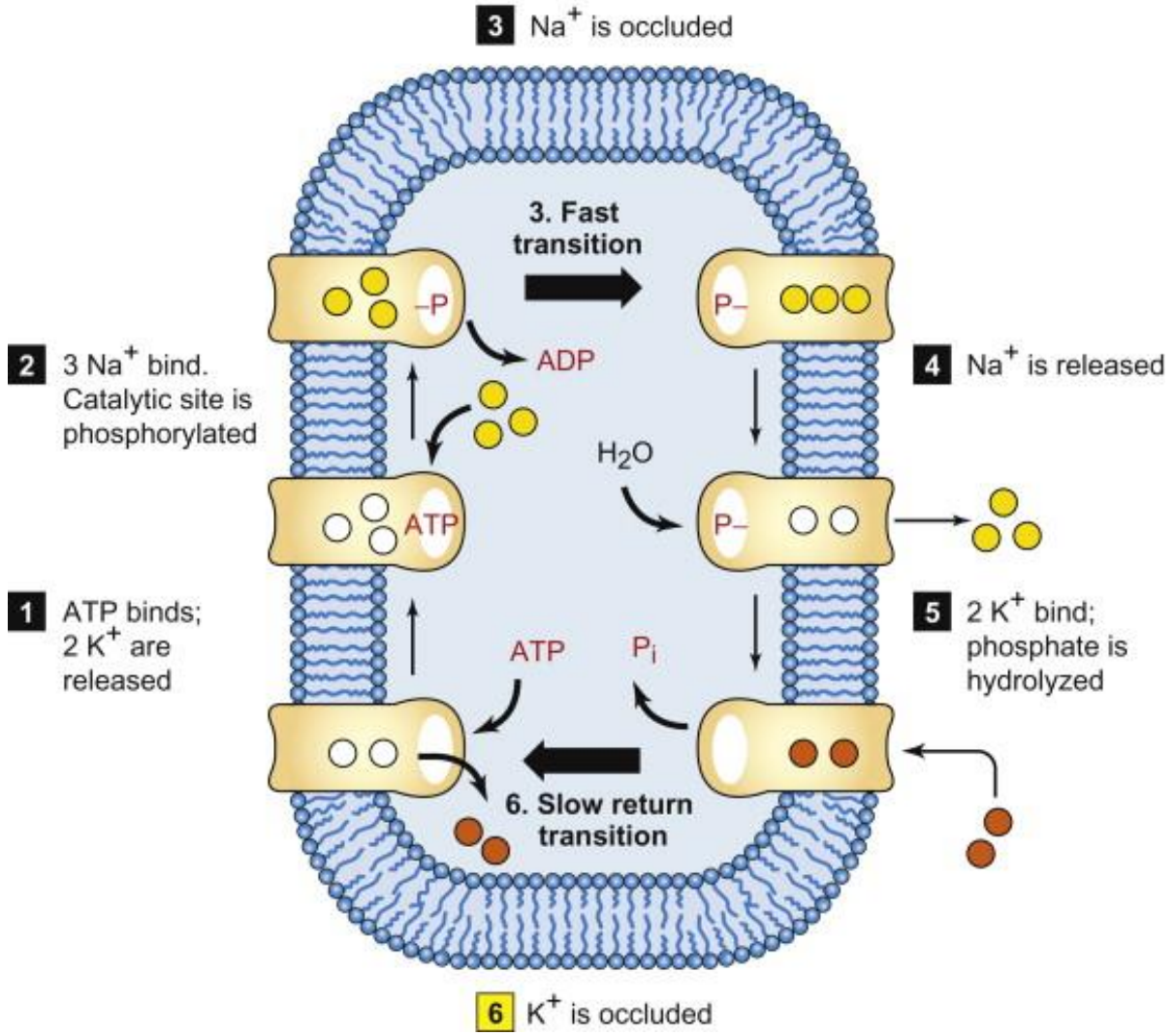


Sodium-Potassium Pump

Active transport of molecules across a membrane

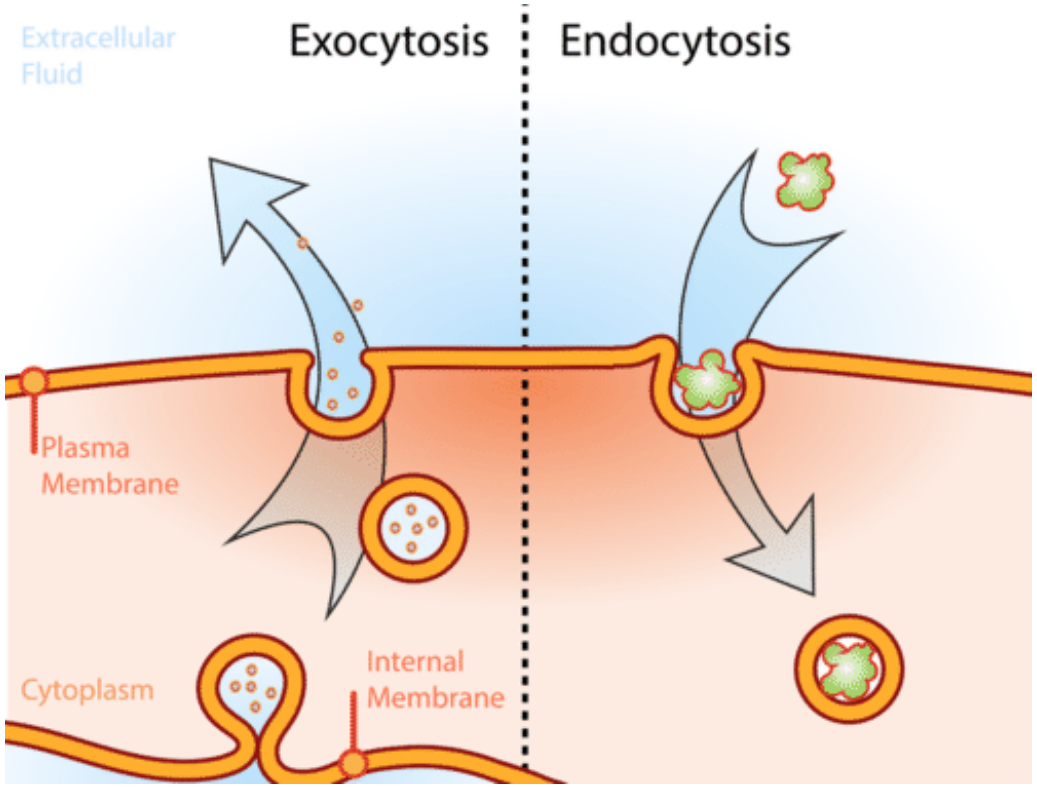
Like a water pump, our cells use energy to **pump various ions or molecules to and from our cells**.

The sodium-potassium pump is associated with muscle and nerve cells. It moves sodium to the outside of the cell and potassium to the inside of the cell. A Phosphate group (**donated by ATP**) is broken down enzymatically to attach and detach to the carrier proteins involved, which allows for the movement of both ions.



Exocytosis and Endocytosis

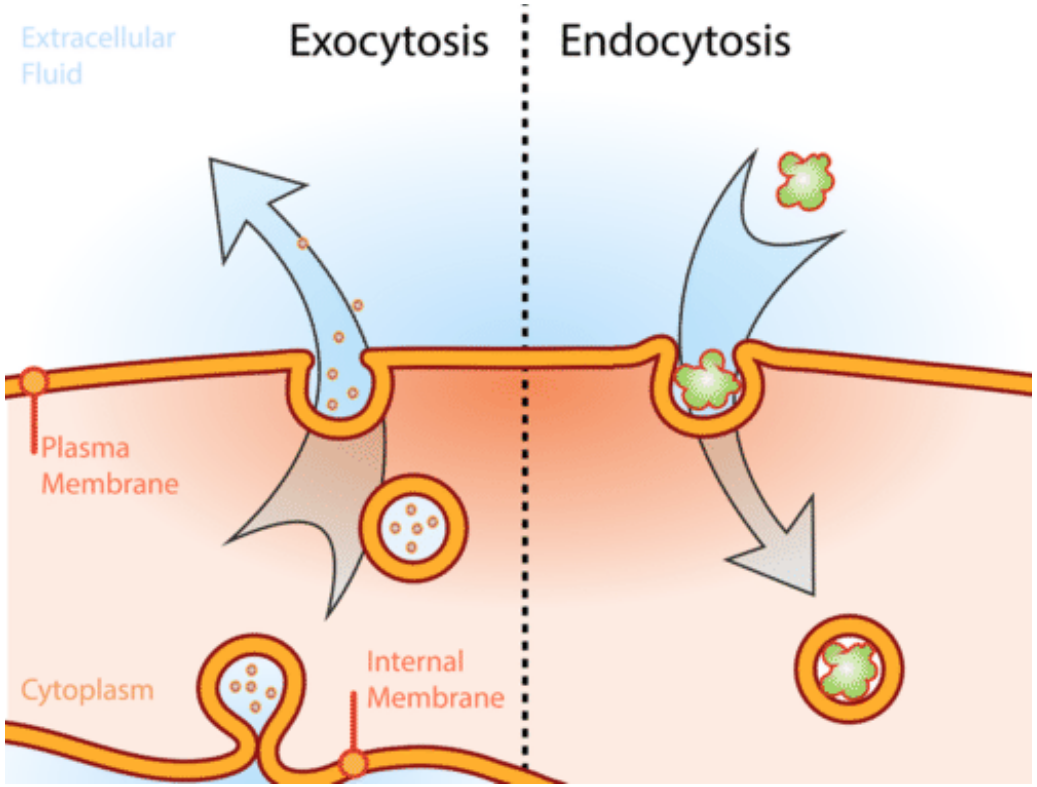
Active transport of molecules across a membrane



During **exocytosis**, vesicles fuse with the plasma membrane as secretion occurs. These vesicles are often produced by the Golgi Aparatus and contain proteins. The proteins adhere to the cell surface or become incorporated into the surface of the exterior of the cell. Some diffuse into tissue fluid to nourish or signal other cells. **Example: Digestive enzymes (rise in blood sugar signals pancreas to make insulin)**

Exocytosis and Endocytosis

Active transport of molecules across a membrane

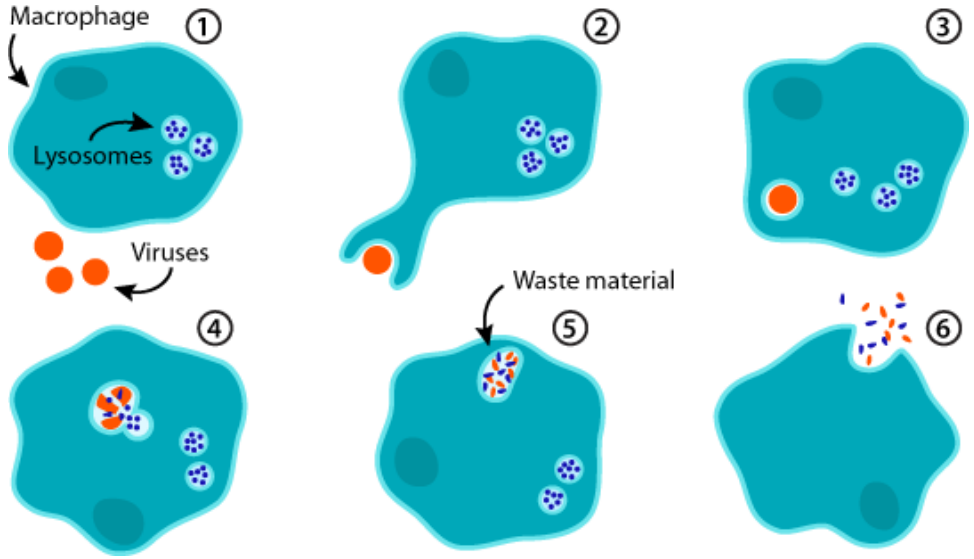


During endocytosis, cells take in substances by vesicle formation. A portion of the membrane envelopes the substance to make an intracellular vesicle. There are many methods:

Phagocytosis
Pinocytosis
Receptor-Mediated Endocytosis

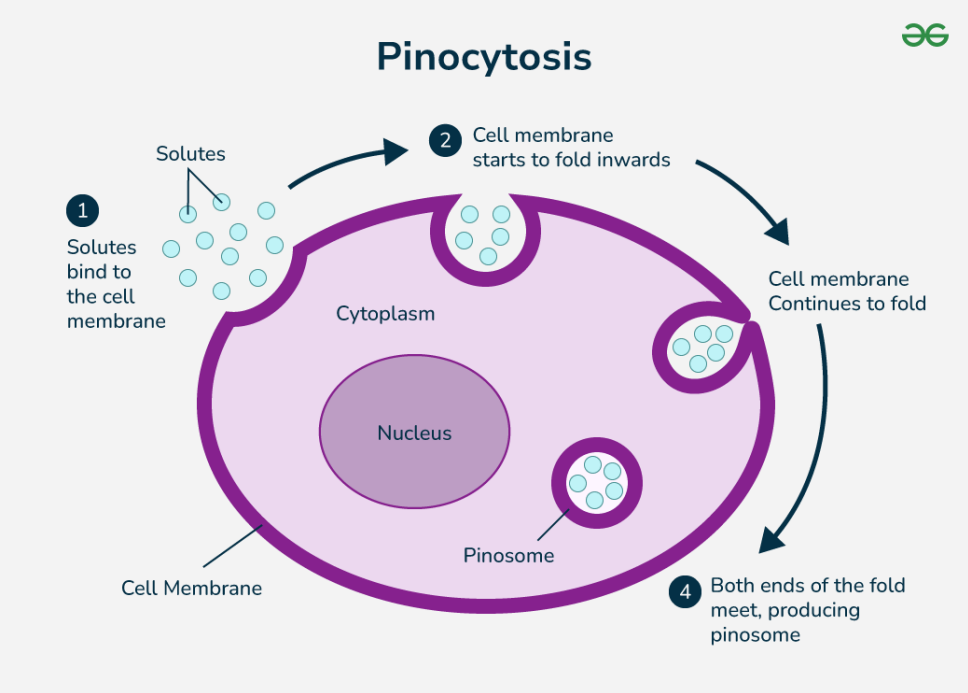
Phagocytosis vs. Pinocytosis

BOTH are Active transport of molecules across a membrane



Material taken in is large – the debris is **engulfed** by the cell

Examples – Amoebas, white blood cells



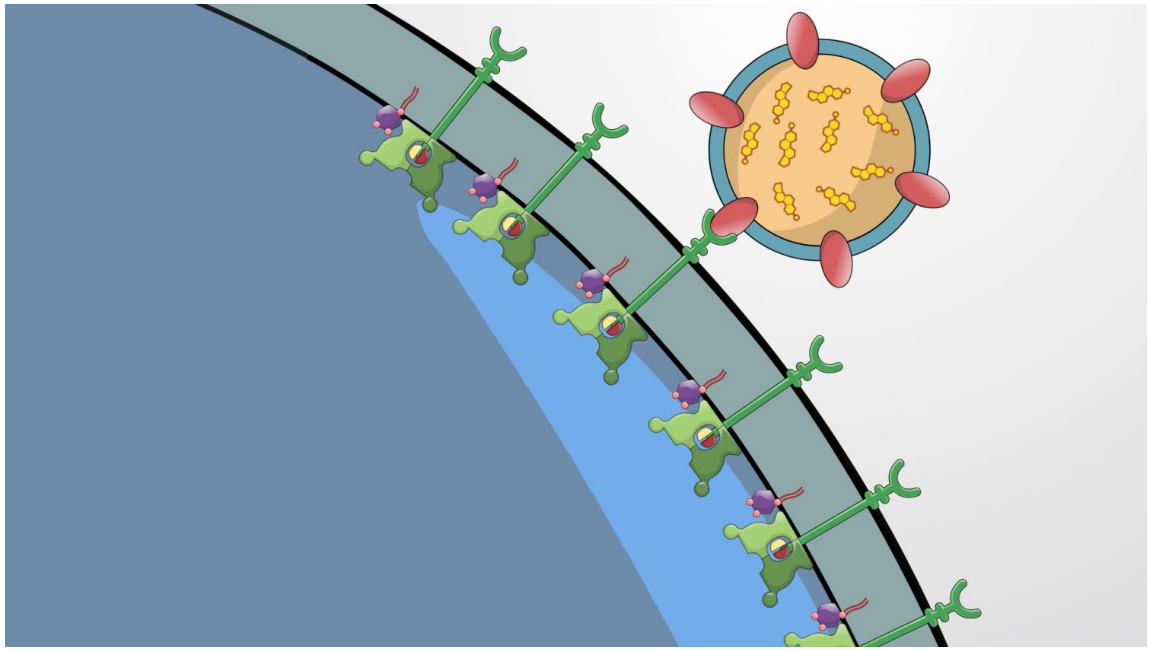
Material taken in is very small; occurs continuously in cells

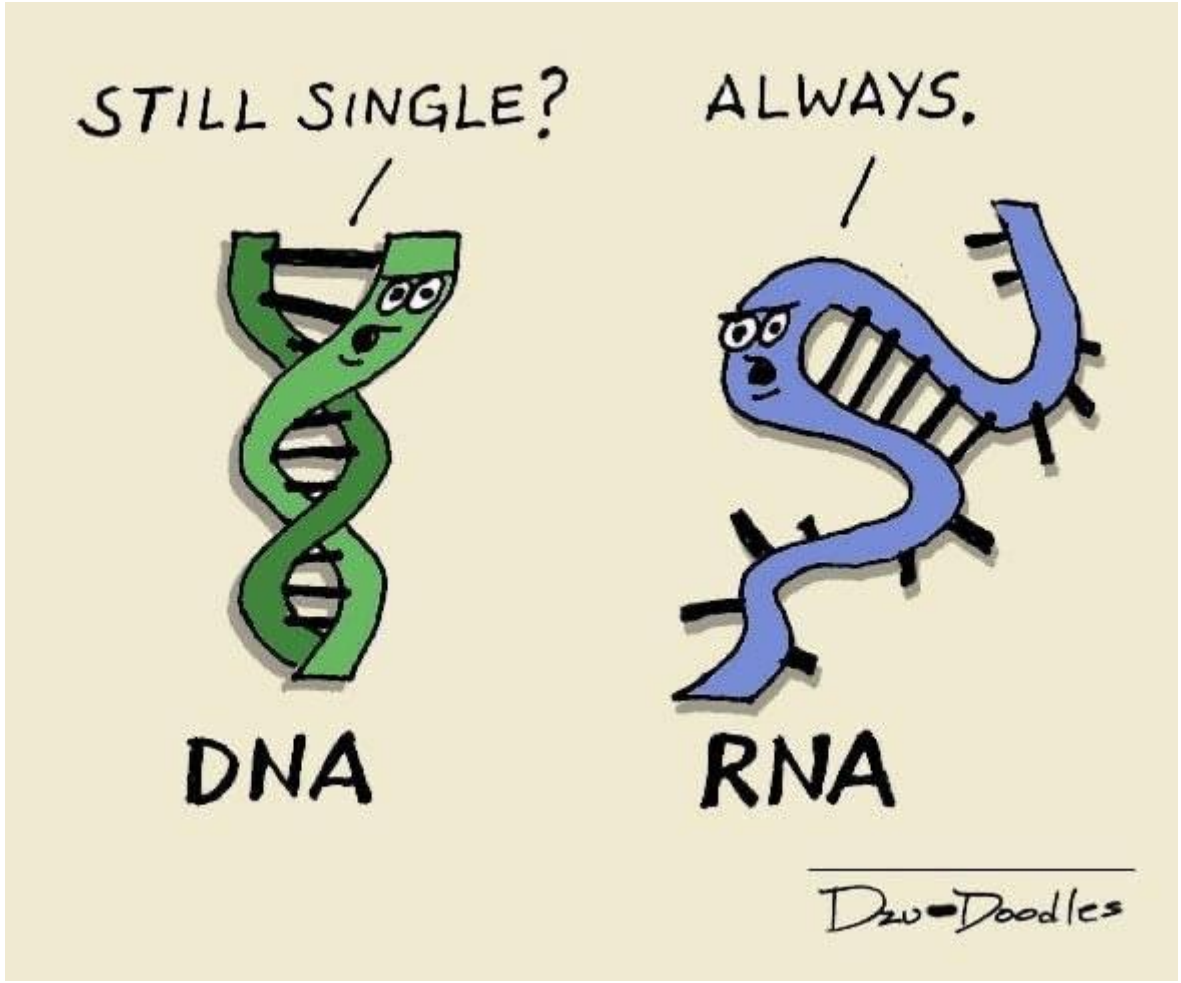
Examples – blood cells, intestinal lining cells, plant roots

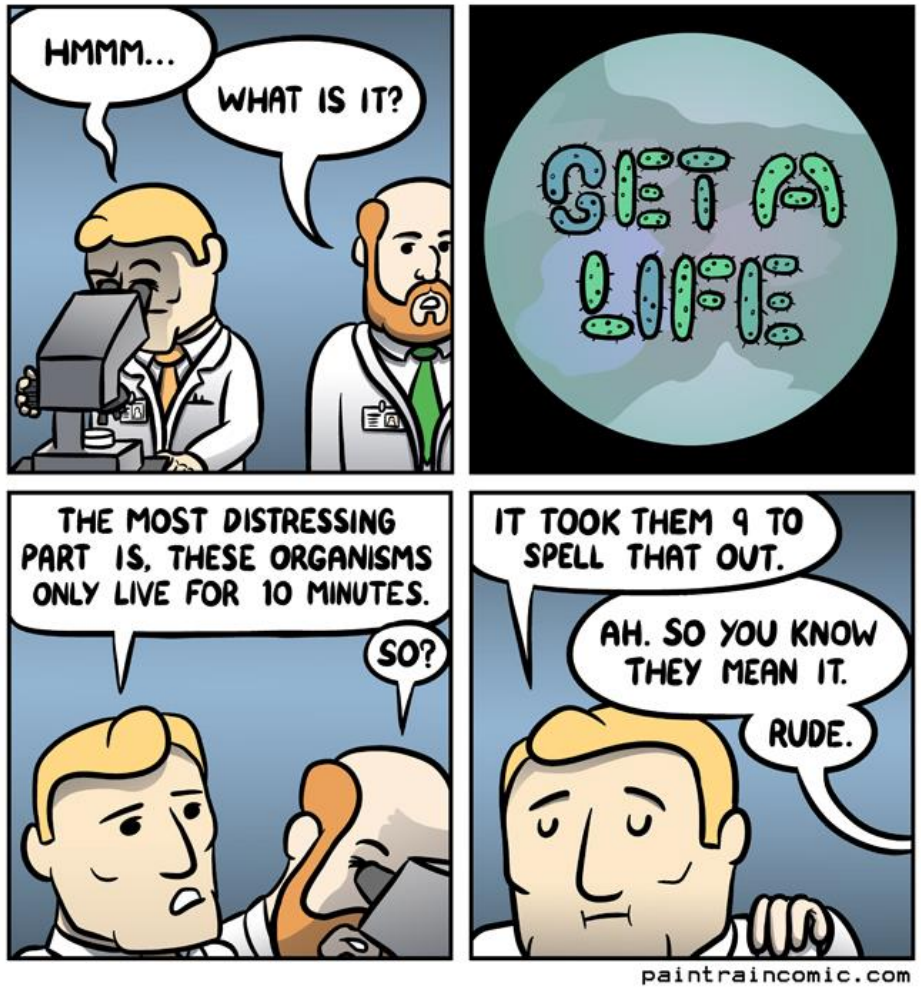
Receptor-Mediated

MORE Active transport of molecules across a membrane

A form of pinocytosis that is specific; it uses a receptor protein shaped so that specific molecules like vitamins, peptide hormones, or lipoproteins can bind to it. The receptors for these substances are located at specific points on the plasma membrane.



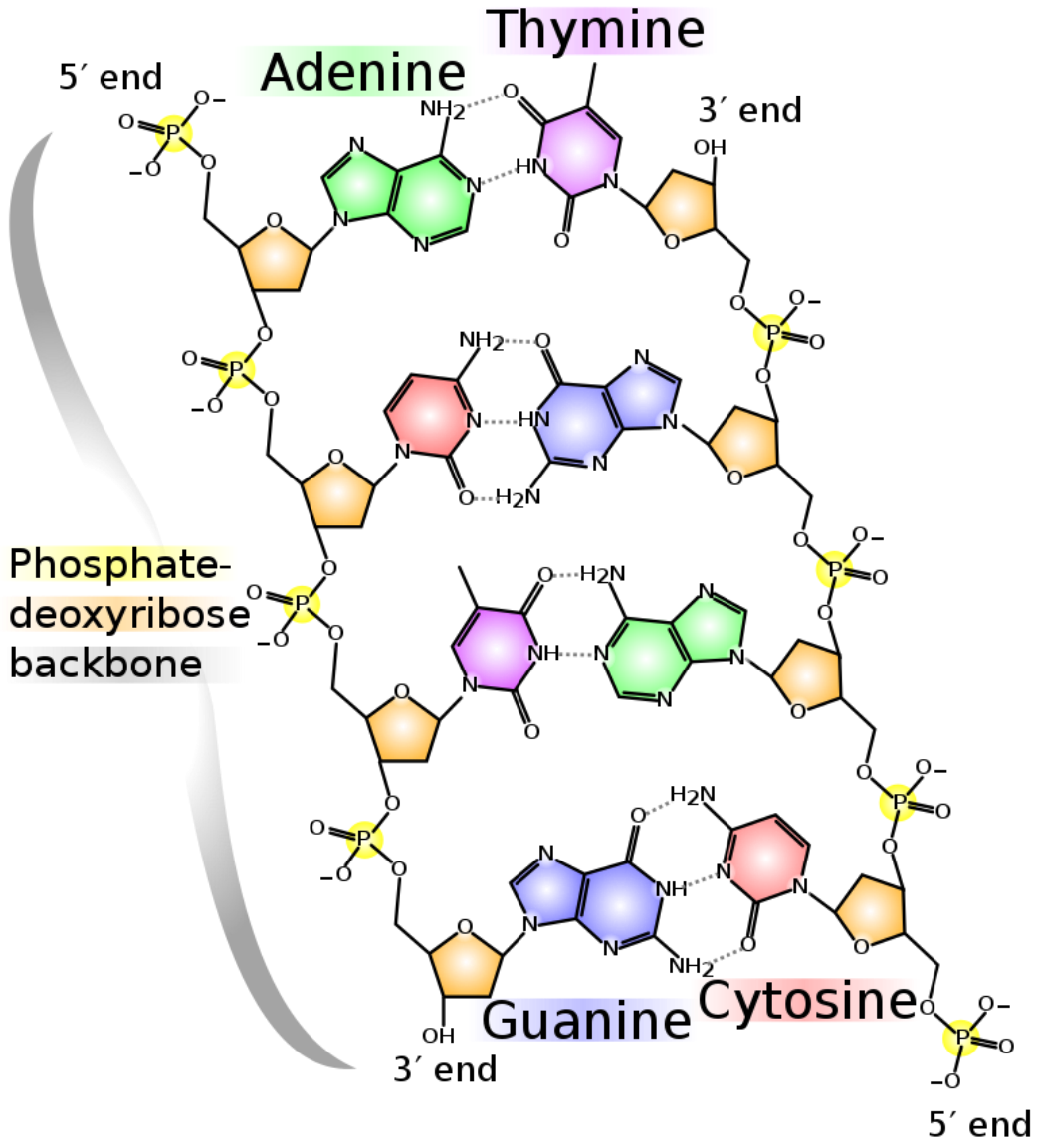




DNA Replication

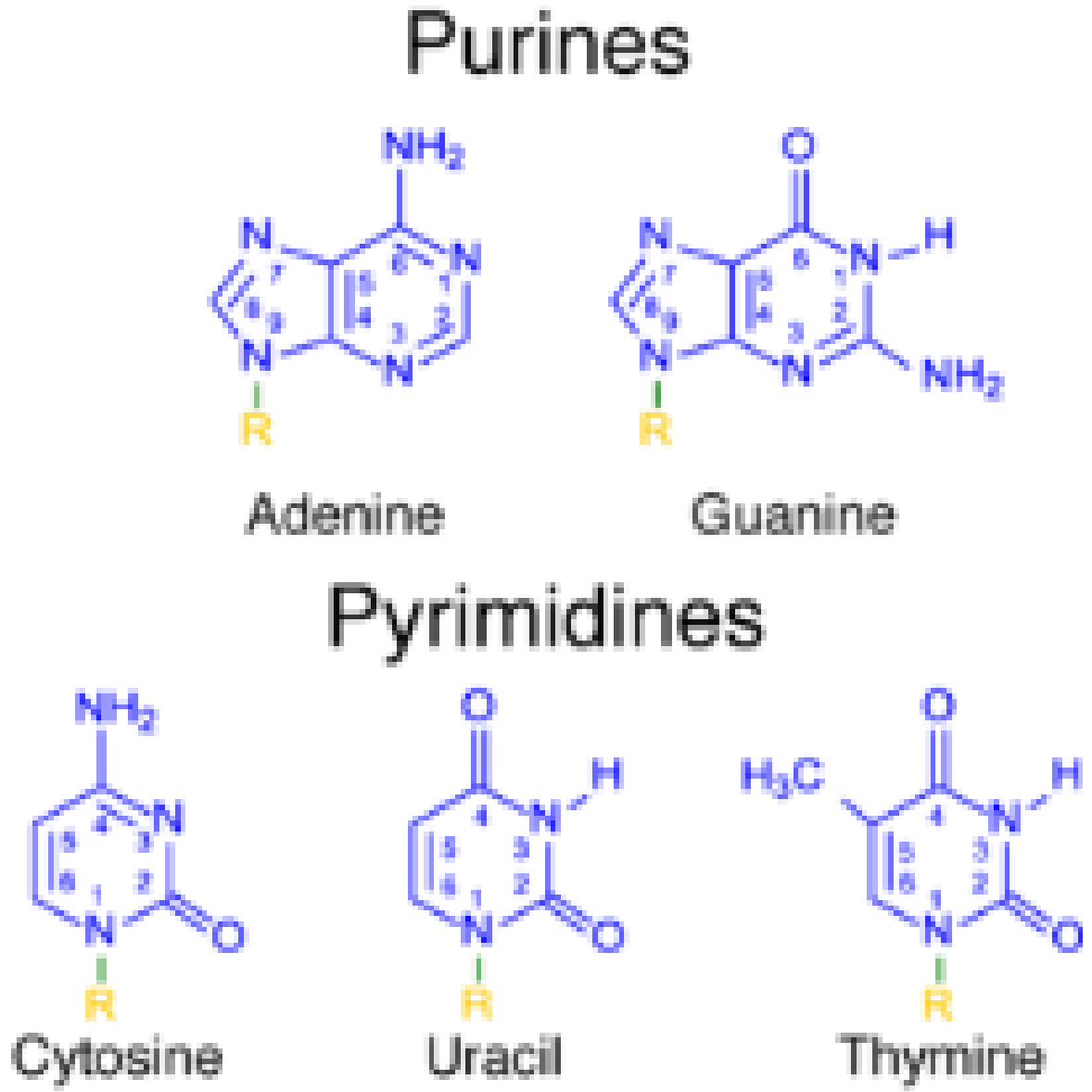
DNA Structure

- Review: DNA is formed from nucleic acids paired together in a ladder to form a <u>double helix structure.</u>
- The bases of DNA are paired together so that they match in a complimentary formation – <u>A to T and C to G</u>



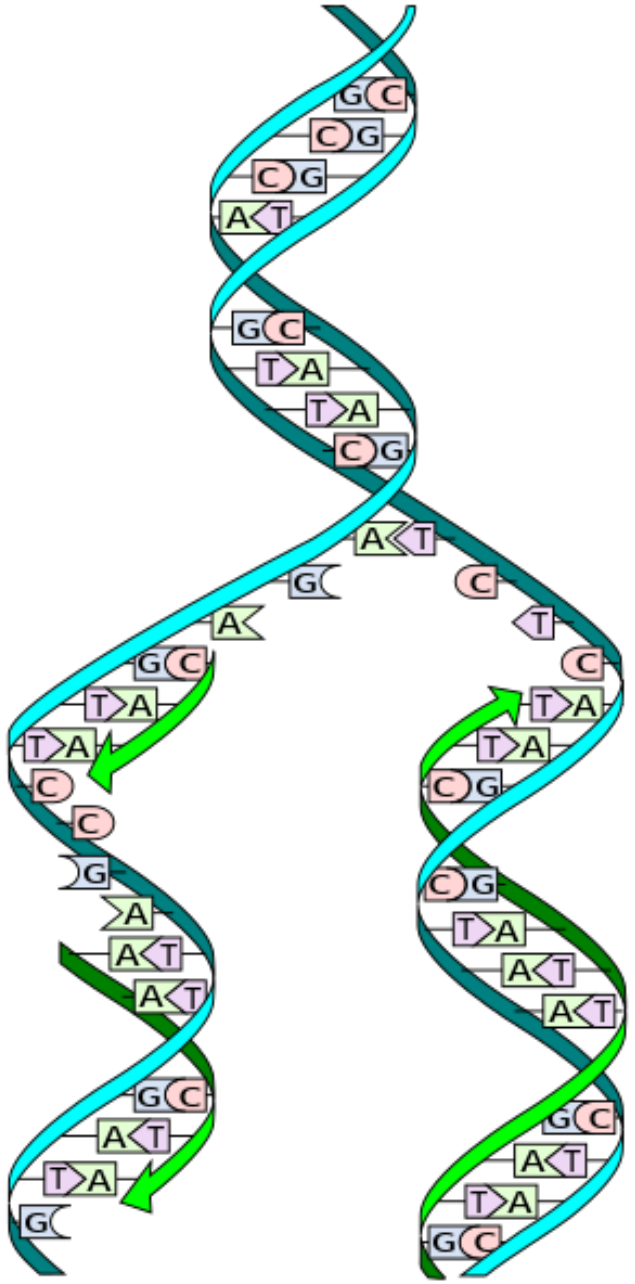
DNA Structure

- Base pairing allows purine bases to match with pyrimidine bases so the DNA ladder always has “rungs” of the same length.
- The double ring structure of the purines is always paired with the single ring structure of the pyrimidines to <u>keep the DNA structure stable</u>.



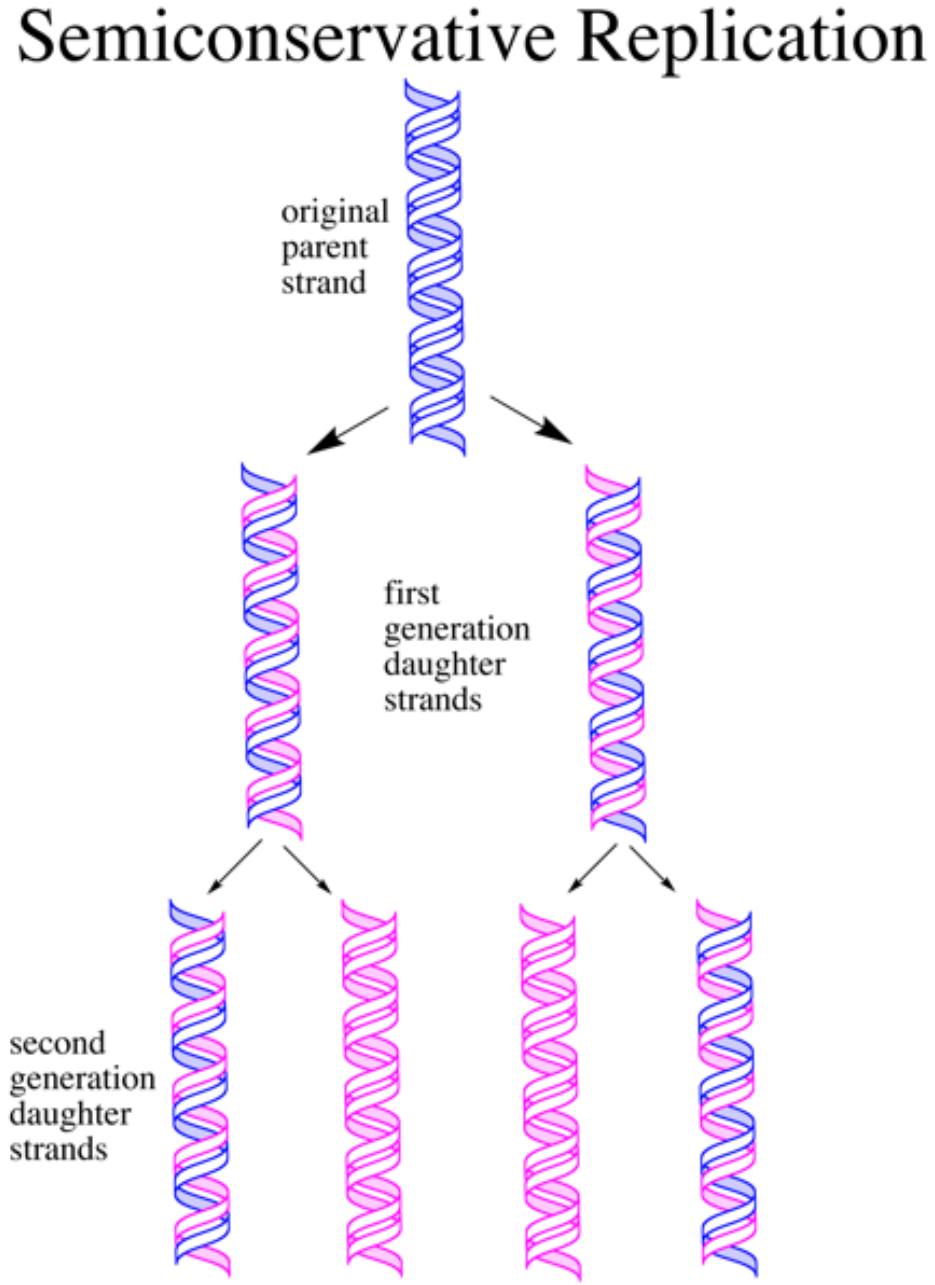
DNA Replication

- DNA needs to be copied for cells to reproduce. This process is referred to as DNA replication.
- DNA replication is facilitated by a series of enzymes (proteins) that interact with the DNA to unwind the DNA and then attach new bases to the strands to make new strands of DNA.



DNA Replication

- There are 3 stages to DNA replication:
  - Initiation
  - Elongation
  - Termination
- Because at the end of the process of DNA replication you end up with two identical strands of DNA that each contain one half of the original DNA strand the process is considered **semiconservative**.

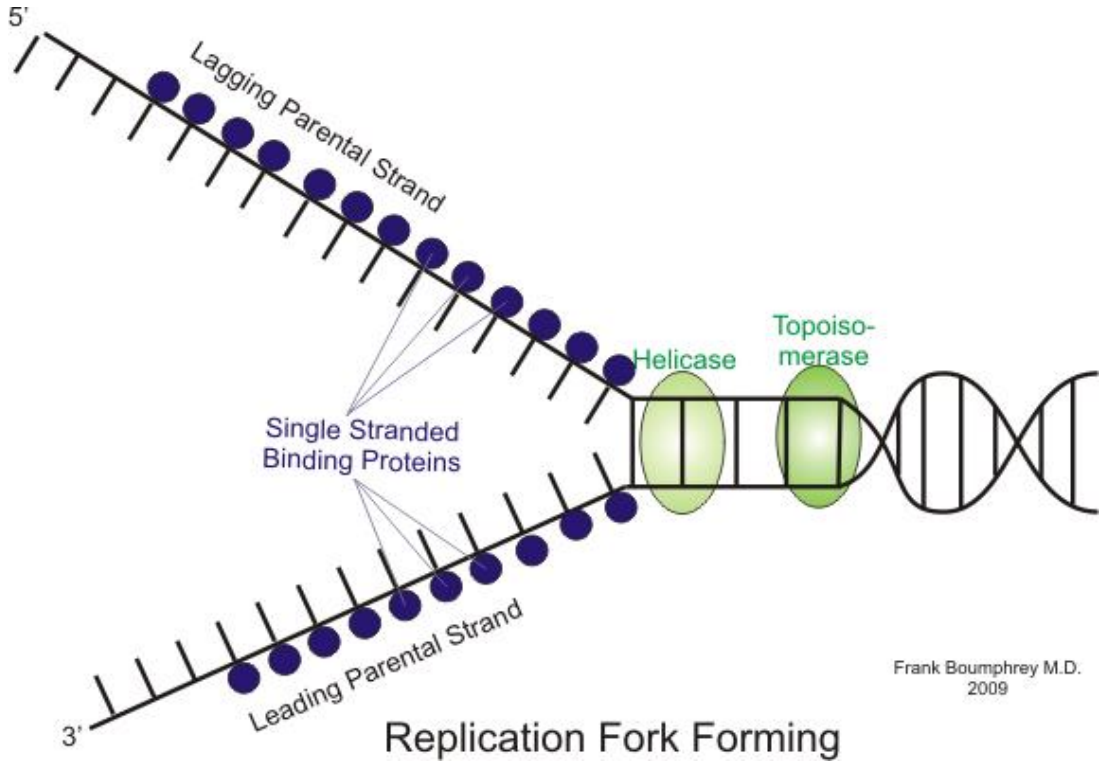


DNA Replication: Initiation

1. Histones (binding the DNA) are unwound by enzyme: topoisomerase.

2. DNA splits at specific sequences called origins of replication by the enzyme: helicase.

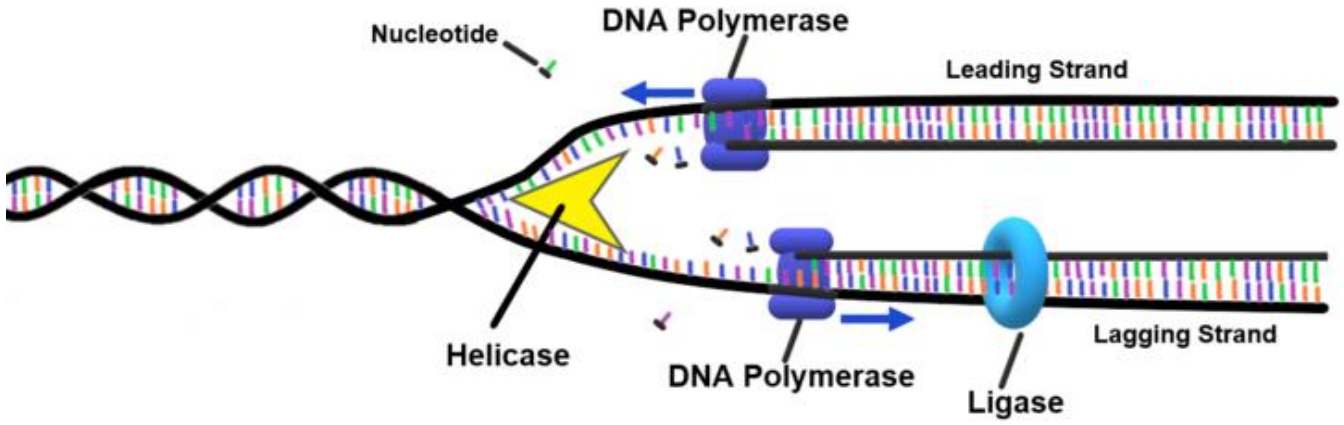
3. Replication forks (Y shaped structures) form as DNA opens up. They extend in both directions as replication proceeds.



DNA Replication: Elongation

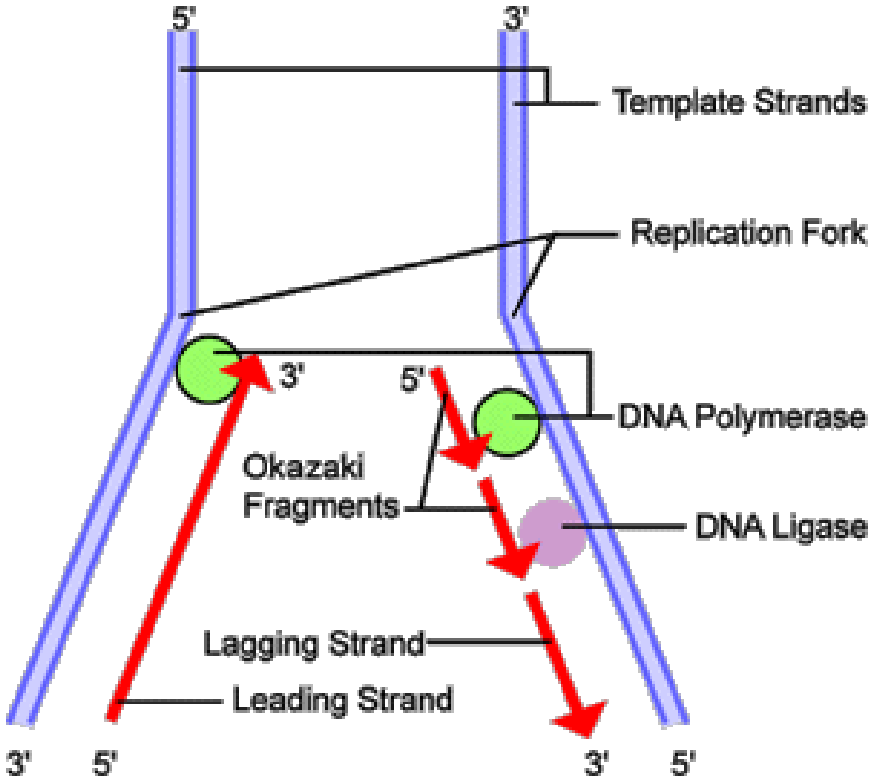
1. DNA polymerase joins nucleotides to the 3’ end of DNA chain

The enzyme can only work on the 3’ end and cannot join nucleotides to the 5’ end of the chain, one strand requires a primer sequence of RNA (Primase) which is removed later and replaced with DNA.



DNA Replication: Elongation

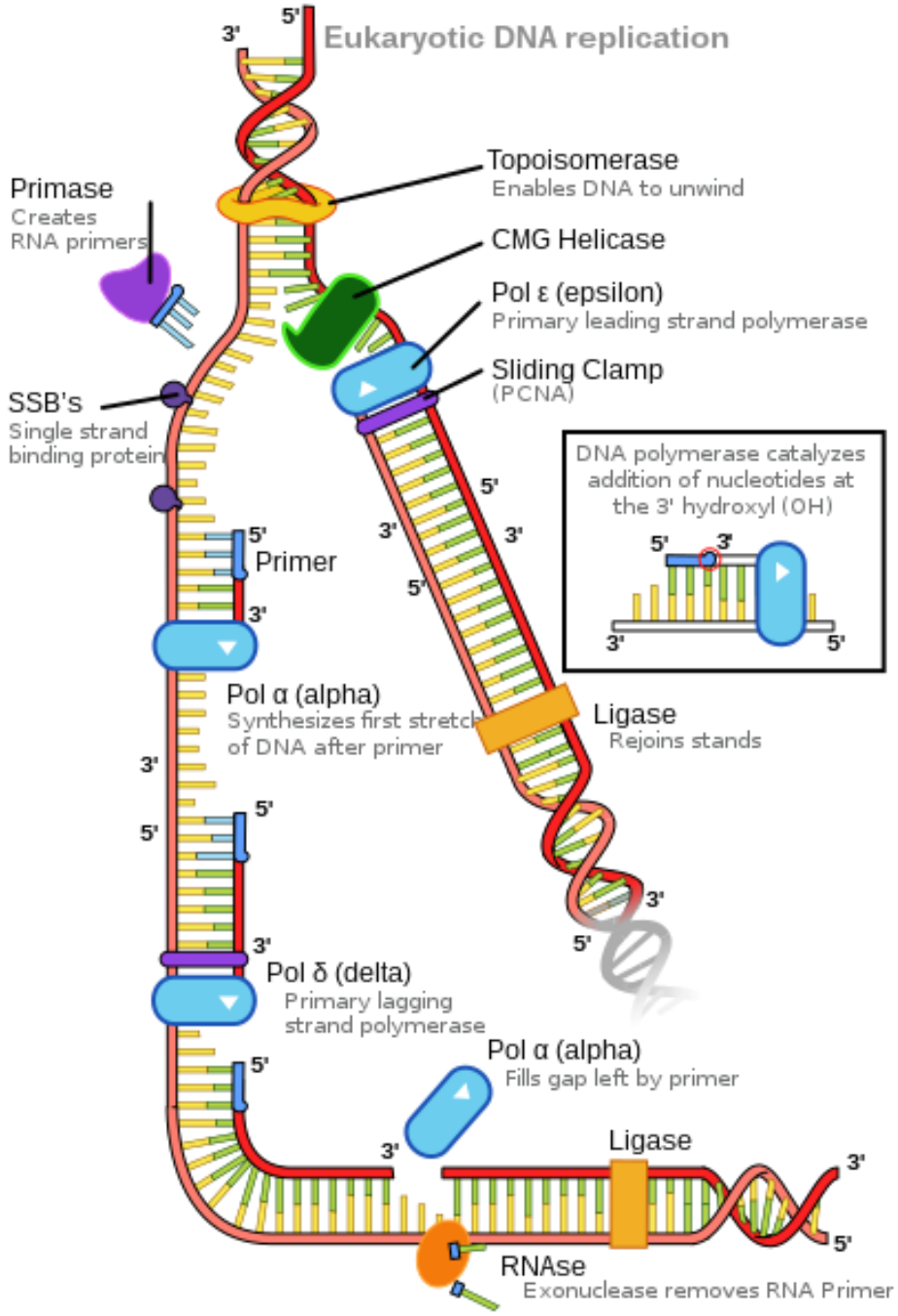
1. DNA polymerase builds new DNA strand and nucleotides are added continuously during elongation.
2. The strand that runs 5’ to 3’ is assembled in short chunks called Okazaki fragments starting at the RNA primer.
3. After the strand is filled, enzymes remove the RNA primers and replace them with nucleotides.



DNA Replication: Elongation

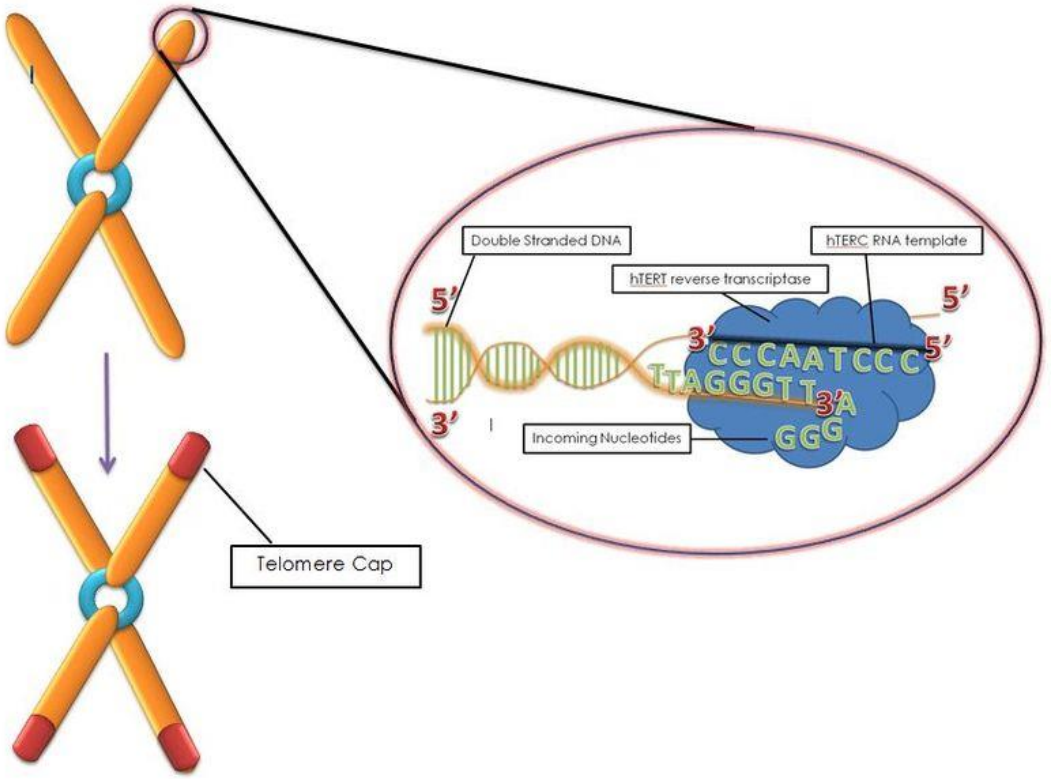
4. <u>DNA ligase</u> moves along the strand of DNA and bonds the sections of nucleotides together.

(This is why the 5’ strand is called the lagging strand – it is a much slower process – the 3’ strand is known as the leading strand)



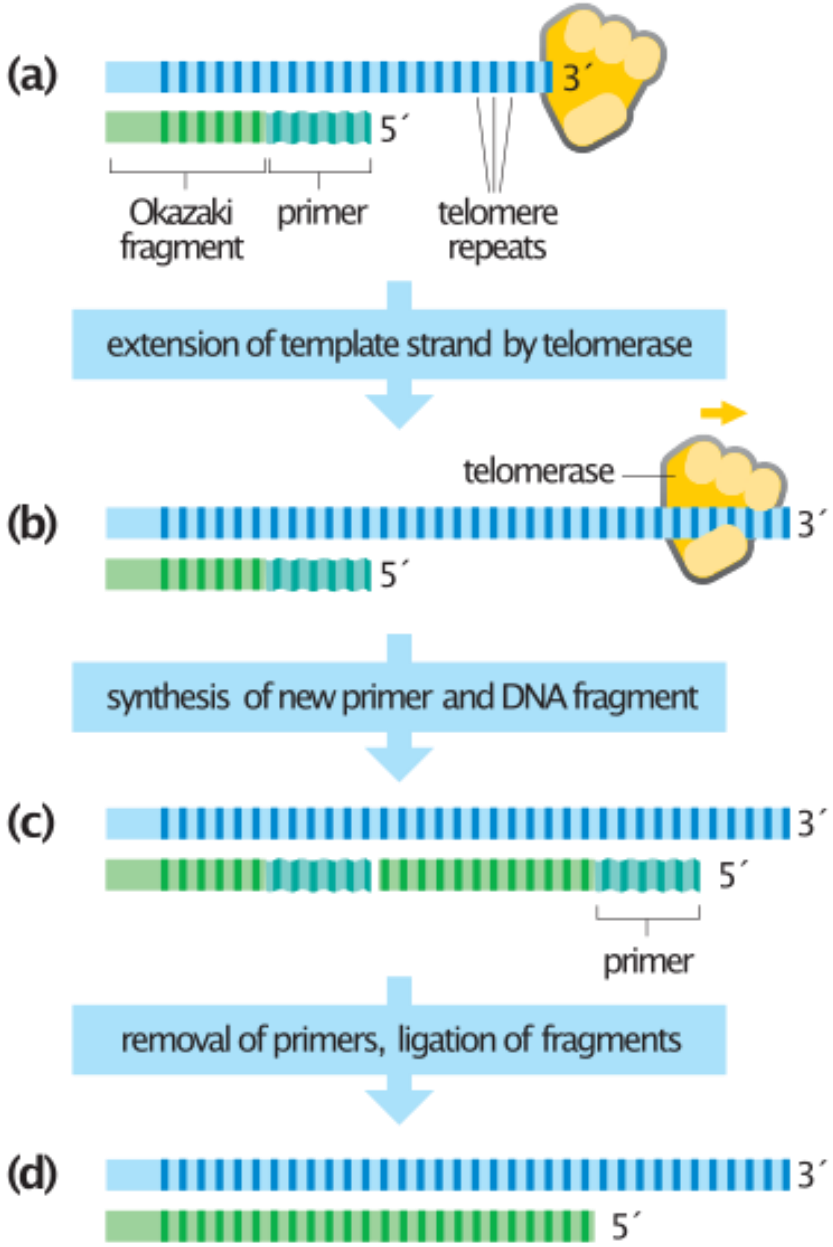
DNA Replication: Termination

- DNA replication ends when the chromosome ends on the leading strand that runs from the 3’ to 5’ direction.
- On the lagging strand, the DNA ends up without a spot to put a primer so that the end of the strand of DNA cannot be replicated using this process.
- This is why the ends of your chromosomes have non-coding regions called **telomeres** at the end.



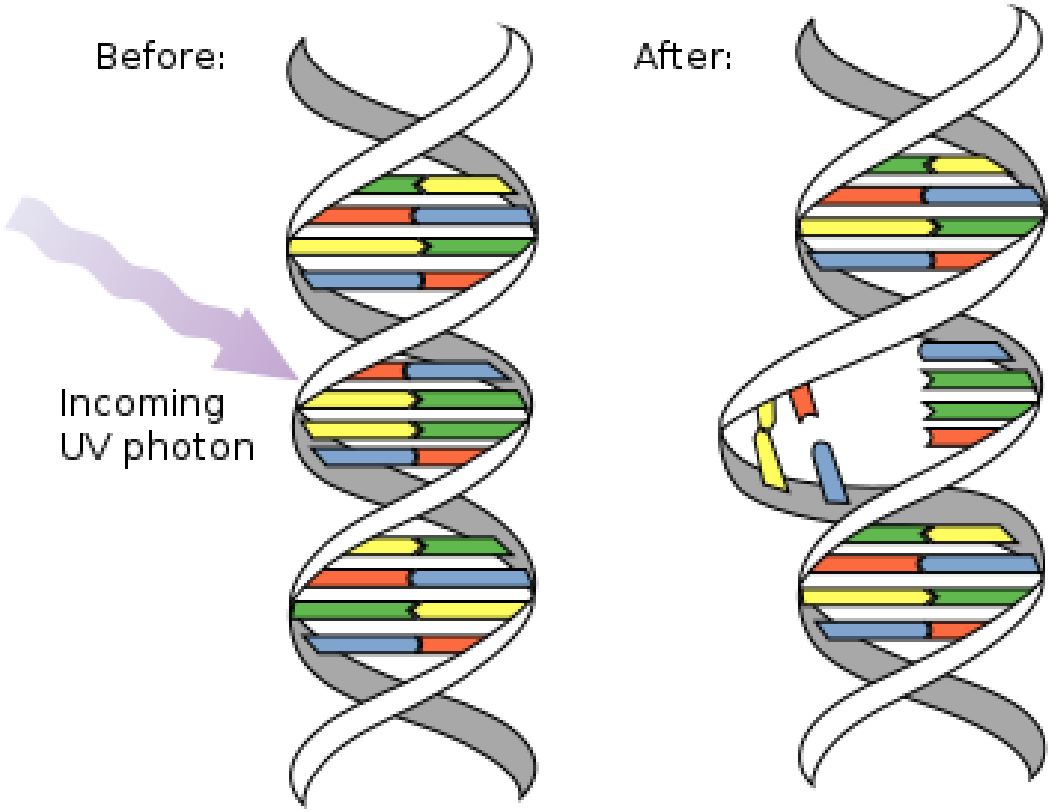
Telomeres

- Telomeres in some cells are maintained by the enzyme telomerase that uses a RNA template to shift along the end of the chromosome.
- This allows primase and DNA polymerase to add complimentary base pairs to the telomeres of chromosomes.
- However, some bases can still be lost during cell division from telomeres so this is why it is important that they do not code for any genes.



Mutations

- If there is an error when DNA polymerase is adding a nucleotide, it is generally checked and corrected by <u>enzymes that are engaged in mismatch repair</u>.
- On rare occasions a mismatch is missed by this mechanism and a mutation occurs, which can result in either a new protein, no change, or no protein being made.
- Most often it results in the death of the organism.

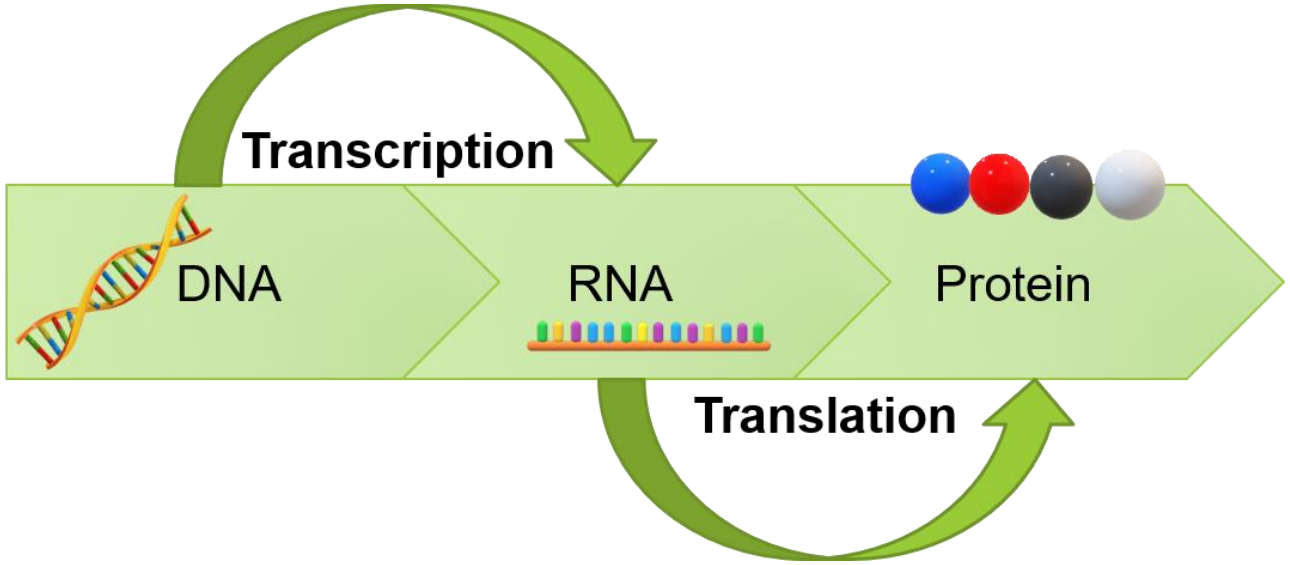


DNA strands: *unzip*
mRNA:

Me after explaining every step in transcription and translation

Protein Synthesis

DNA vs RNA

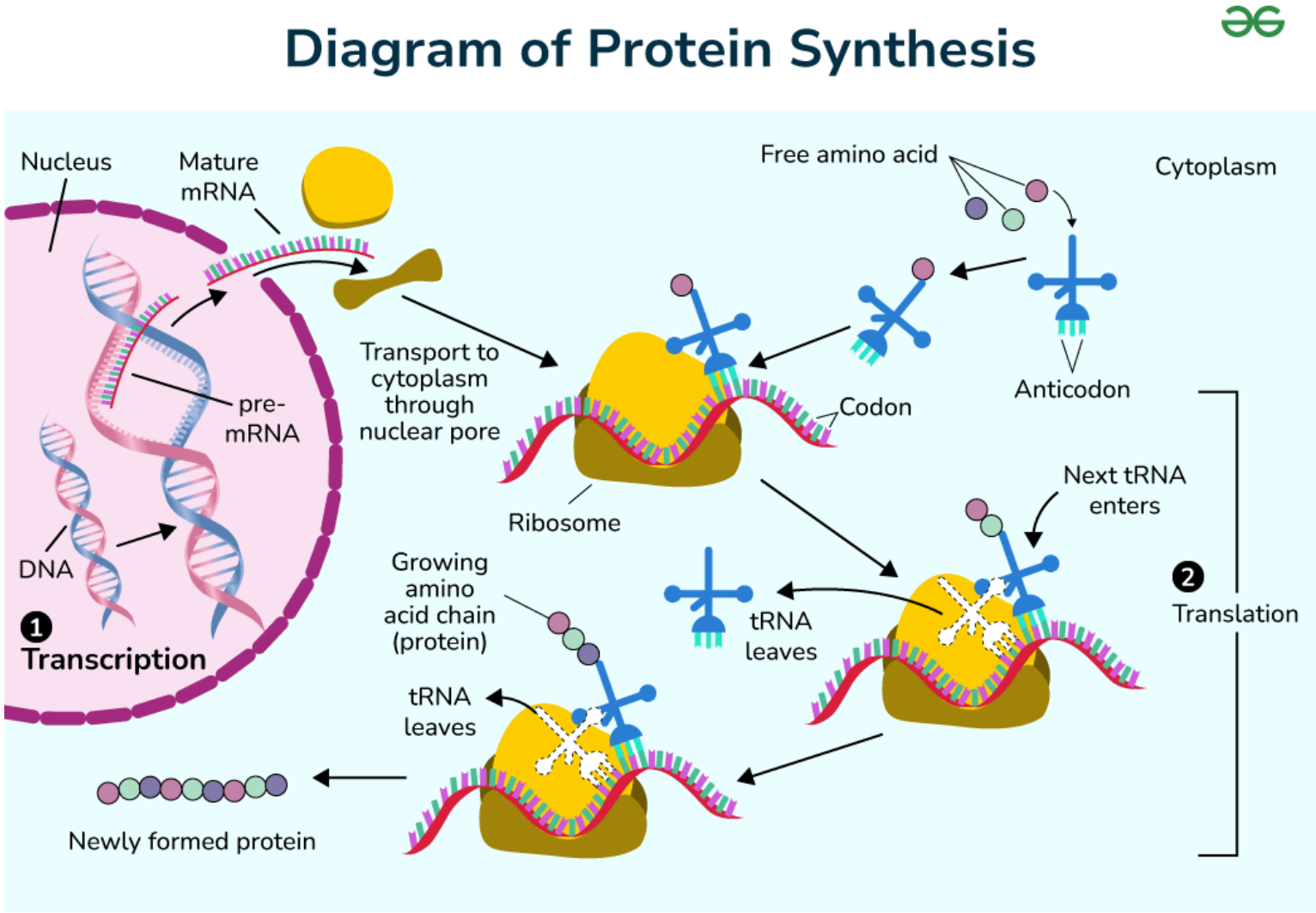


DNA	RNA
• double stranded • bases are Adenine (A) – Thymine (T) and Cytosine (C) – Guanine (G) • sugar is deoxyribose	• single strand • bases are Adenine (A) – Uracil (U) and Cytosine (C) – Guanine (G) • sugar is ribose

Protein Formation- Transcription

Transcription

- since DNA is too large to fit through a pore in the nuclear membrane, it needs to create a smaller messenger
- a gene sequence unwinds and one side of the chromosome is copied as a messenger RNA (mRNA)



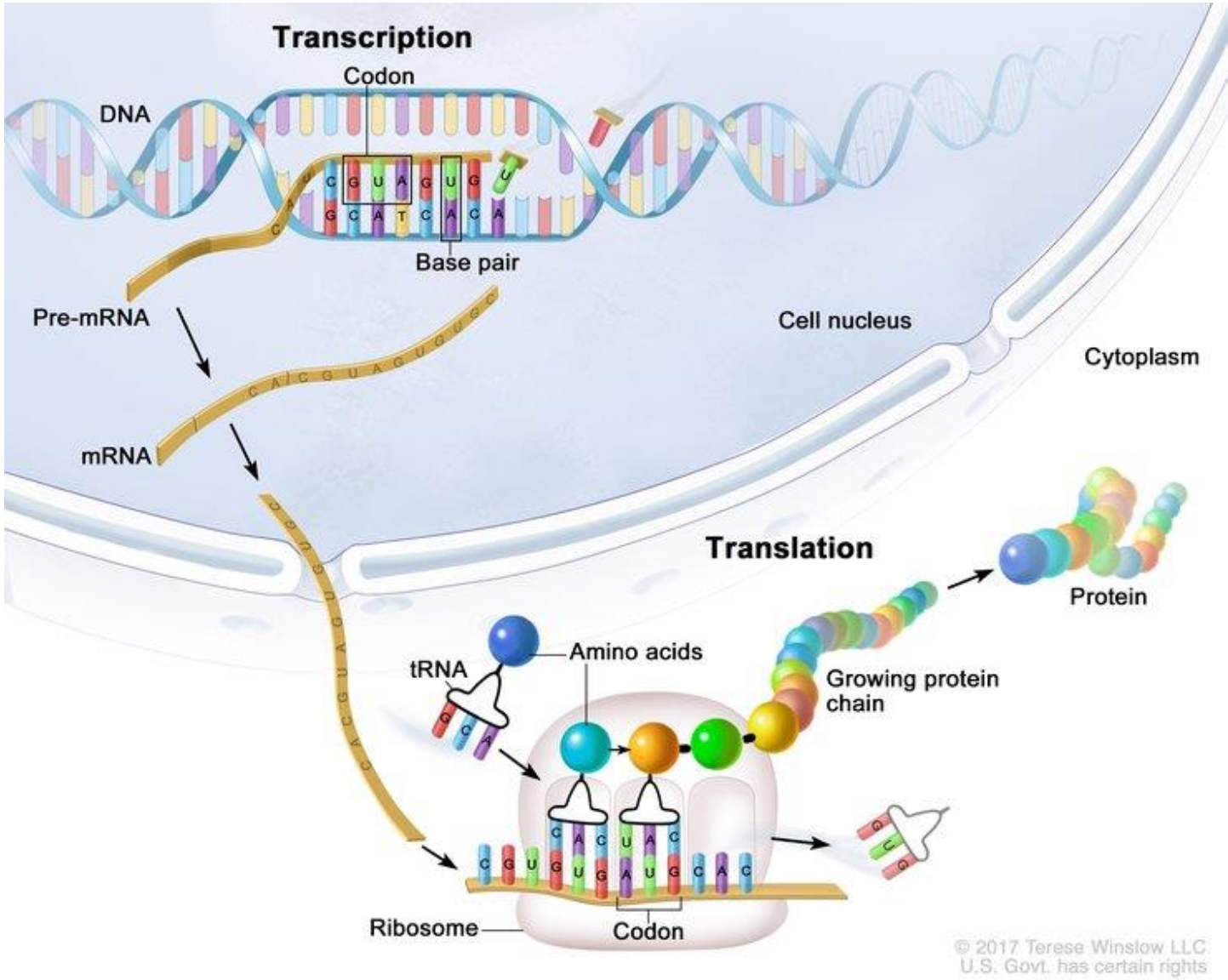
Transcription

4 Steps

1. **Initiation**:

RNA polymerase binds to a specific region on the DNA called the promoter, signaling the start of a gene

2. **Elongation**: RNA polymerase unwinds the DNA strands and synthesizes a single strand of mRNA by adding complementary RNA nucleotides (A, U, C, G) to the growing mRNA strand based on the DNA template.

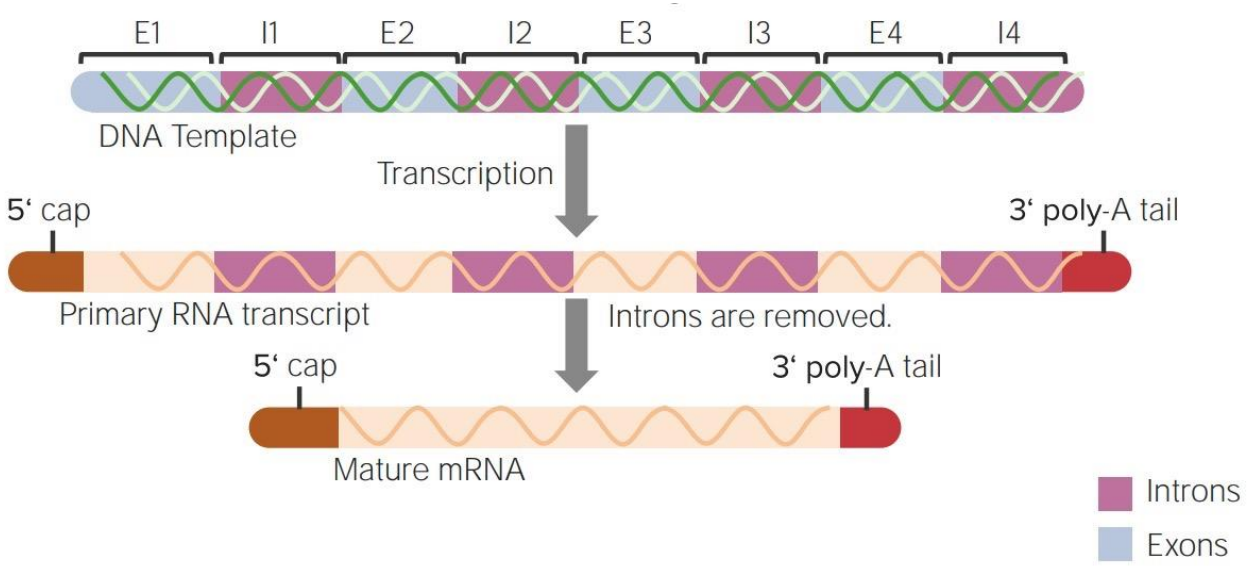


Transcription

4 Steps (Continued)

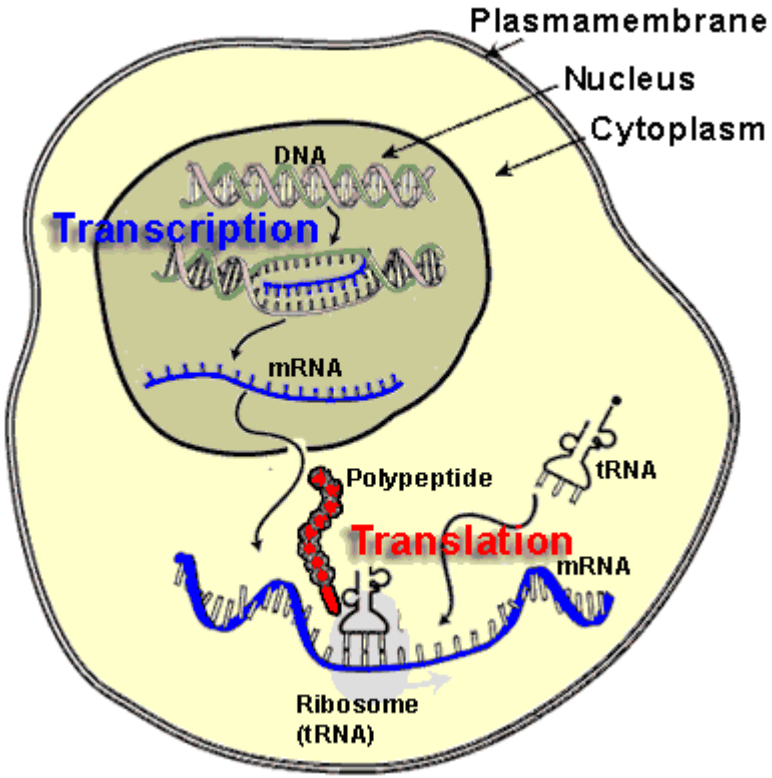
3. Termination: RNA polymerase continues until it reaches a termination signal in the DNA, at which point it detaches, and the newly formed mRNA strand is released.

4. Post-Transcriptional Modifications: In eukaryotes, the mRNA undergoes capping (adding a 5' cap) and polyadenylation (adding a poly-A tail), and introns are spliced out, resulting in mature mRNA.



Example

- DNA T A C G C G A A T T G T C A C T A G A C C A C T
- mRNA A U G C G C U U A A C A G U G A U C U G G U G A

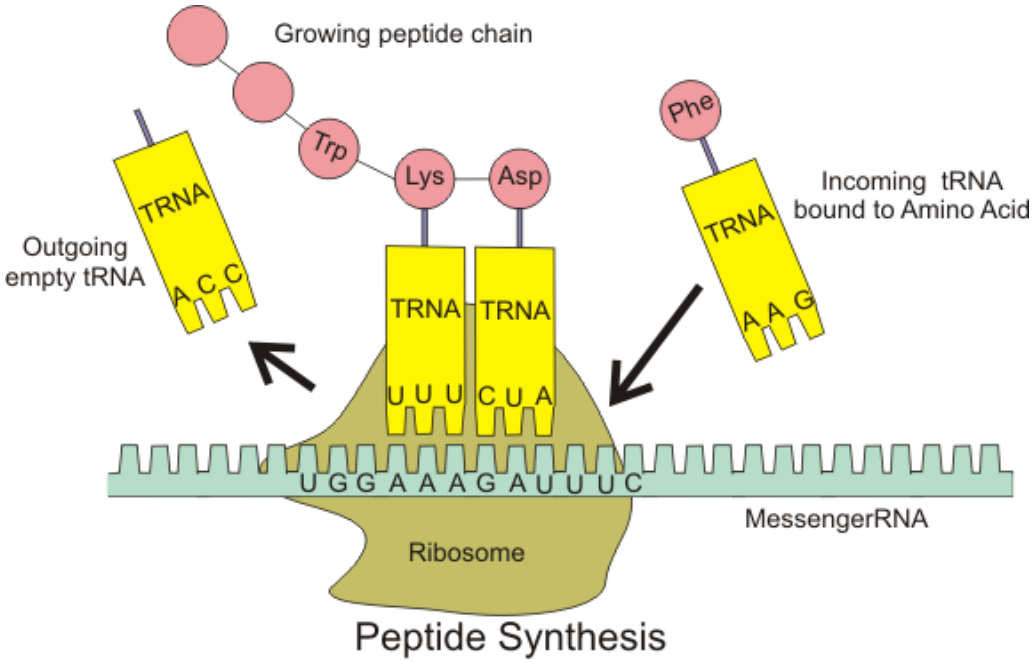


Protein Formation- Translation

Translation

1. mRNA moves into the cytoplasm and binds with a ribosome

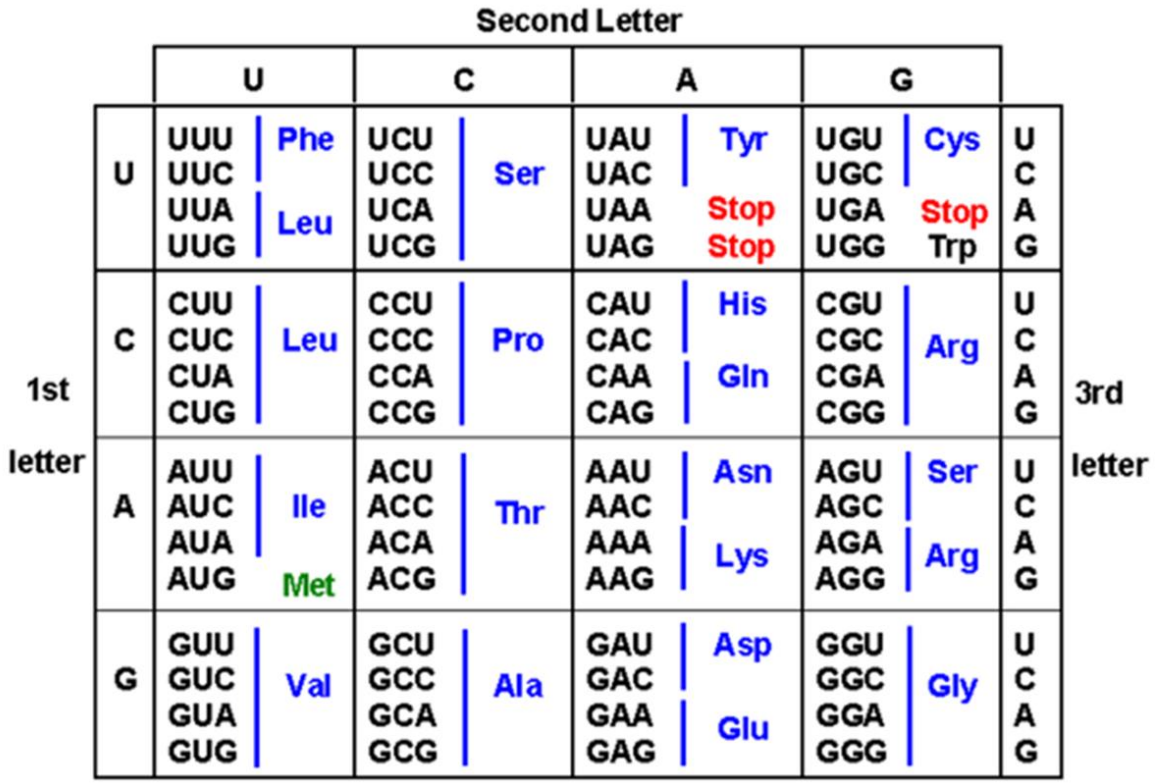
2. Ribosome translates the instructions in the mRNA into a chain of amino acids



mRNA is read in sets of 3 bases called a **codon** that codes for a specific amino acid

Example

- DNA T A C G C G A A T T G T C A C T A G A C C A C T
- mRNA A U G C G C U U A A C A G U G A U C U G G U G A
- Amino Acid met – arg – leu – thr – val – ile – trp – stop



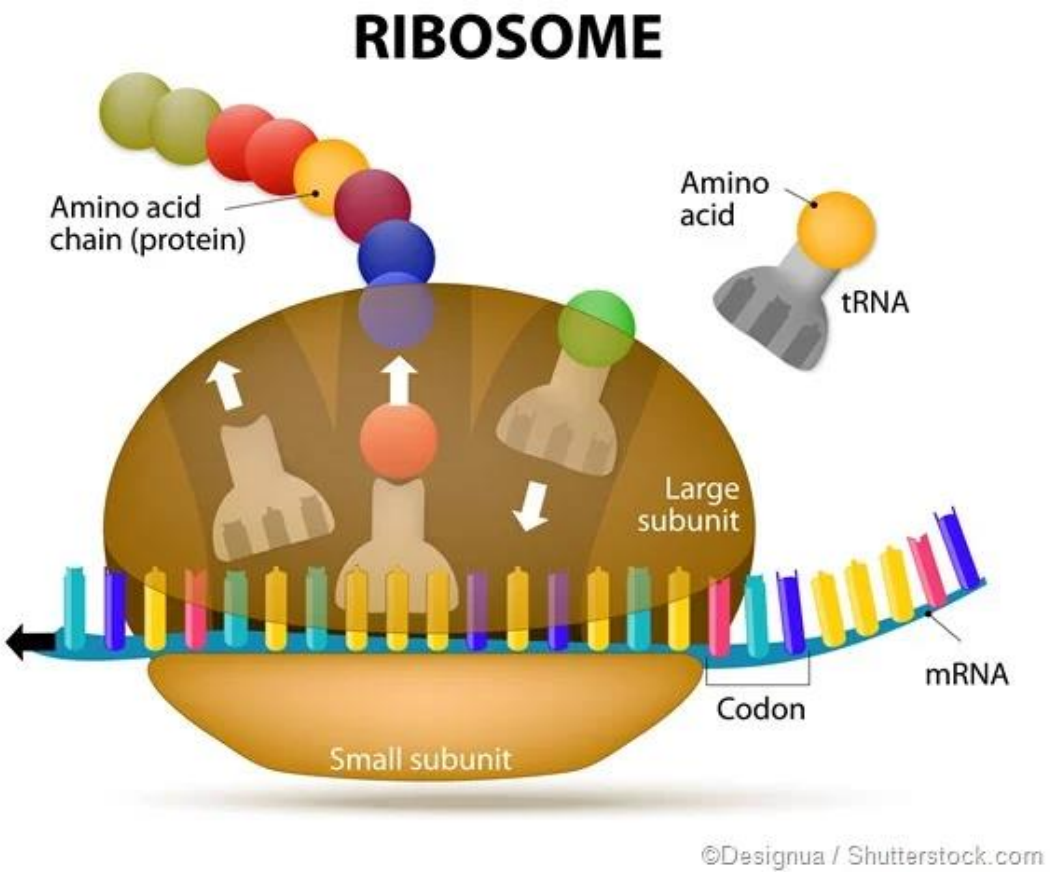
Translation

3 Steps (Sometimes 4)

1. Initiation: The mature mRNA binds to the ribosome. The ribosome assembles around the mRNA, and the first tRNA molecule, carrying the amino acid methionine, binds to the start codon (AUG).

2. **Elongation**: The ribosome moves along the mRNA, reading codons (three-nucleotide sequences) and recruiting the appropriate tRNA molecules that carry specific amino acids.

Each tRNA anticodon pairs with the corresponding mRNA codon, and the ribosome catalyzes the formation of peptide bonds between the amino acids, elongating the polypeptide chain.

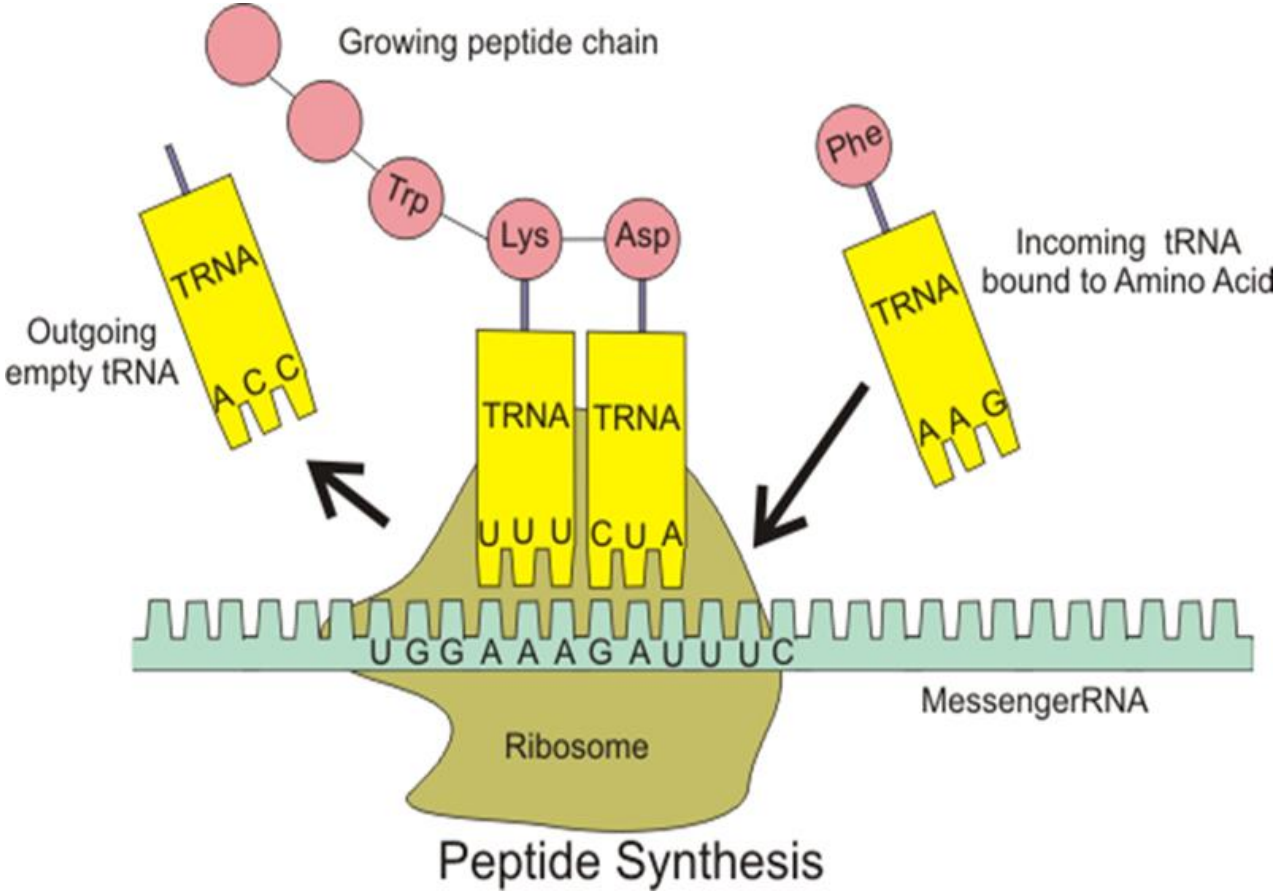


Translation

3 Steps (Continued)

3. Termination: The process continues until the ribosome reaches a stop codon (UAA, UAG, UGA) on the mRNA. No tRNA corresponds to stop codons, so release factors bind to the ribosome.

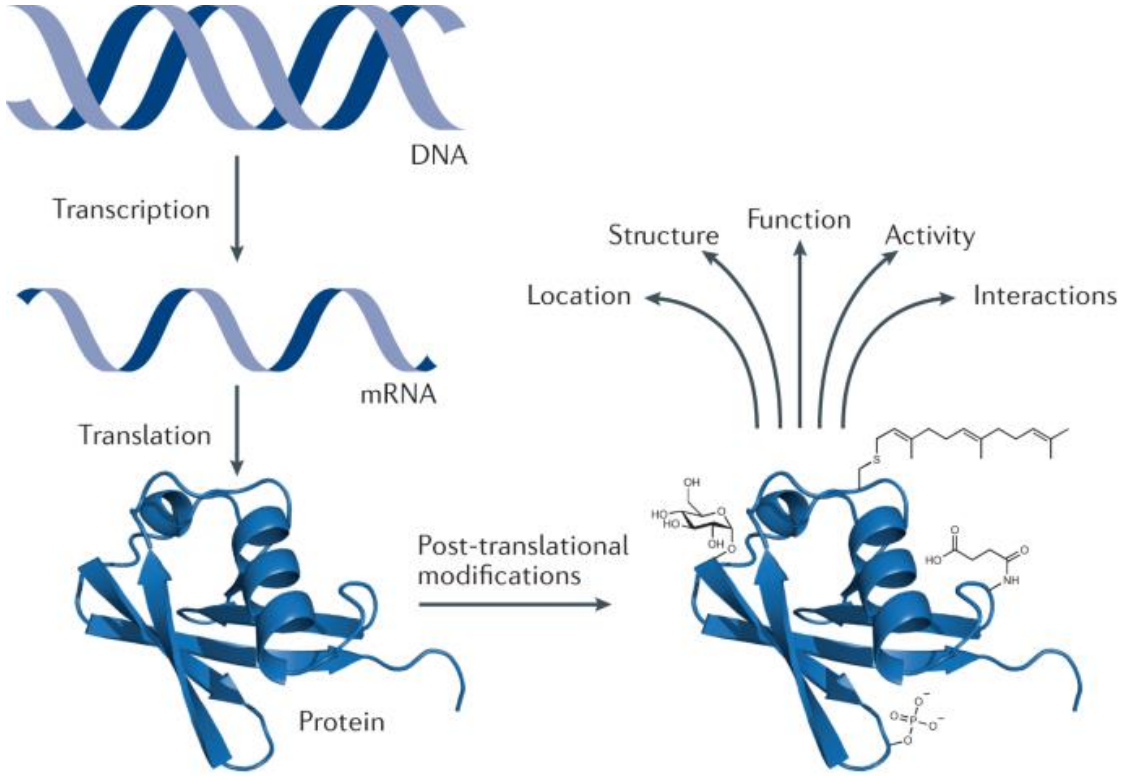
The completed polypeptide chain is released, and the ribosomal subunits <u>disassemble</u>.

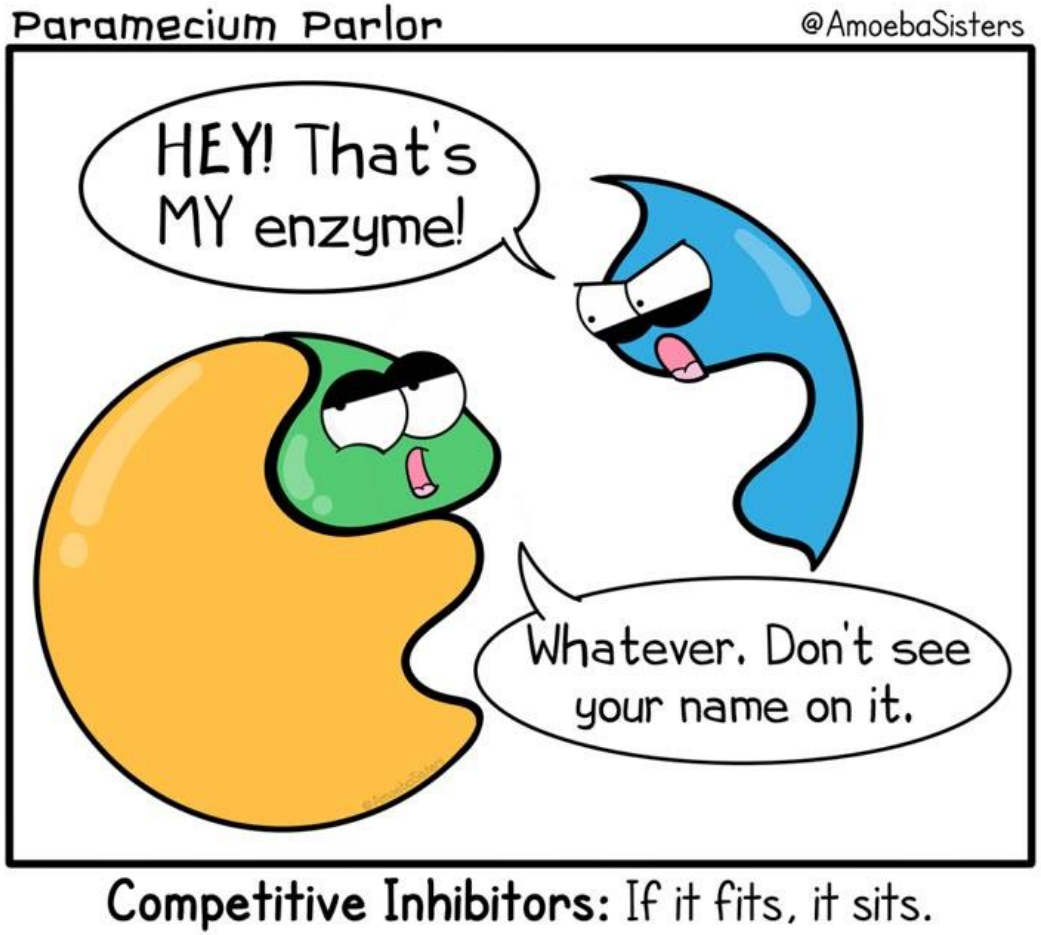


3. **Post-Translational Modifications** (if applicable)

- The new protein may undergo further modifications, such as folding, cleavage, or the addition of functional groups, which are essential for its final functional form.

Once fully finished, the Golgi Body packages the protein and sends it out to do its job




Paramecium Parlor
@AmoebaSisters
HEY! That's MY enzyme!
Whatever. Don't see your name on it.
Competitive Inhibitors: If it fits, it sits.

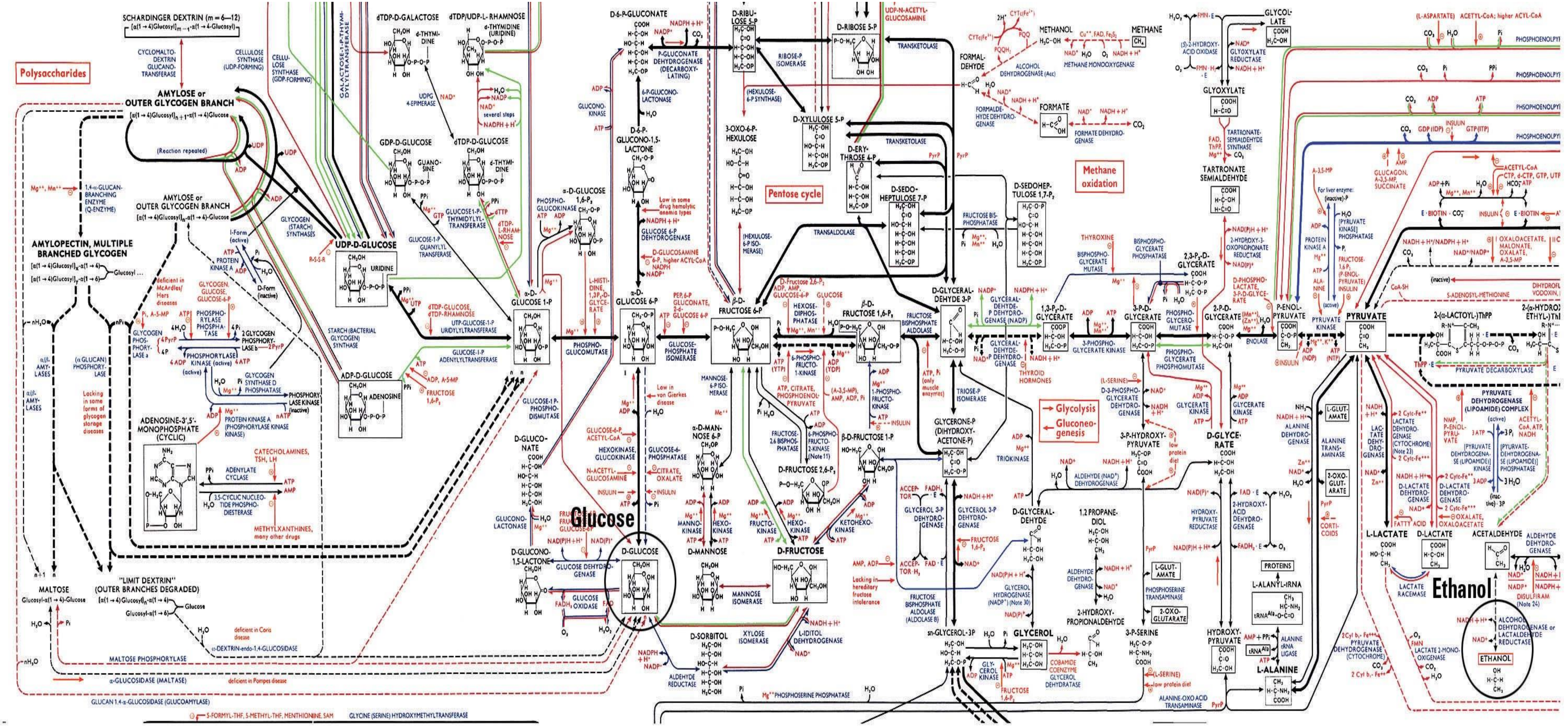

Enzyme
Substrate
Substrate
@future_biotechnology

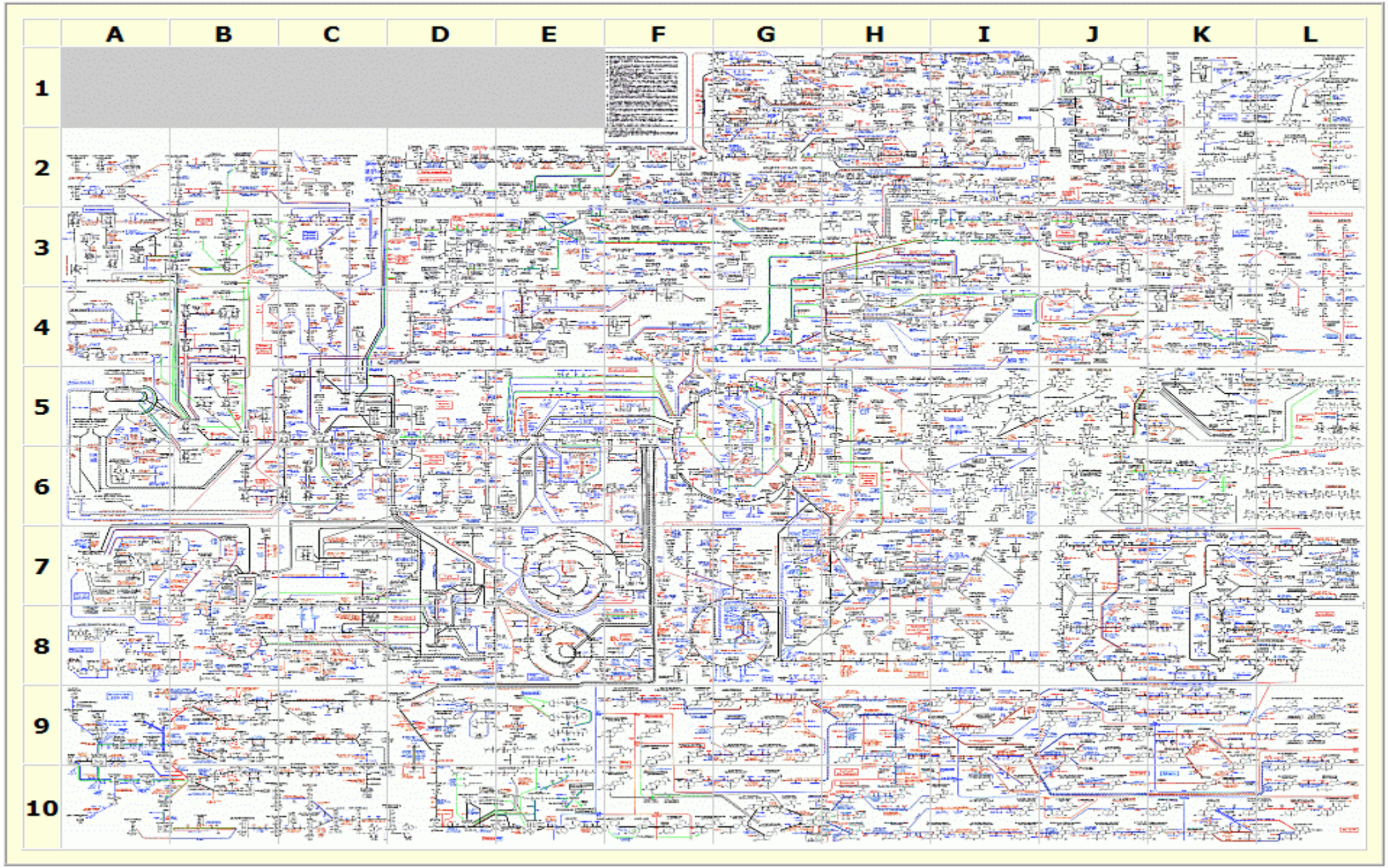
ENZYMES

What is metabolism?

- **The constant occurring reactions which are vital to the activities of the cell.**
- **These reactions do not occur randomly**
- **They occur in a metabolic pathway.**
- **It begins with a reactant(s) and ends with a product(s)**
- **Enzymes facilitate each reaction**

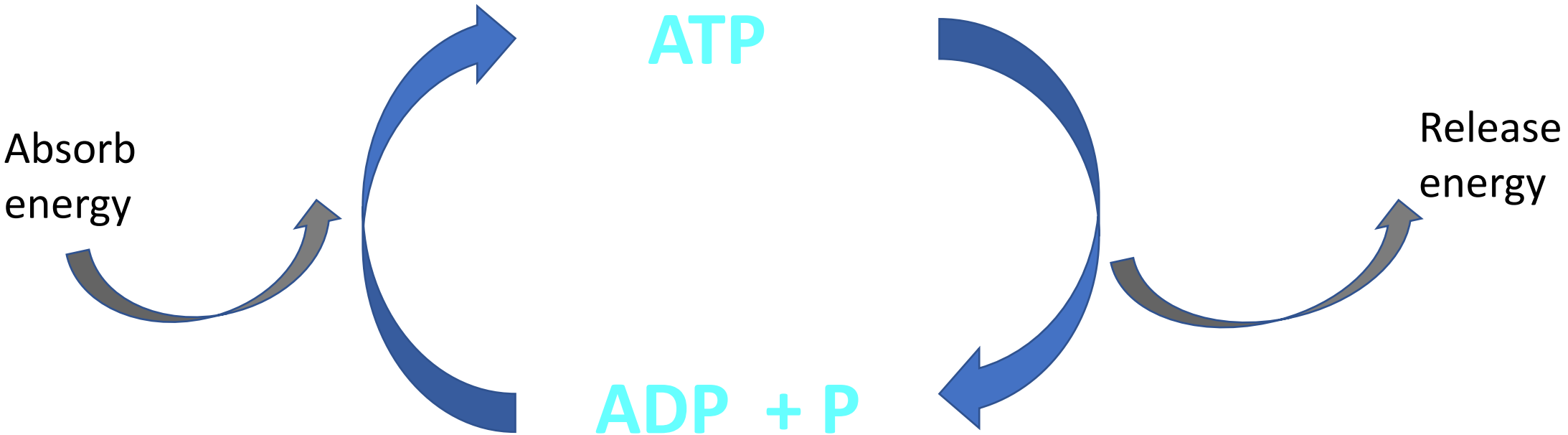
Letters = reactants or/and products (eg, B is a reactant and a product)
Numbers = enzymes


Polysaccharides
SCHARDINGER DEXTRIN (m = 6—12)
CYCLOMALTO-DEXTRIN GLUCANO-TRANSFERASE
CELLULOSE SYNTHASE (UDP-FORMING)
CELLULOSE SYNTHASE (GDP-FORMING)
AMYLOSE or OUTER GLYCOGEN BRANCH
(Reaction repeated)
1,4-α-GLUCAN-BRANCHING ENZYME (Q-ENZYME)
AMYLOPECTIN, MULTIPLE BRANCHED GLYCOGEN
GLYCOGEN (STARCH) SYNTHASES
UDP-D-GLUCOSE
ADP-D-GLUCOSE
dTDP-D-GALACTOSE
dTDP/UDP-L-RHAMNOSE
GDP-D-GLUCOSE
dTDP-D-GLUCOSE
GALACTOSE-1-P THYMIDYLYLTRANSFERASE
GLUCOSE-1-P THYMIDYLYLTRANSFERASE
GLUCOSE-1-P GUANYLYLTRANSFERASE
UTP-GLUCOSE-1-P URIDYLYLTRANSFERASE
GLUCOSE-1-P ADENYLYLTRANSFERASE
STARCH (BACTERIAL GLYCOGEN) SYNTHASE
GLYCOGEN PHOSPHORYLASE a
PHOSPHORYLASE PHOSPHATASE
PHOSPHORYLASE KINASE
GLYCOGEN SYNTHASE D PHOSPHATASE
PROTEIN KINASE A
ADENOSINE-3',5'-MONOPHOSPHATE (CYCLIC)
ADENYLATE CYCLASE
3,5-CYCLIC NUCLEOTIDE PHOSPHODIESTERASE
CATECHOLAMINES, TSH, LH
METHYLXANTHINES, many other drugs
α/β-AMYLASES
(α GLUCAN) PHOSPHORYLASE
MALTOSE
"LIMIT DEXTRIN" (OUTER BRANCHES DEGRADED)
α-DEXTRIN-endo-1,6-α-GLUCOSIDASE
MALTOSE PHOSPHORYLASE
α-GLUCOSIDASE (MALTASE)
deficient in Pompes disease
GLUCAN 1,4-α-GLUCOSIDASE (GLUCOAMYLASE)
5-FORMYL-THF, 5-METHYL-THF, METHIONINE, SAM
GLYCINE (SERINE) HYDROXYMETHYLTRANSFERASE
α-D-GLUCOSE 1-P
α-D-GLUCOSE 1,6-P2
PHOSPHOGLUCOMUTASE
α-D-GLUCOSE 6-P
GLUCOSE-6-P DEHYDROGENASE
D-GLUCONO-1,5-LACTONE 6-P
6-P-GLUCONOLACTONASE
D-6-P-GLUCONATE
P-GLUCONATE DEHYDROGENASE (DECARBOXYLATING)
GLUCONOKINASE
D-GLUCONATE
D-GLUCONO-1,5-LACTONE
GLUCONOLACTONASE
GLUCOSE DEHYDROGENASE
GLUCOSE OXIDASE
Glucose
D-GLUCOSE
HEXOKINASE, GLUCOKINASE
GLUCOSE-6-PHOSPHATASE
GLUCOSE-1-P PHOSPHODISMUTASE
GLUCOSE-PHOSPHATE ISOMERASE
β-D-FRUCTOSE 6-P
β-D-FRUCTOSE 1,6-P2
HEXOSE-DIPHOSPHATASE
6-PHOSPHOFRUCTO-1-KINASE
6-PHOSPHOFRUCTO-2-KINASE
FRUCTOSE-2,6-BISPHOSPHATASE
D-FRUCTOSE 2,6-P2
β-D-FRUCTOSE 1-P
1-PHOSPHOFRUCTOKINASE
α-D-MANNOSE 6-P
MANNOSE-6-P ISOMERASE
D-MANNOSE
MANNOKINASE
HEXOKINASE
FRUCTOKINASE
KETOHEXOKINASE
D-FRUCTOSE
MANNOSE ISOMERASE
D-SORBITOL
XYLOSE ISOMERASE
L-IDITOL DEHYDROGENASE
ALDEHYDE REDUCTASE
Lacking in hereditary fructose intolerance
FRUCTOSE BISPHOSPHATE ALDOLASE (ALDOLASE B)
D-RIBULOSE 5-P
RIBOSE-P ISOMERASE
D-RIBOSE 5-P
TRANSKETOLASE
D-XYLULOSE 5-P
3-OXO-6-P-HEXULOSE
(HEXULOSE-6-P SYNTHASE)
(HEXULOSE-6-P ISOMERASE)
Pentose cycle
D-ERYTHROSE 4-P
D-SEDOHEPTULOSE 7-P
D-SEDOHEPTULOSE 1,7-P2
FRUCTOSE BISPHOSPHATASE
TRANSALDOLASE
D-GLYCERALDEHYDE 3-P
FRUCTOSE BISPHOSPHATE ALDOLASE
TRIOSE-P ISOMERASE
GLYCERONE-P (DIHYDROXYACETONE-P)
TRIOKINASE
GLYCERALDEHYDE-P DEHYDROGENASE (NADP)
GLYCERALDEHYDE-P DEHYDROGENASE
1,3-P2-D-GLYCERATE
3-PHOSPHOGLYCERATE KINASE
3-P-D-GLYCERATE
BISPHOSPHOGLYCERATE MUTASE
BISPHOSPHOGLYCERATE PHOSPHATASE
2,3-P2-D-GLYCERATE
PHOSPHOGLYCEROMUTASE
PHOSPHOGLYCERATE PHOSPHOMUTASE
2-P-D-GLYCERATE
ENOLASE
P-ENOL-PYRUVATE
PYRUVATE KINASE
PYRUVATE
Glycolysis
Gluconeogenesis
THYROXINE
THYROID HORMONES
GLYCEROL 3-P DEHYDROGENASE
sn-GLYCEROL-3P
GLYCEROL KINASE
GLYCEROL
GLYCEROL HYDROGENASE (NADP+)
GLYCEROL DEHYDRATASE
D-GLYCERALDEHYDE
ALDEHYDE (NAD+) DEHYDROGENASE
1,2 PROPANEDIOL
2-HYDROXYPROPIONALDEHYDE
D-3-PHOSPHOGLYCERATE DEHYDROGENASE
3-P-HYDROXYPYRUVATE
PHOSPHOSERINE TRANSAMINASE
3-P-SERINE
PHOSPHOSERINE PHOSPHATASE
D-GLYCERATE
GLYCERATE KINASE
HYDROXYPYRUVATE REDUCTASE
2-HYDROXY-ACID DEHYDROGENASE
HYDROXYPYRUVATE
ALANINE-OXO ACID TRANSAMINASE
L-ALANINE
L-ALANYL-tRNA
ALANINE tRNA LIGASE
PROTEINS
TARTRONATE SEMIALDEHYDE
TARTRONATE-SEMIALDEHYDE SYNTHASE
2-HYDROXY-3-OXOPROPIONATE REDUCTASE
GLYOXYLATE
GLYOXYLATE REDUCTASE
GLYCOLLATE
(S)-2-HYDROXY-ACID OXIDASE
METHANOL
METHANE
METHANE MONOOXYGENASE
ALCOHOL DEHYDROGENASE (Acc)
FORMALDEHYDE
FORMALDEHYDE DEHYDROGENASE
FORMATE
FORMATE DEHYDROGENASE
Methane oxidation
PHOSPHOENOLPYRUVATE
GLUCAGON, A-3,5-MP, SUCCINATE
ACETYL-CoA
OXALOACETATE, MALONATE, OXALATE, A-3,5-MP
S-ADENOSYL-METHIONINE
PYRUVATE DECARBOXYLASE
PYRUVATE DEHYDROGENASE (LIPOAMIDE) COMPLEX
[PYRUVATE DEHYDROGENASE (LIPOAMIDE)] KINASE
[PYRUVATE DEHYDROGENASE (LIPOAMIDE)] PHOSPHATASE
[PYRUVATE KINASE] PHOSPHATASE
ALANINE DEHYDROGENASE
ALANINE TRANSAMINASE
L-GLUTAMATE
2-OXOGLUTARATE
L-LACTATE DEHYDROGENASE
D-LACTATE DEHYDROGENASE
L-LACTATE
D-LACTATE
LACTATE RACEMASE
LACTATE 2-MONOOXIGENASE
PYRUVATE DEHYDROGENASE (CYTOCHROME)
ACETALDEHYDE
ALDEHYDE DEHYDROGENASE
DISULFIRAM
ALCOHOL DEHYDROGENASE or LACTALDEHYDE REDUCTASE
Ethanol
ETHANOL


A
B
C
D
E
F
G
H
I
J
K
L
1
2
3
4
5
6
7
8
9
10

ATP

- **Adenosine triphosphate**
- Bonds between the phosphates represent high energy bonds
- ATP cycle



Enzymes: biological catalysts

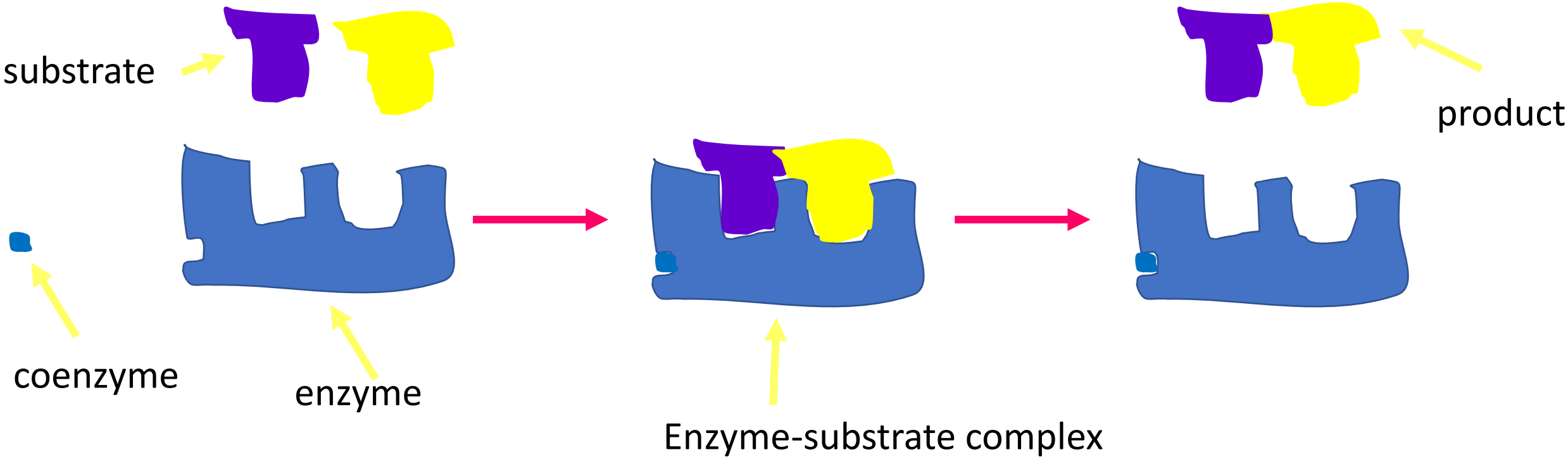
- They speed up chemical reactions without being used up in the reaction
- They are specific to a reaction meaning they speed up only one reaction
- Enzymes have an "**ase**" ending with the substrate in the name ie lipase breaks down lipids

E = enzyme
S = substrate (reactant)
ES = enzyme substrate complex
P = product

How do enzymes work?

- 2 theories:

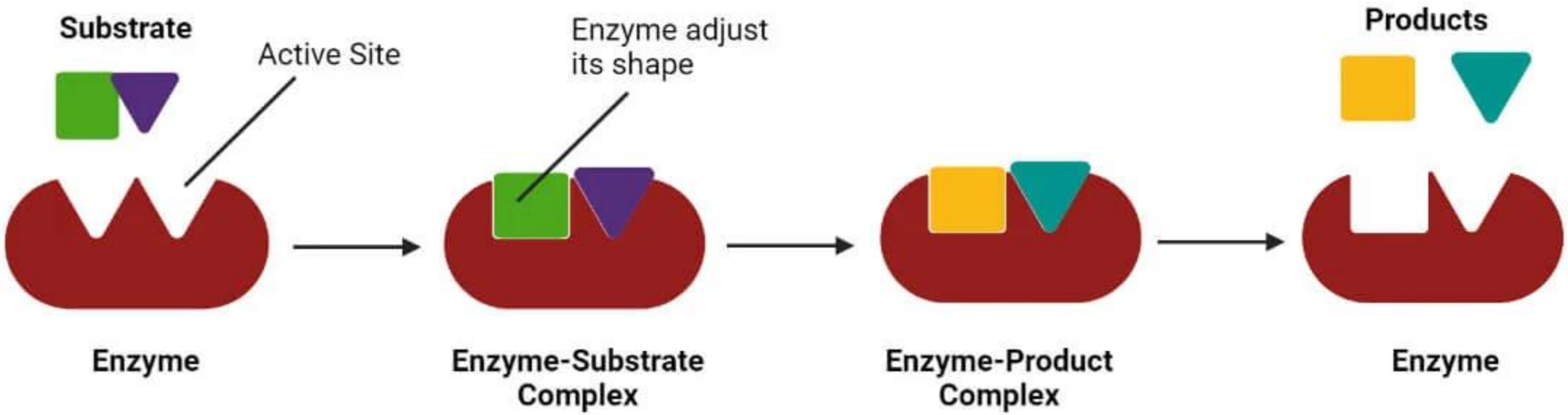
1. **Lock and key model**: the substrates are attracted the to enzyme due to their exact fit. The coenzyme must be in place in order for it to work.



2. **Induced Fit**: the enzyme's **active site** and the substrate don't fit so they both must alter their shape slightly.

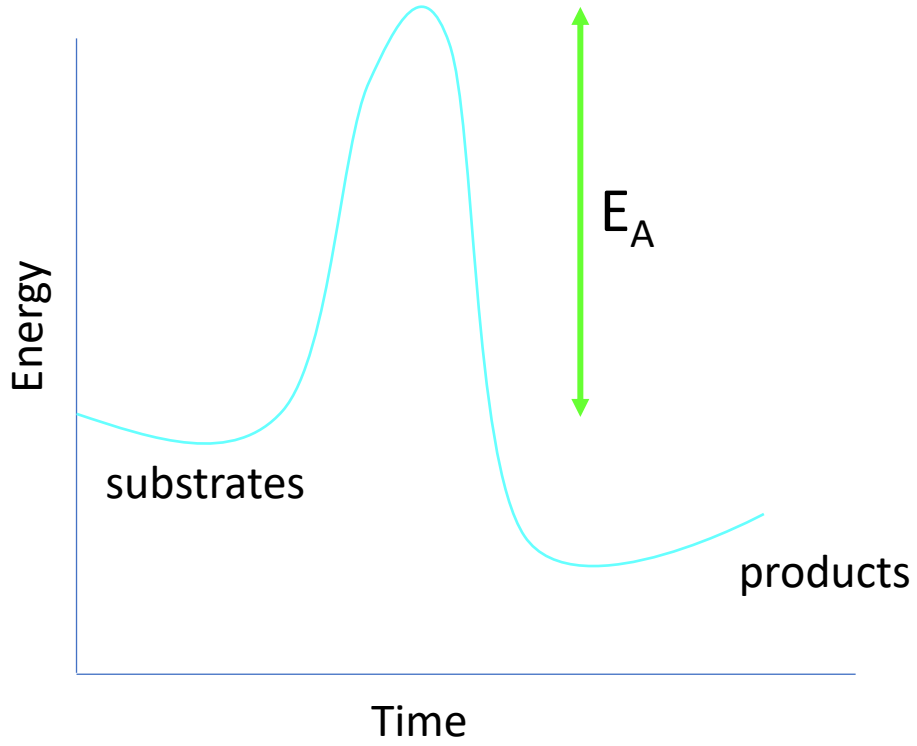
- The active site (3D protein structure) is where the reaction takes place for both the induced fit and lock and key.
- After the reaction the site has changed and it must return to its original state.

Induced Fit Model

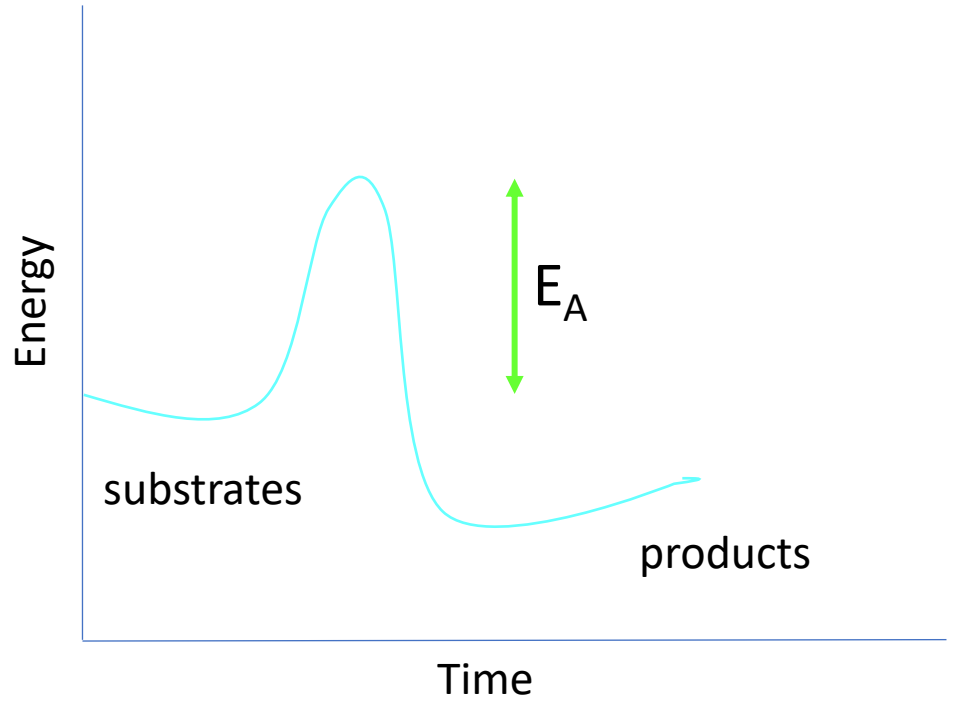


Energy Activation: E_A

- The energy that must be provided in order for the molecules to react with one another.
- Enzymes lower the energy activation so the reaction occurs sooner.



WITHOUT ENZYME

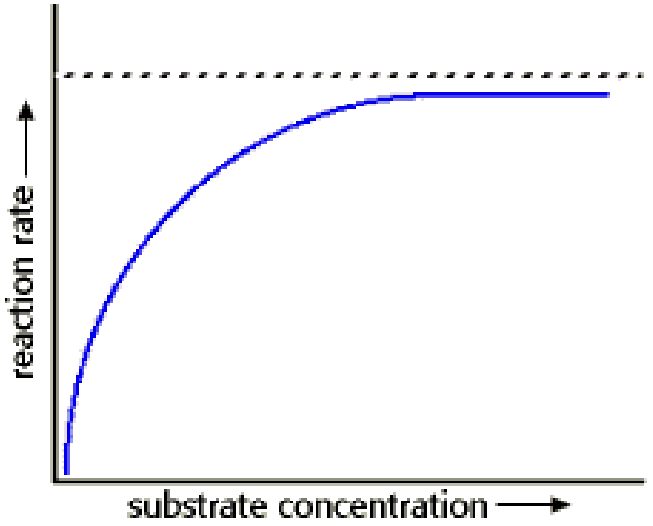


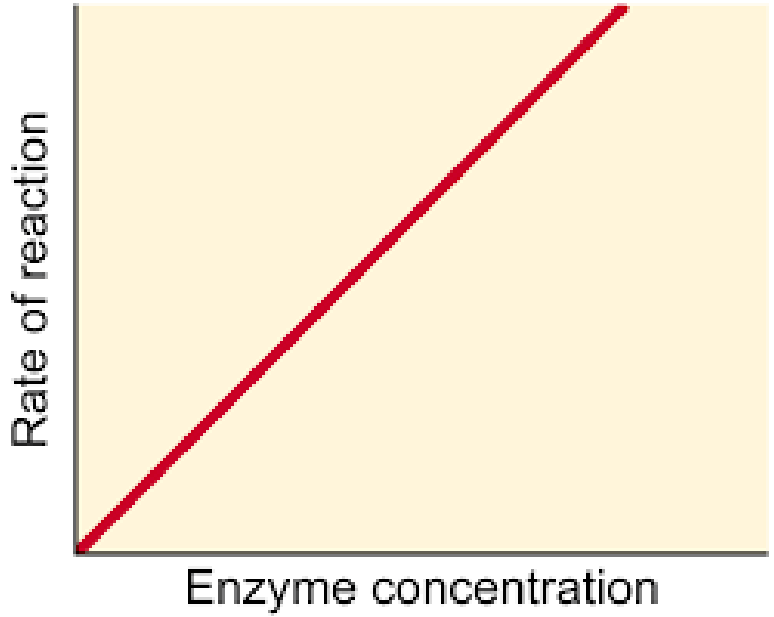
WITH ENZYME

Factors affecting Enzyme activity

1. Concentration

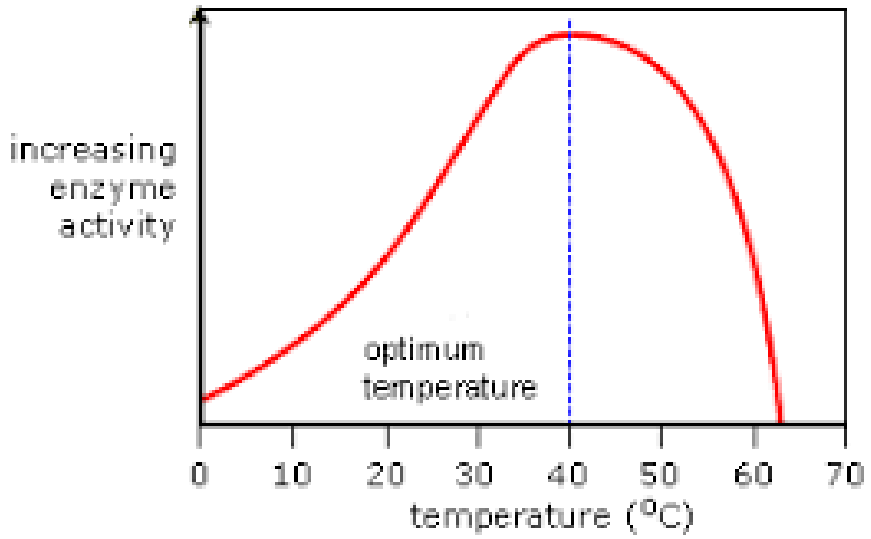
- Substrate concentration increase will increase the amount of product produced. After awhile the rate won't be affected as the enzymes are saturated
- Enzyme concentration increase will increase the amount of product so long as there is enough substrate.





2. **Temperature**:

- **Low temperature** will slow the reaction rate but normally not denature the enzyme.
- **Warm temperature** will maximize the reaction rate (ie body temp for us)
- **High temperatures** will increase the rate at first but will denature the enzyme



3. **Inhibitors**:

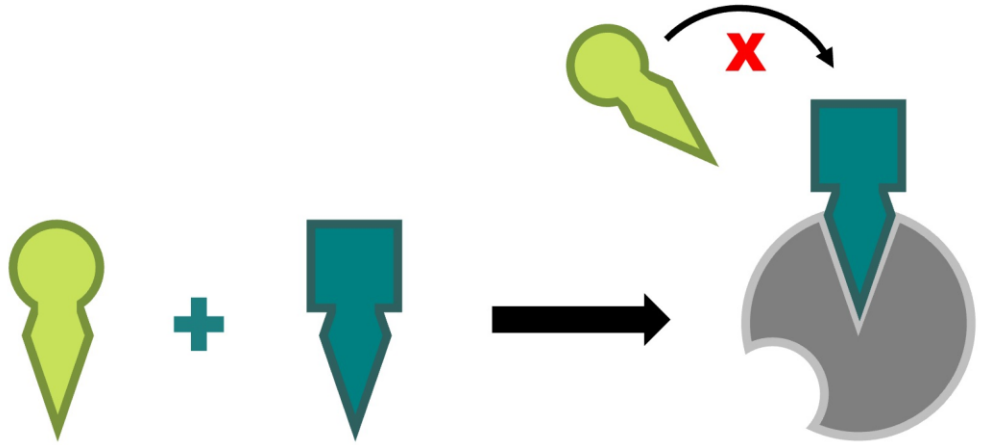
Competitive: an inhibitor that looks like the substrate will compete for the active site on an enzyme. The binding to the enzyme can be reversible or irreversible

Non-competitive: the inhibitor does not look like the substrate. The inhibitor binds to another place (not active site) on the enzyme thus causing it to change shape at the active site. The substrate can't bind.

Ie penicillin – competitive

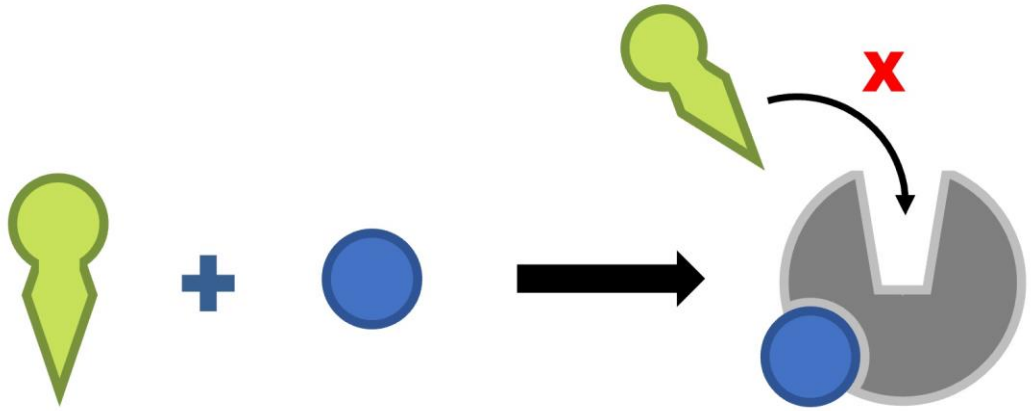
Lead, mercury& other heavy metals – non-competitive

Competitive



substrate inhibitor enzyme – inhibitor complex

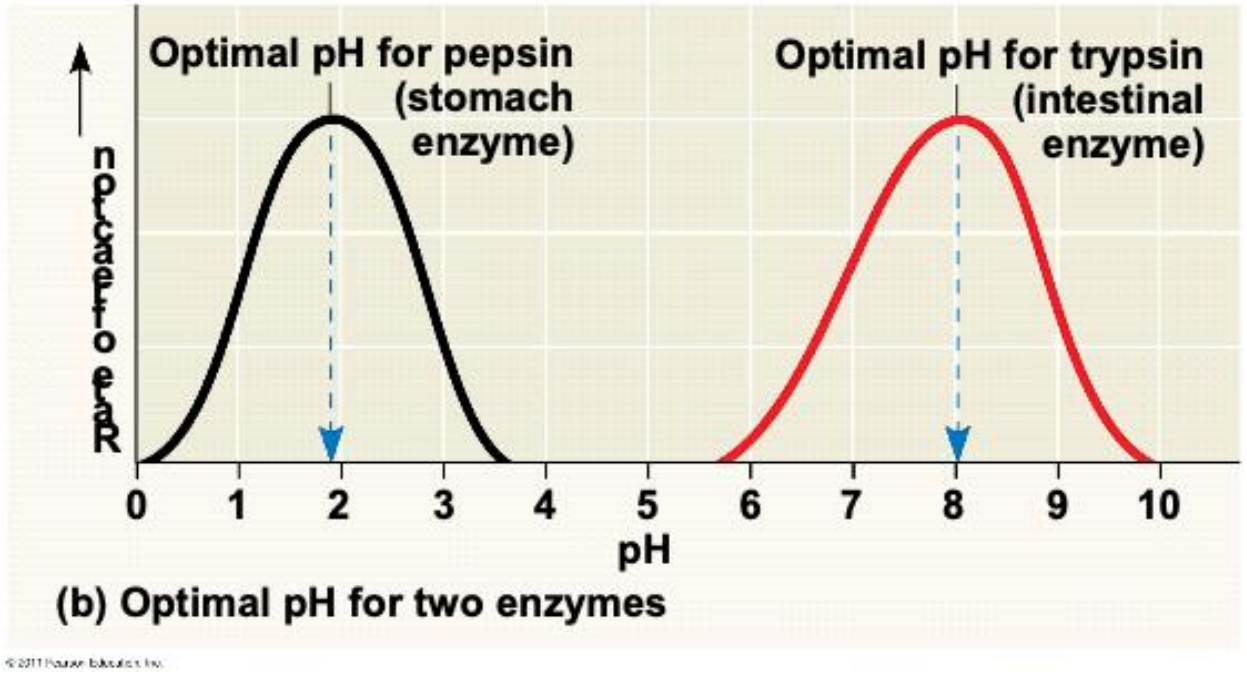
Non-Competitive

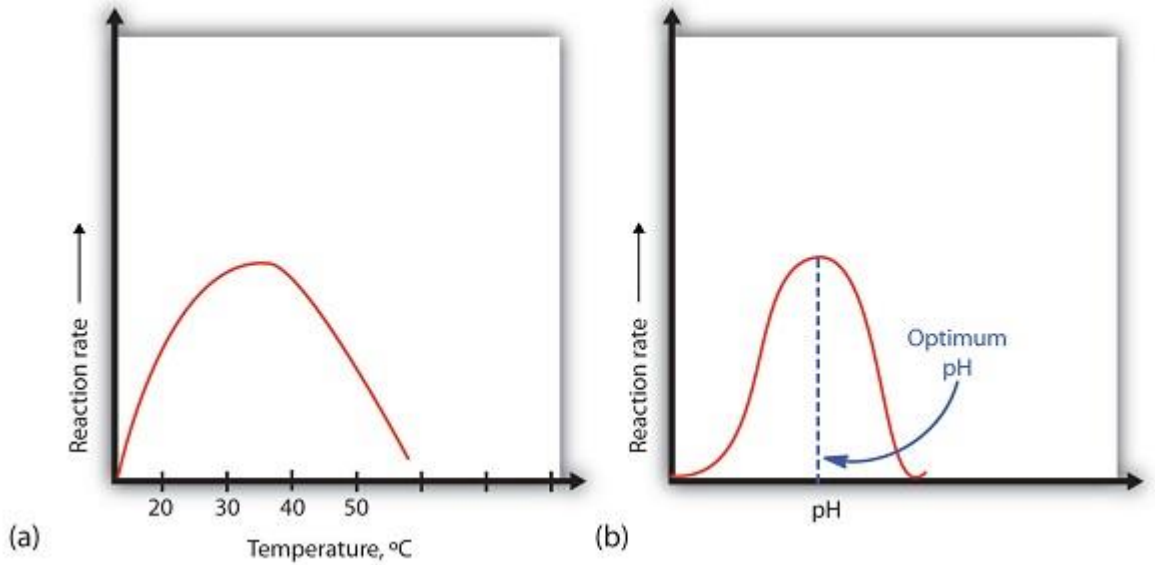


substrate inhibitor enzyme – inhibitor complex

4. pH:

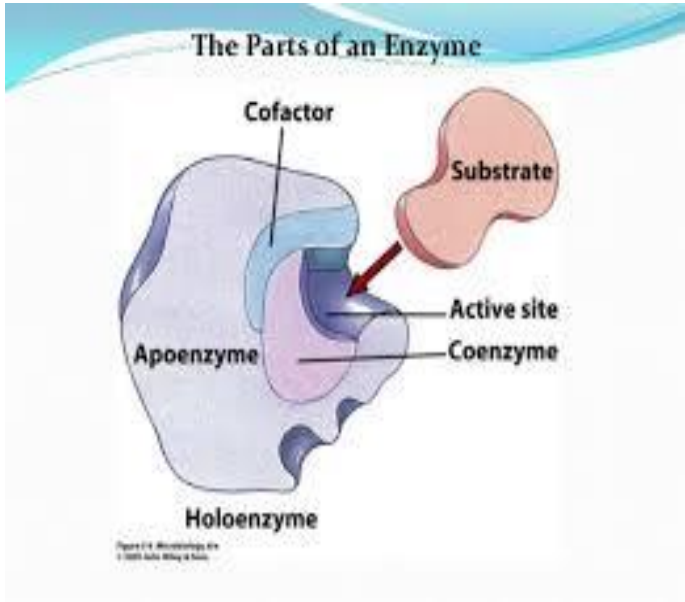
- **Optimum** pH: favourable pH
- There is no specific pH that works for all enzymes… it varies
- Any other pH will cause denaturation… in the right hand graph below, any pH besides 2 for pepsin will cause denaturation





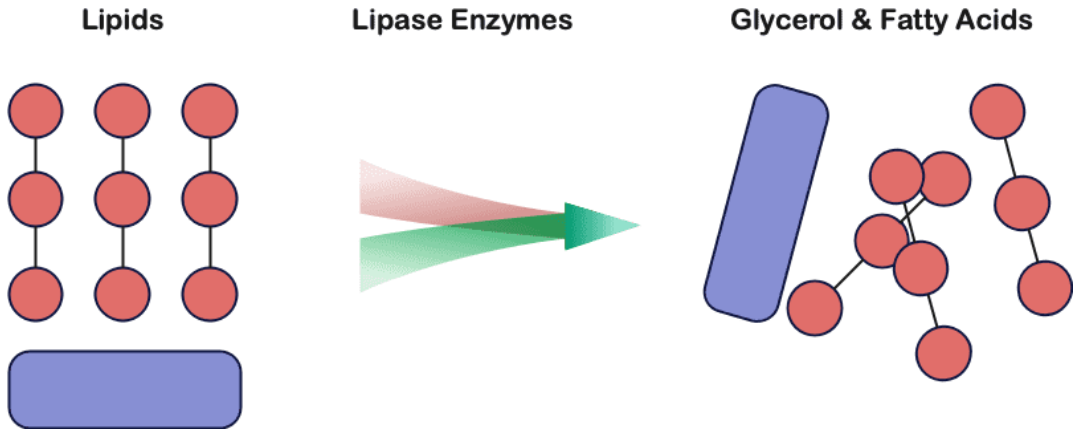
Parts of an enzyme

- **Cofactor**: the mineral, usually a metal ion, that forms part of the active site.
- **Coenzyme**: a vitamin which also forms part of the active site.
- **Apoenzyme**: where the cofactor and coenzyme attach. It is the protein part of the enzyme and is responsible for specificity and "speeding up" function.
- **Holoenzyme**: cofactor + coenzyme + apoenzyme



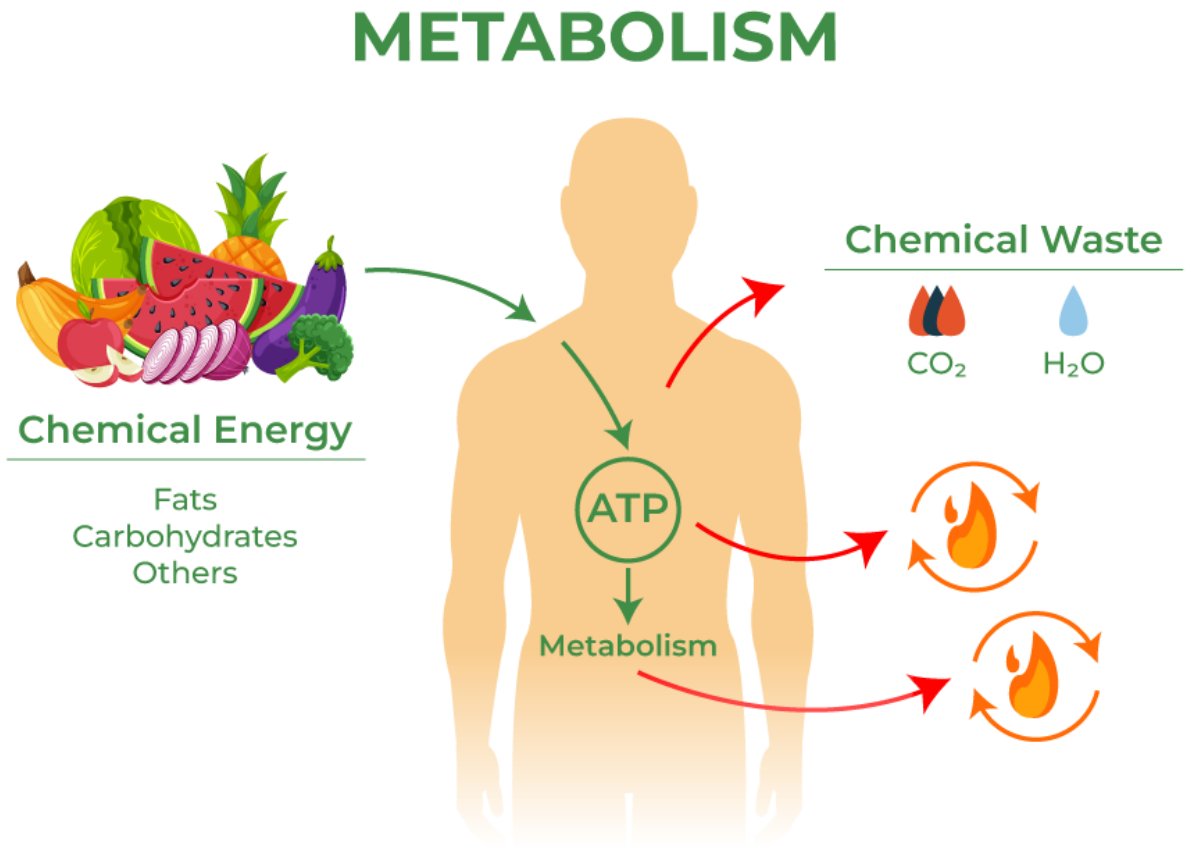
Examples of Substrates & Their Enzymes

- Lipid → Lipase
- Urea → Urease
- Maltose → Maltase
- Ribonucleic Acid → Ribonuclease
- Lactose → Lactase

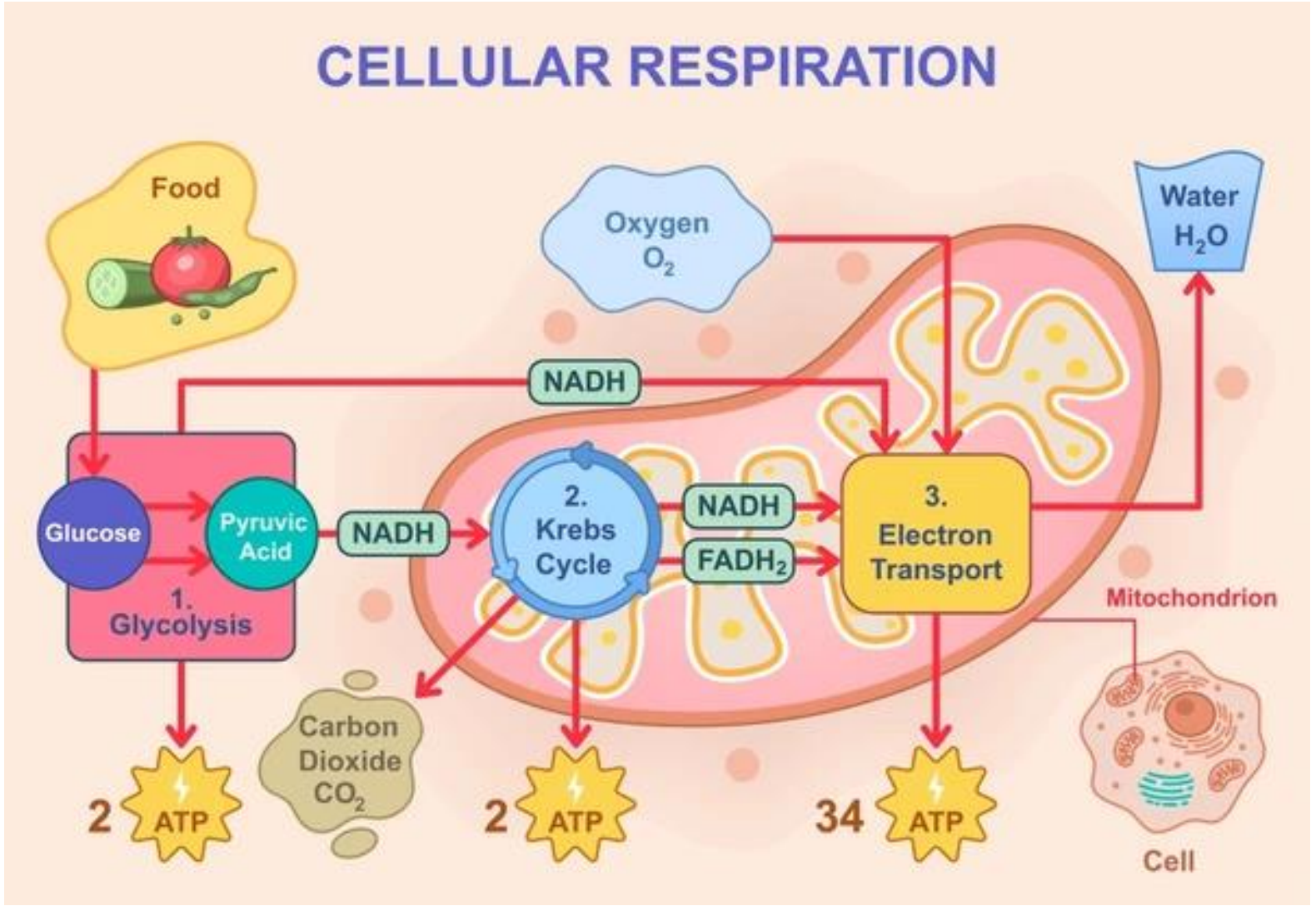


Metabolism

Metabolism is the collection of chemical processes within the body's cells that convert food and drinks into energy. This energy is vital for all bodily functions, including breathing, moving, thinking, growing, repairing cells, and maintaining body temperature. Metabolism runs continuously, providing the energy needed for survival and performing every task, from the smallest cellular activity to the largest movements.

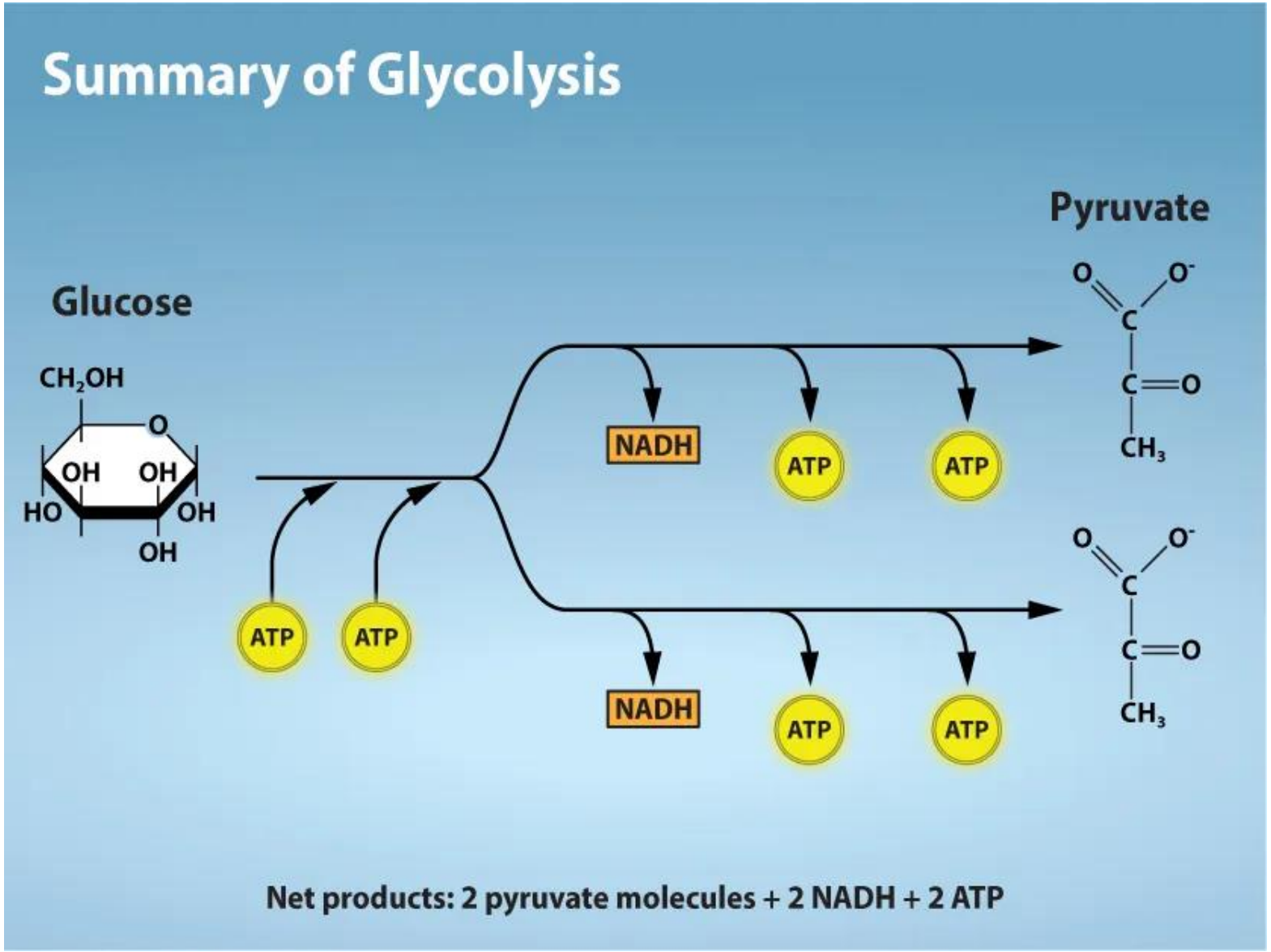


Steps of Metabolism (Cellular Respiration)



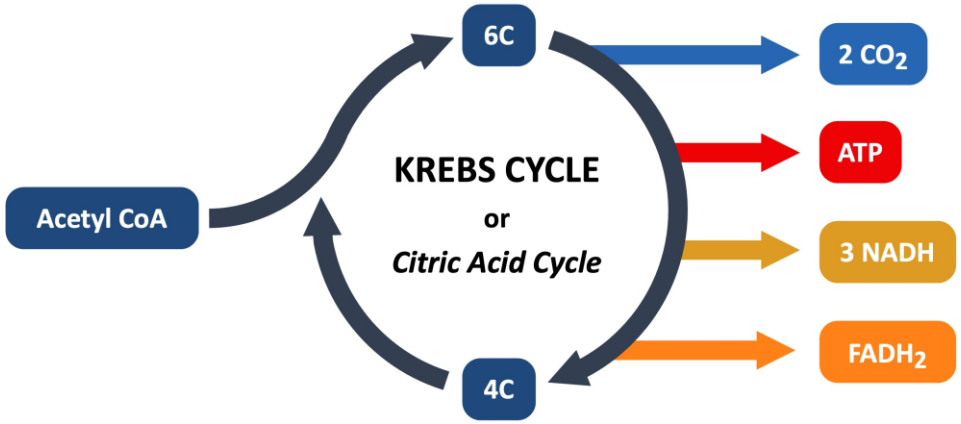
Glycolysis

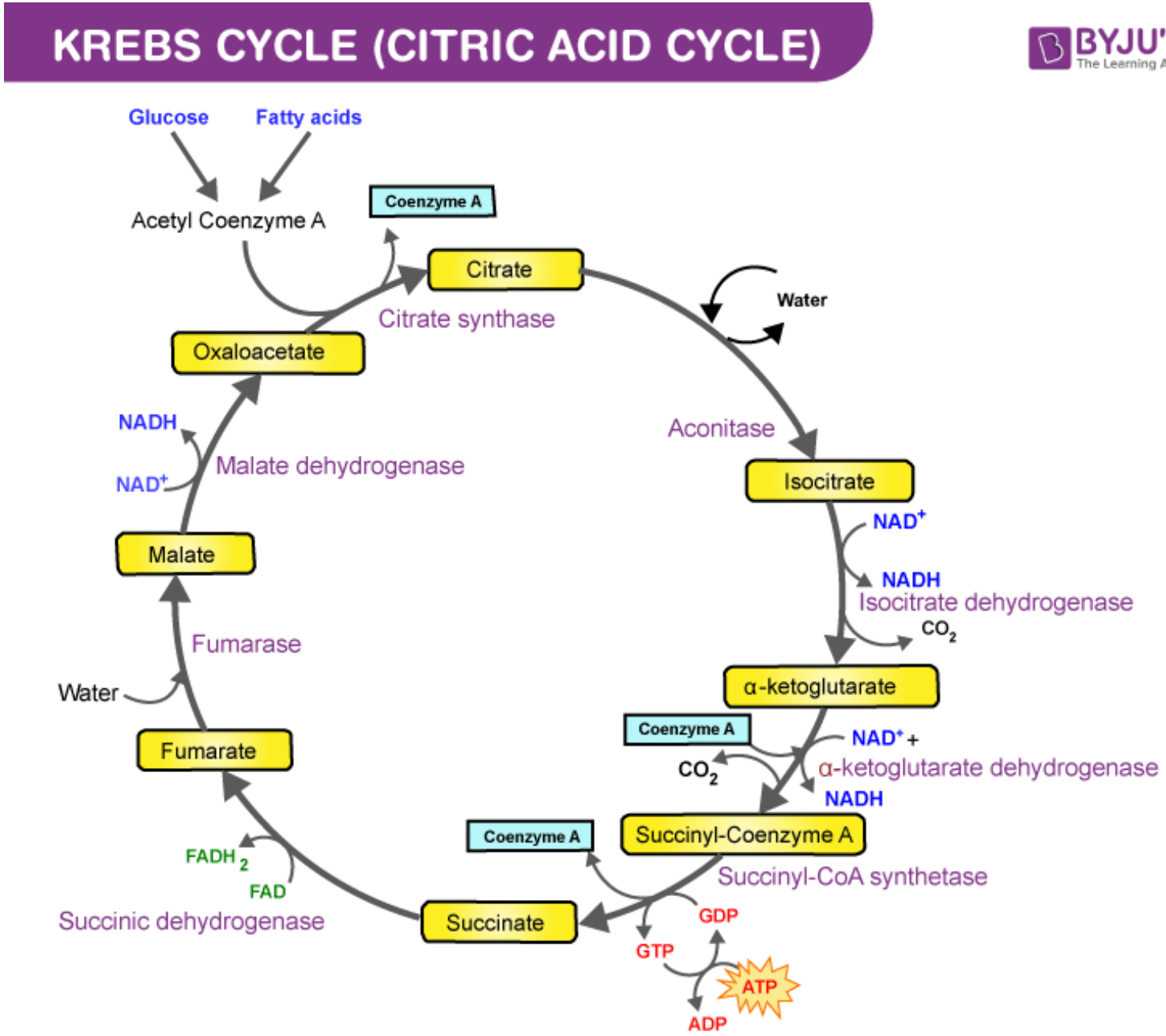
Occurs in Cytoplasm



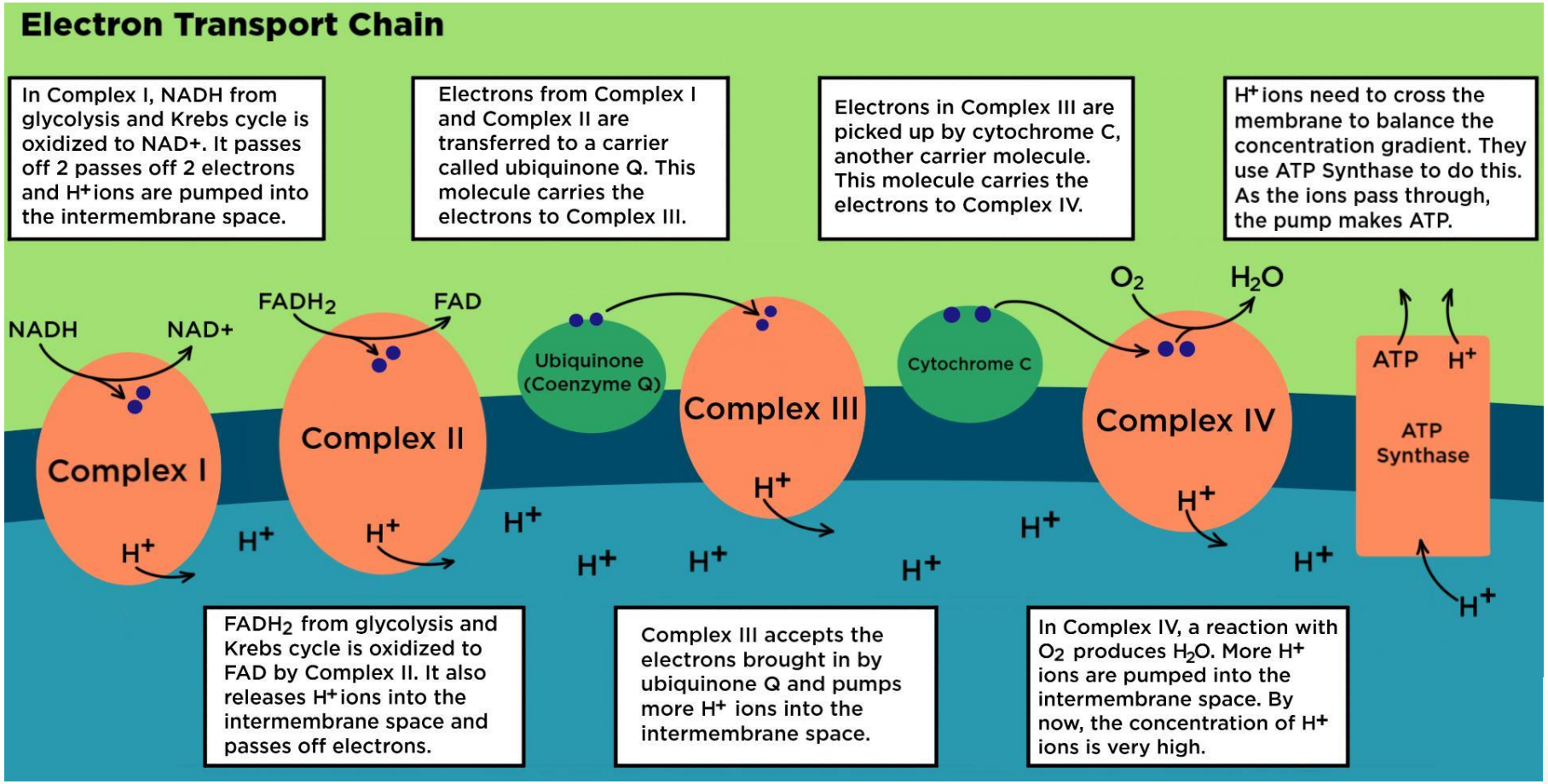
Krebs Cycle

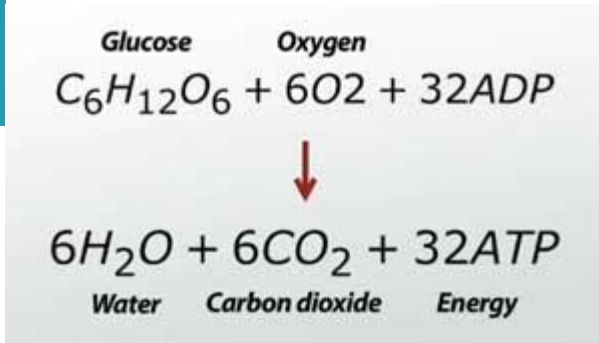
Occurs in Mitochondria

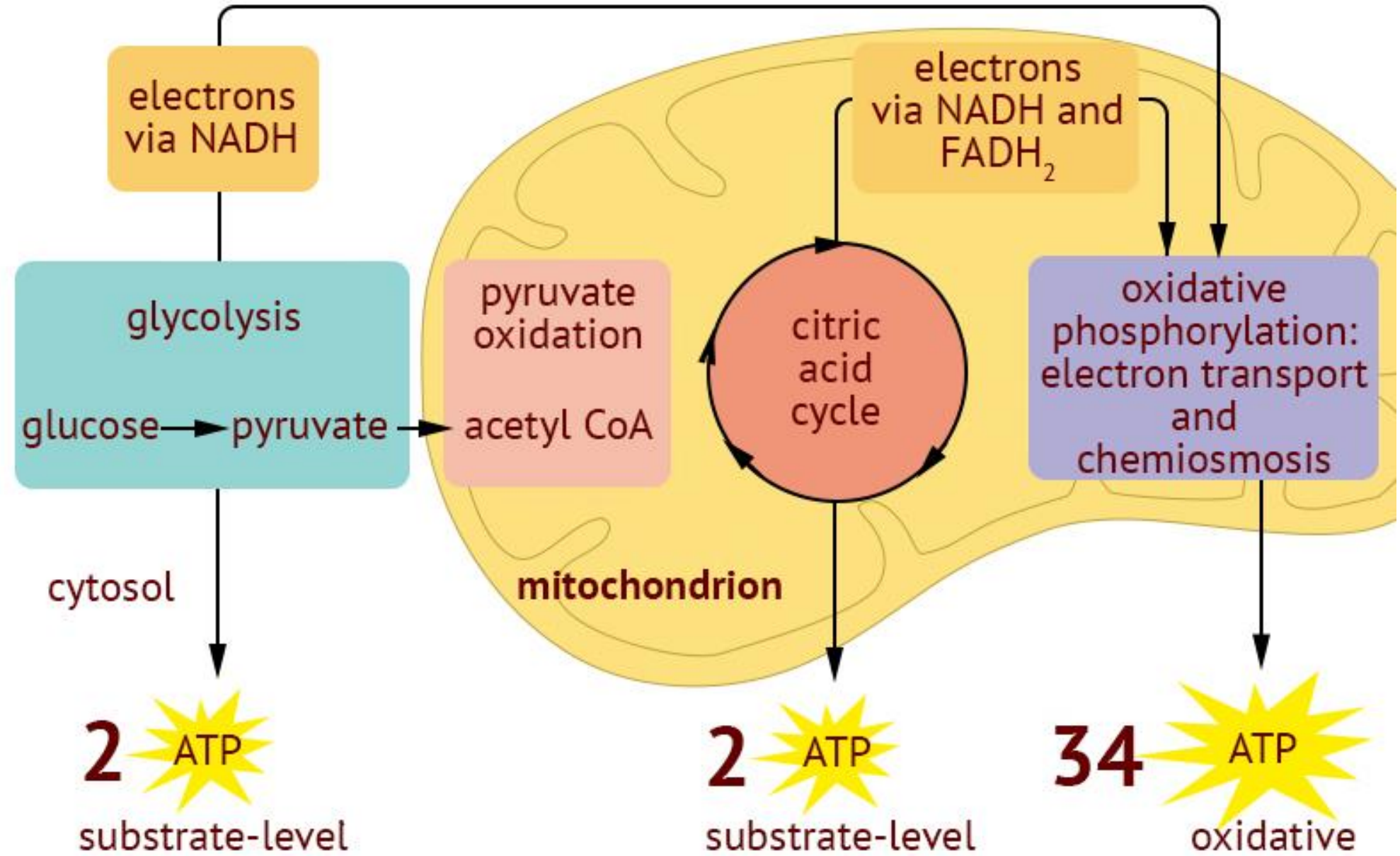




Electron Transport Chain (Mitochondria)






electrons via NADH
electrons via NADH and $FADH_2$
glycolysis
glucose → pyruvate
pyruvate oxidation
acetyl CoA
citric acid cycle
oxidative phosphorylation: electron transport and chemiosmosis
cytosol
mitochondrion
2 ATP
substrate-level
2 ATP
substrate-level
34 ATP
oxidative