

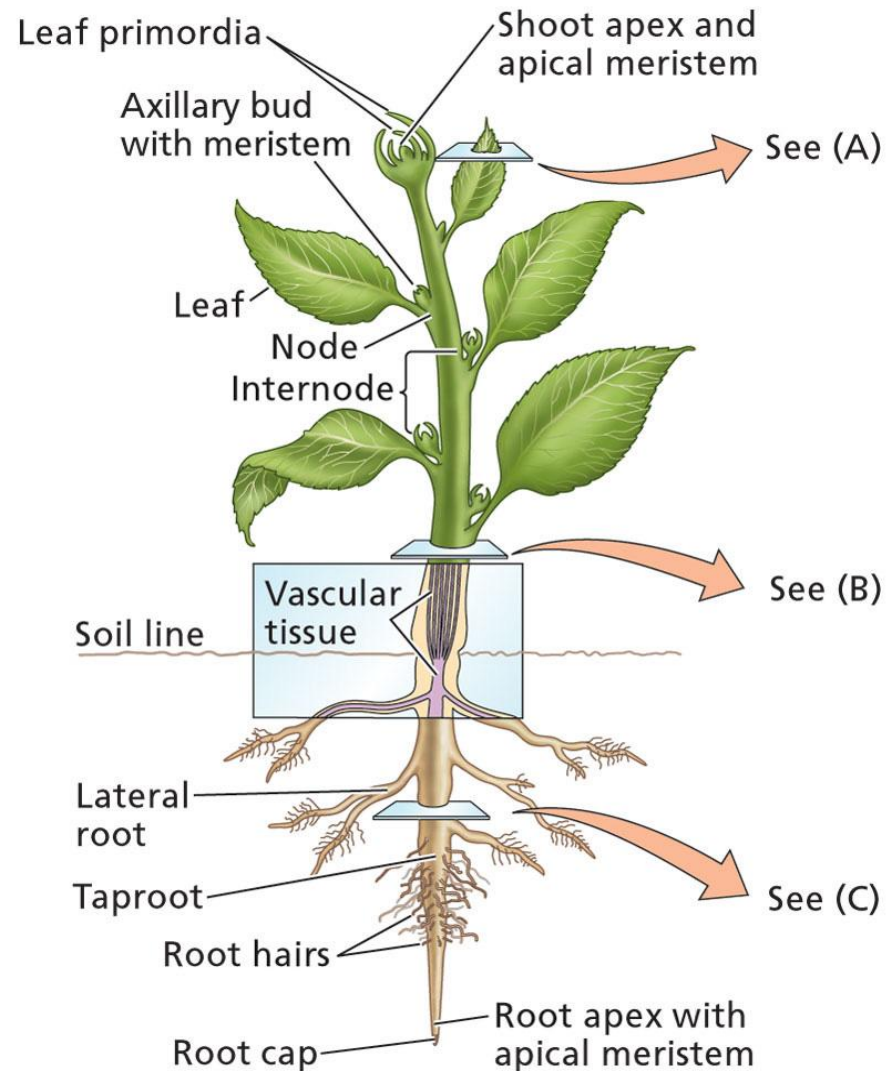
Plant Cells

Overview of Plant Structure

- Plants are Earth's Primary Producers
 - Harvest Energy from sunlight by converting **light** energy into **chemical** energy
- They store this Chemical Energy in bonds formed when they synthesize **Carbohydrates** from Carbon Dioxide and Water.
- Non- motile
 - Have evolved to grow towards resources throughout their life span.

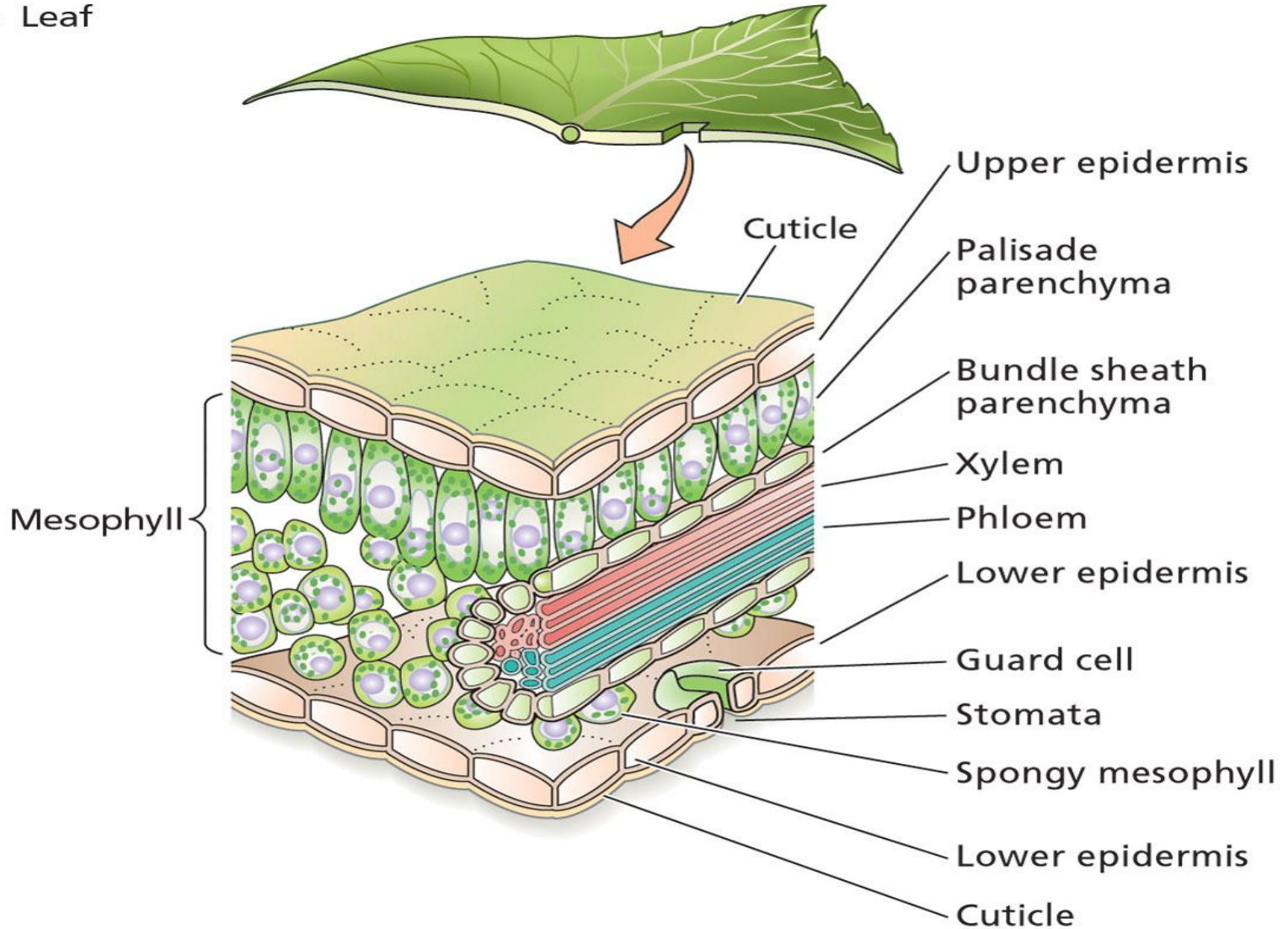
Overview of Plant Structure

- The vegetative body consists of:
- **Leaf:** *Photosynthesis*
- **Stem:** *Support*
- **Roots:** *anchorage* and absorption of *water* & *minerals*.
- **Nodes:** leaf attached to stem.
- **Internode:** Region of stem between two nodes



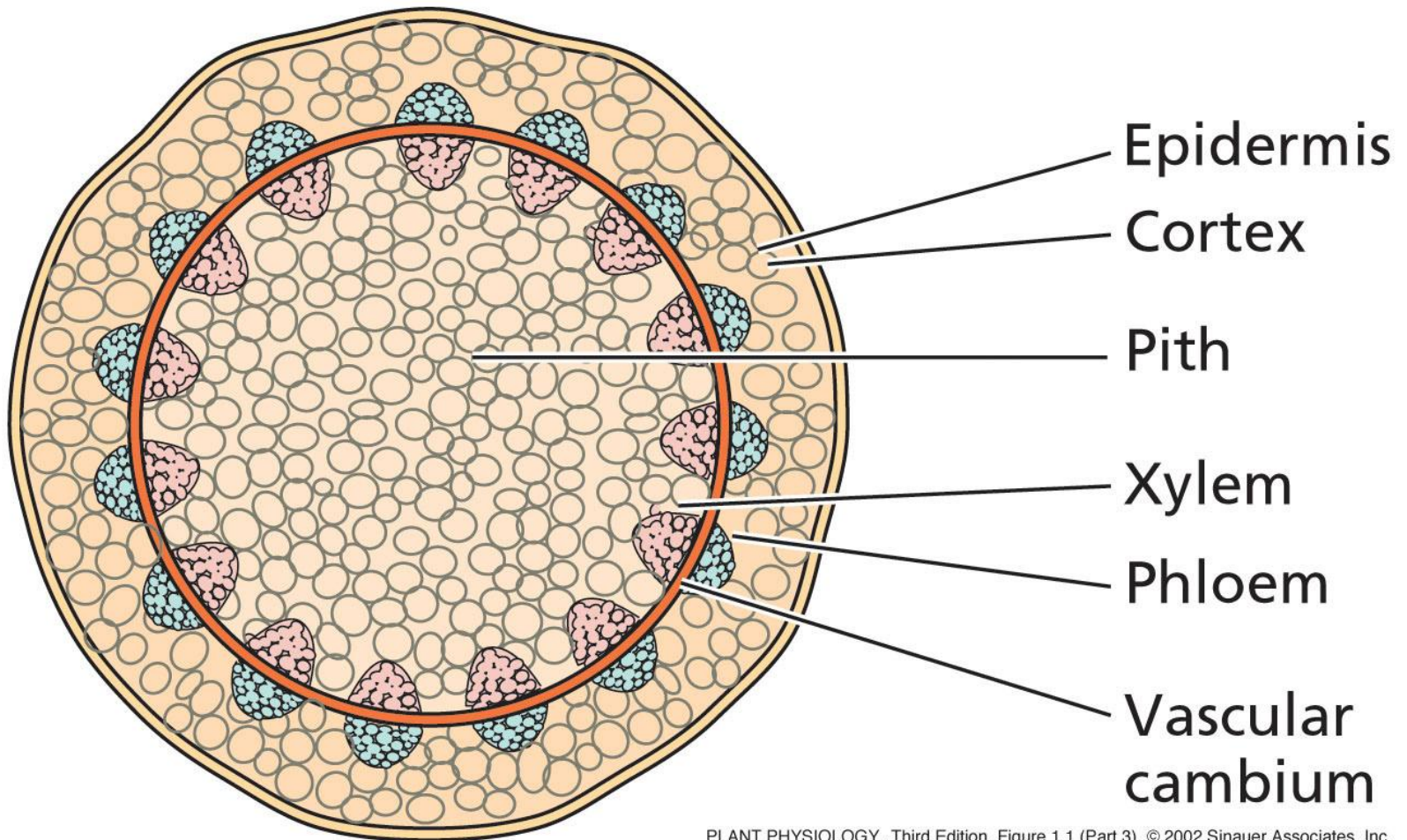
The leaf

(A) Leaf



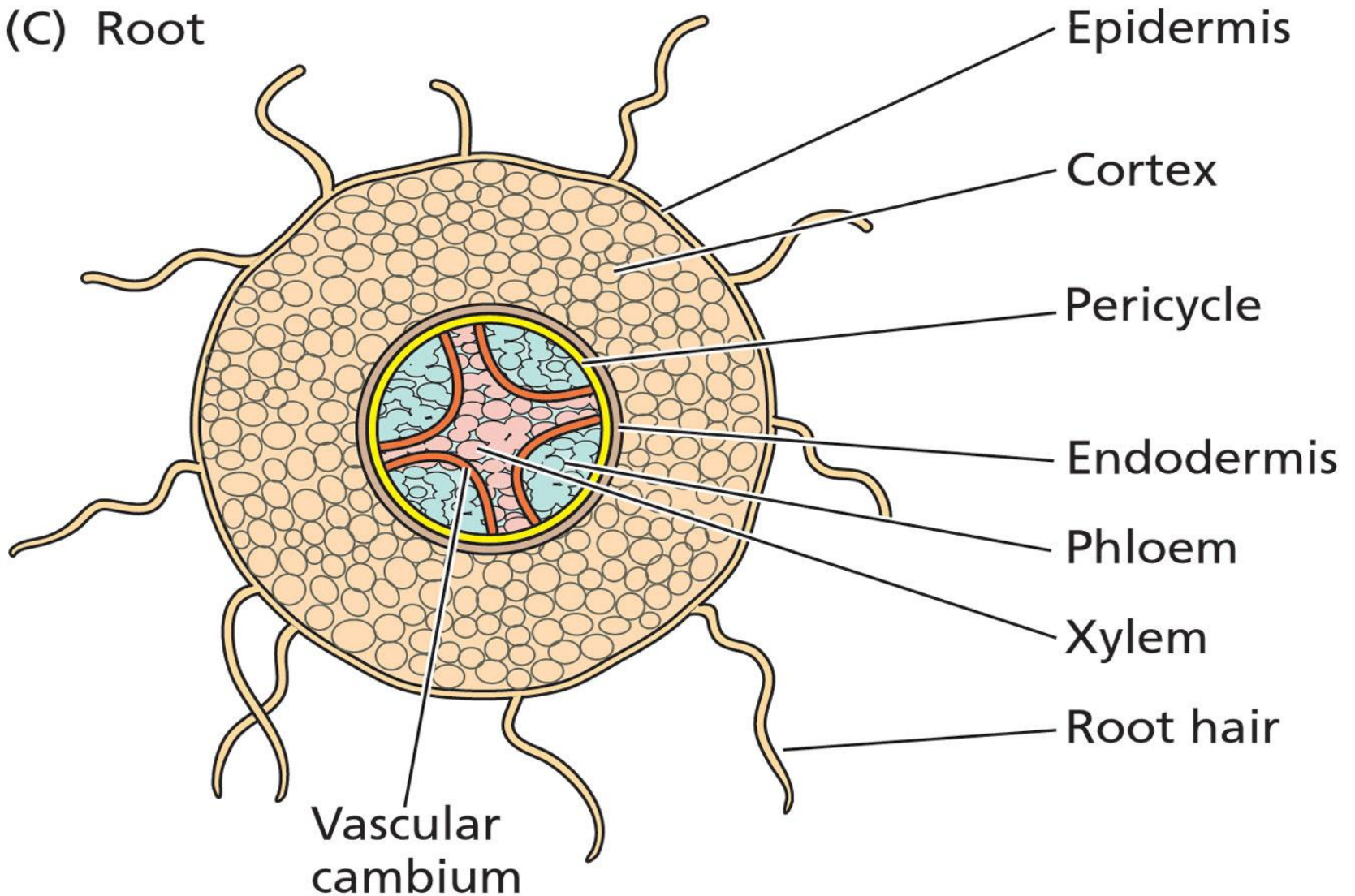
The stem

(B) Stem



The Root

(C) Root



Overview of Plant Structure

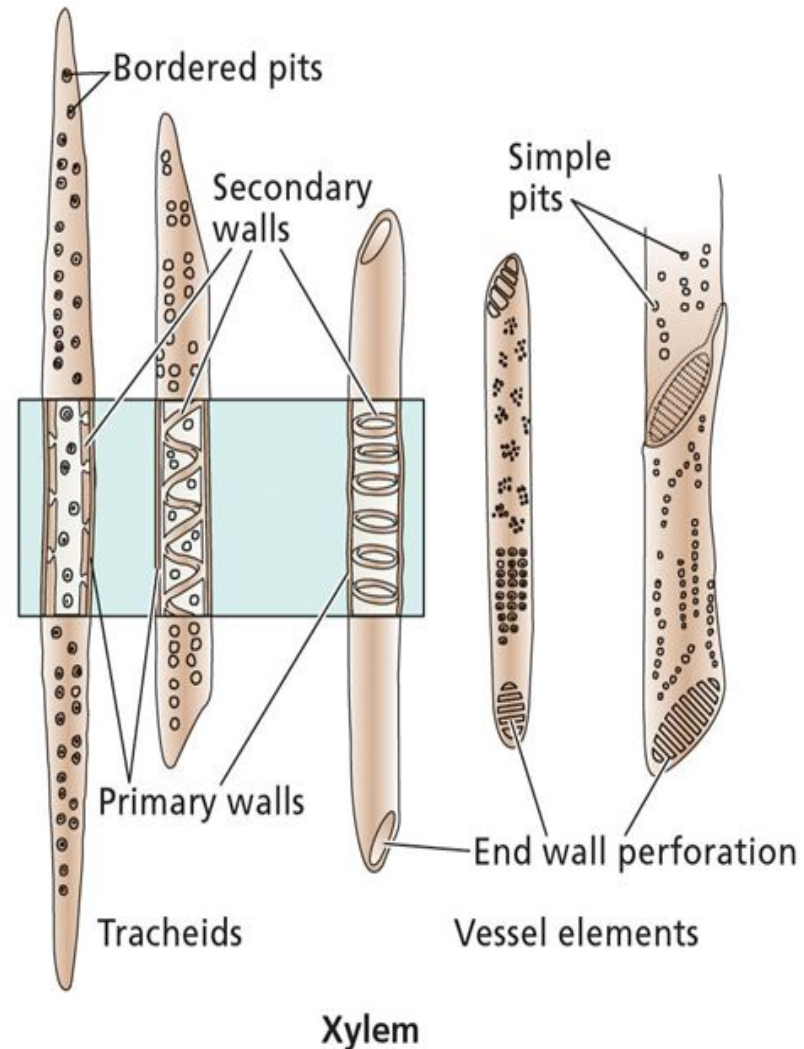
- Two general types of plants:
- **Angiosperms:**
 - More advanced type of plant
 - About 250,000 species known
 - Major innovation is the Flower
 - So these are also known as flowering plants!
- **Gymnosperms:**
 - Less advanced than angiosperms
 - About 700 species known
 - Largest group is the conifer (cone bearer)
 - ie, pine, fir, spruce, and redwood

Overview of Plant Structure

• Xylem:

- Main water-conducting tissue of vascular plants.
- arise from individual cylindrical cells oriented end to end.
- At maturity the end walls of these cells dissolve away and the cytoplasmic contents die.
- **The result is the xylem vessel, a continuous nonliving duct.**
- carry water and some dissolved solutes, such as inorganic ions, up the plant

(E) Vascular tissue: xylem and phloem



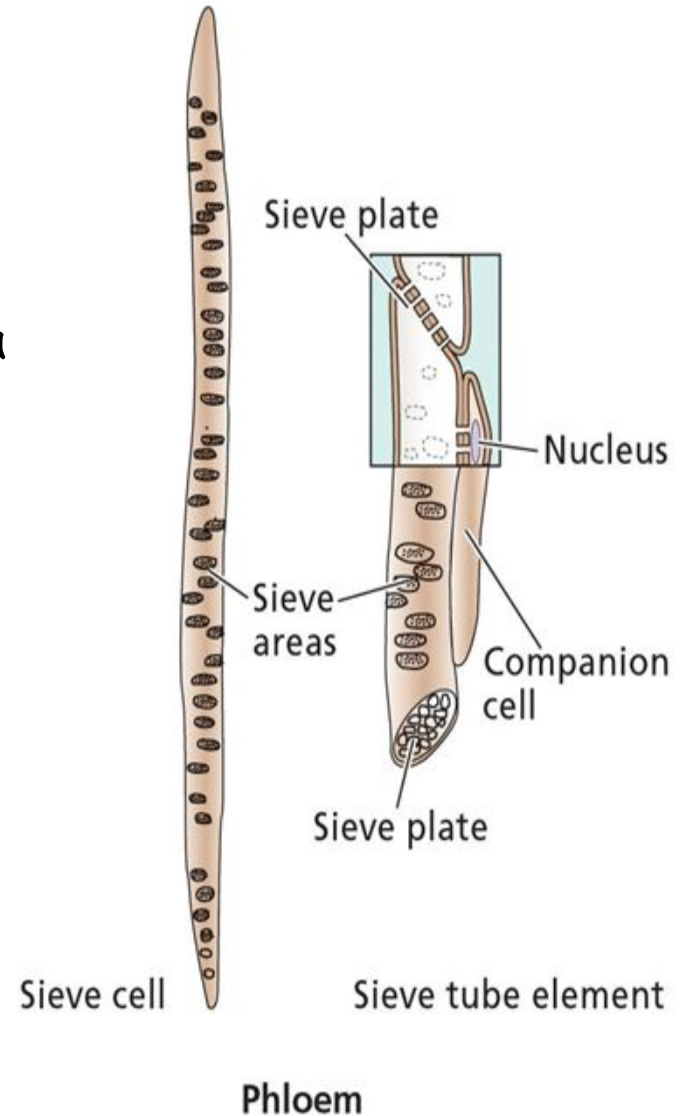
Overview of Plant Structure

• *Phloem:*

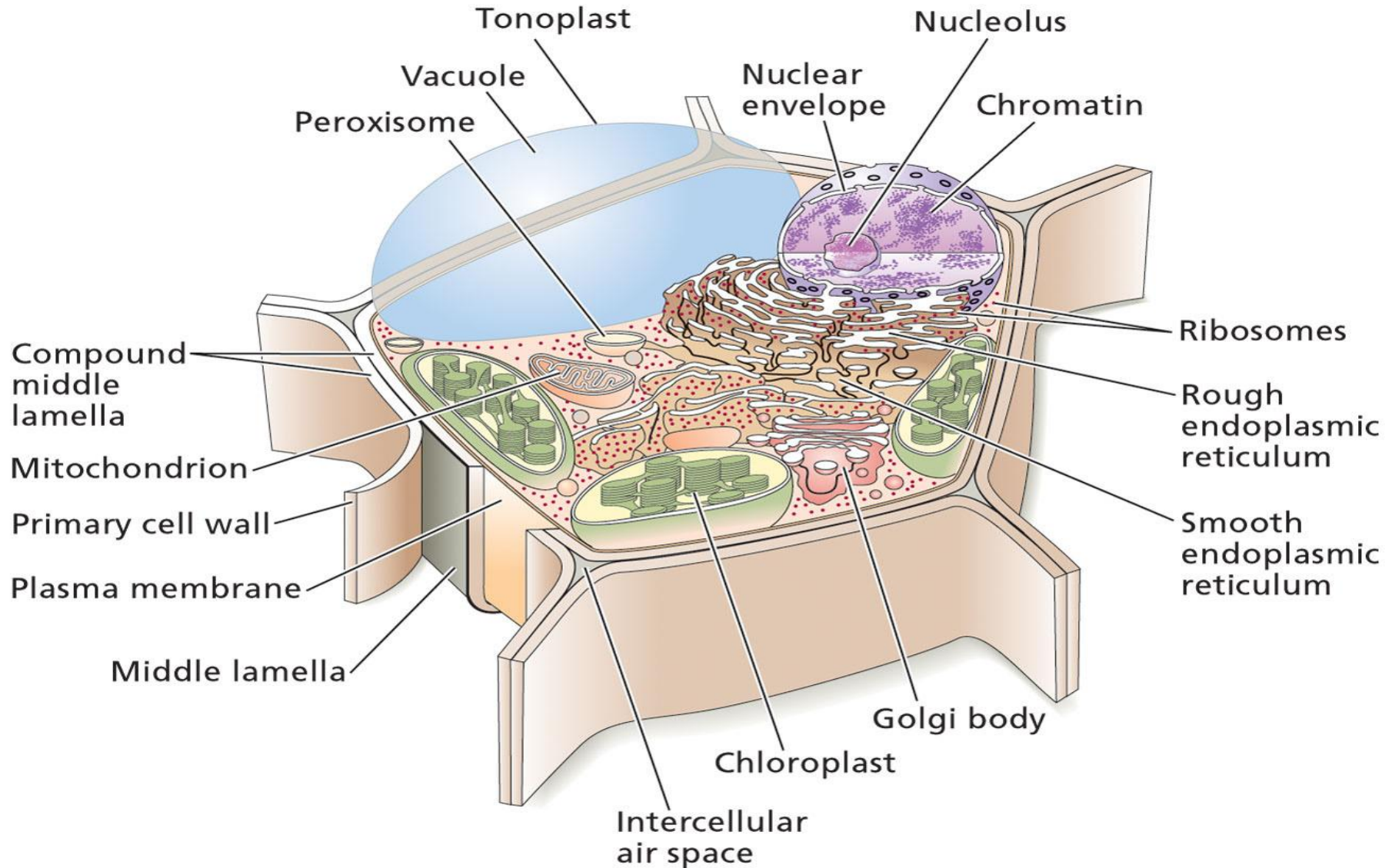
- The main components of phloem are
 - *sieve elements*
 - *companion cells*.
- Sieve elements have no nucleus and only a sparse collection of other organelles .

Companion cell provides energy

- so-named because end walls are perforated - allows cytoplasmic connections between vertically-stacked cells .
- conducts sugars and amino acids - from the leaves, to the rest of the plant



The Plant Cell

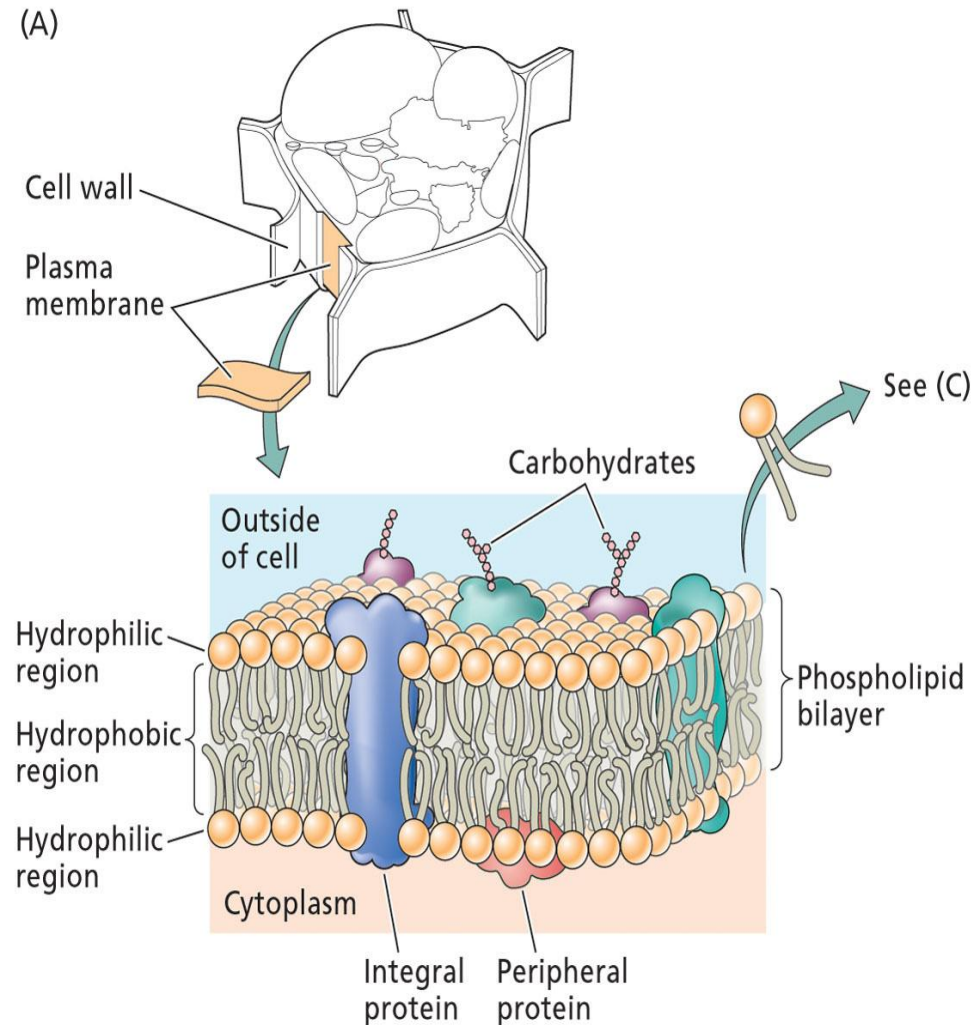


The Plant Cell

- All plant cells have the same basic eukaryotic organization
 - *However*, at maturity when they become specialized, plant cells may differ greatly from one another in their structures and functions
 - *Even those physically next to each other.*
 - *Even the nucleus can be lost in some plant cells*
- Contains many organelles with specific functions
- Enclosed by a membrane which defines their boundaries
- *Don't Forget the Cell Wall!!!!!!!!!!!!*

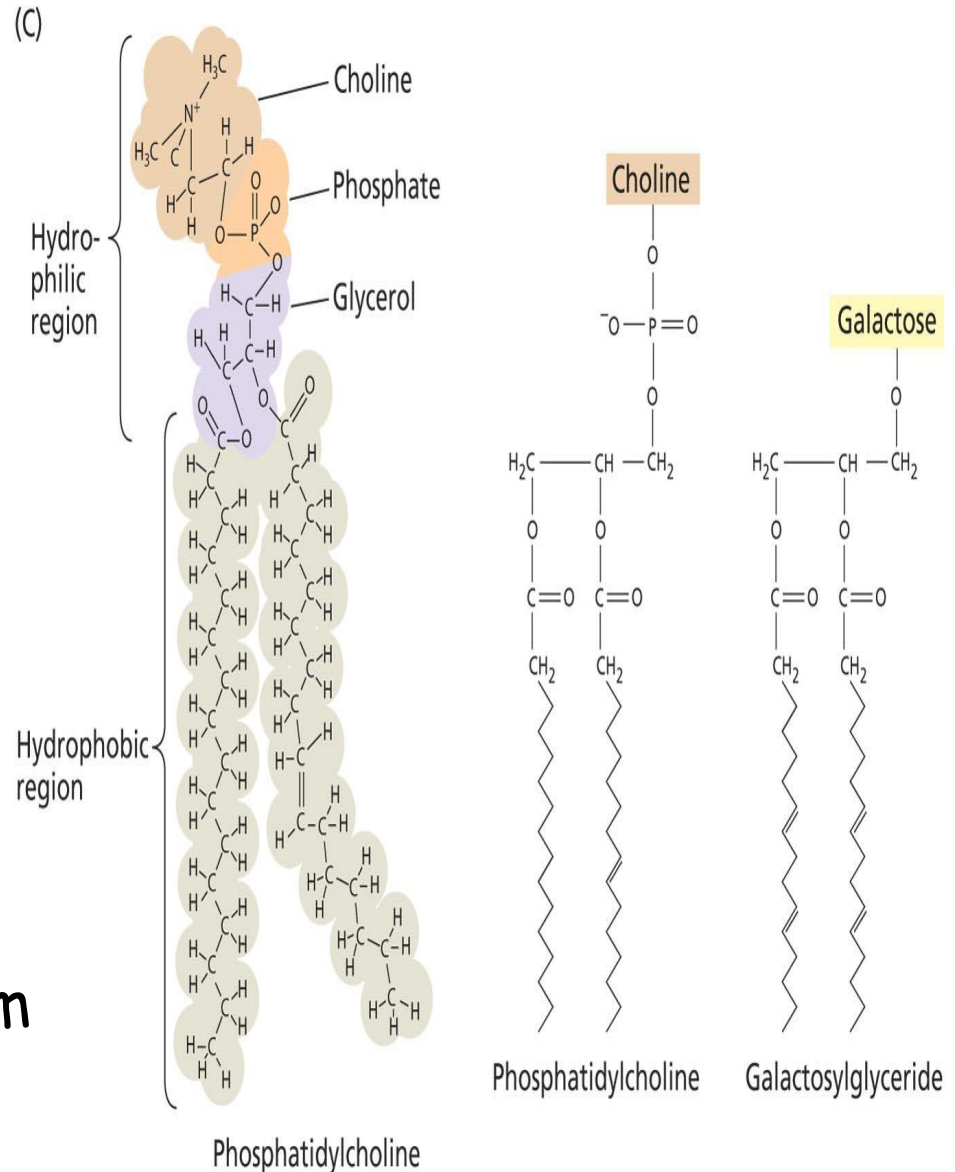
The Plasma Membrane

- Composed of a phospholipid bilayer and proteins.
- The phospholipid sets up the bilayer structure
- Phospholipids have hydrophilic heads and fatty acid tails.
- The plasma membrane is fluid--that is proteins move in a fluid lipid background



The Plasma Membrane

- **Phospholipids:**
- Two fatty acids covalently linked to a **glycerol**, which is linked to a **phosphate**.
- All attached to a "head group", such as **choline**, an amino acid.
- Head group POLAR - so **hydrophilic** (loves water)
- Tail is non-polar **-hydrophobic**
- The tail varies in length from 14 to 28 carbons.



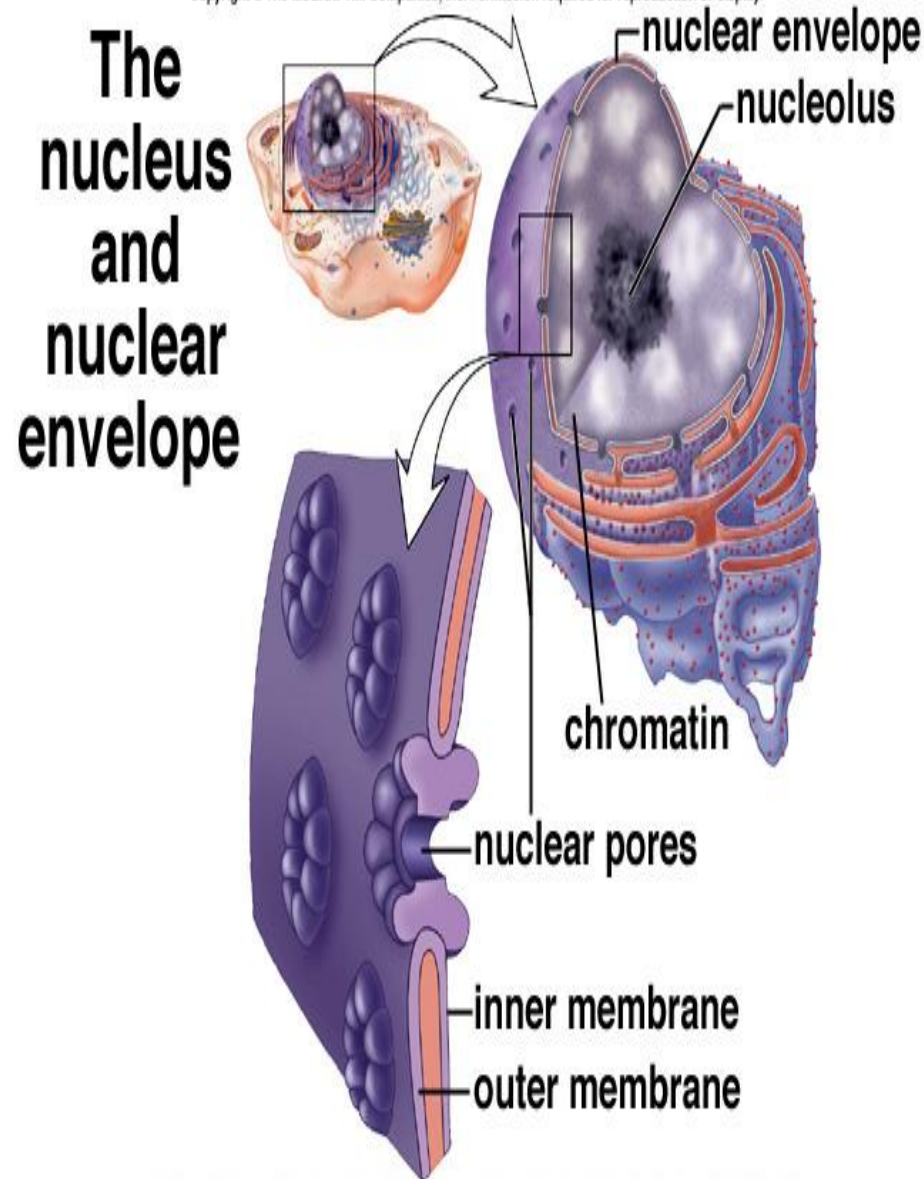
The Plasma Membrane

- *Proteins:*
- *Integral proteins:*
 - Embedded in lipid bilayer - serve as "ion pumps"
 - They pump ions across the membrane against their concentration gradient
- *Peripheral proteins:*
 - Bound to membrane surface by ionic bonds.
 - Interact with components of the cytoskeleton
- *Anchored proteins:*
 - Bound to surface via lipid molecules

The nucleus

- Contains *almost all* of the genetic material
- What it contains is called the **nuclear genome** - this varies greatly between plant species.
- Surrounded by **nuclear envelope** - double membrane - *same as the plasma membrane*.
- The **nuclear pores** allow for the passage of macromolecules and ribosomal subunits in and out of the nucleus.

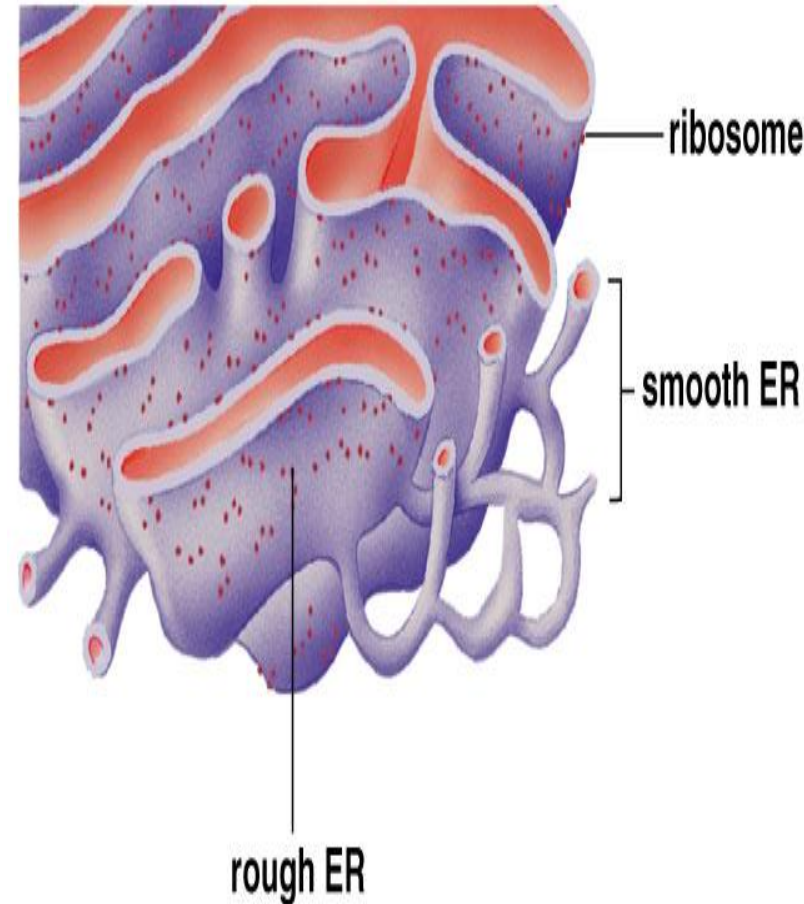
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The Endoplasmic reticulum

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- Connected to the nuclear envelope
- 3D-network of continuous tubules that course through the cytoplasm.
- **Rough ER:** Synthesize, process, and sort proteins targeted to membranes, vacuoles, or the secretory pathway.
- **Smooth ER:** Synthesize lipids and oils.
- Also:
 - Acts as an anchor points for actin filaments
 - Controls cytosolic concentrations of calcium ions

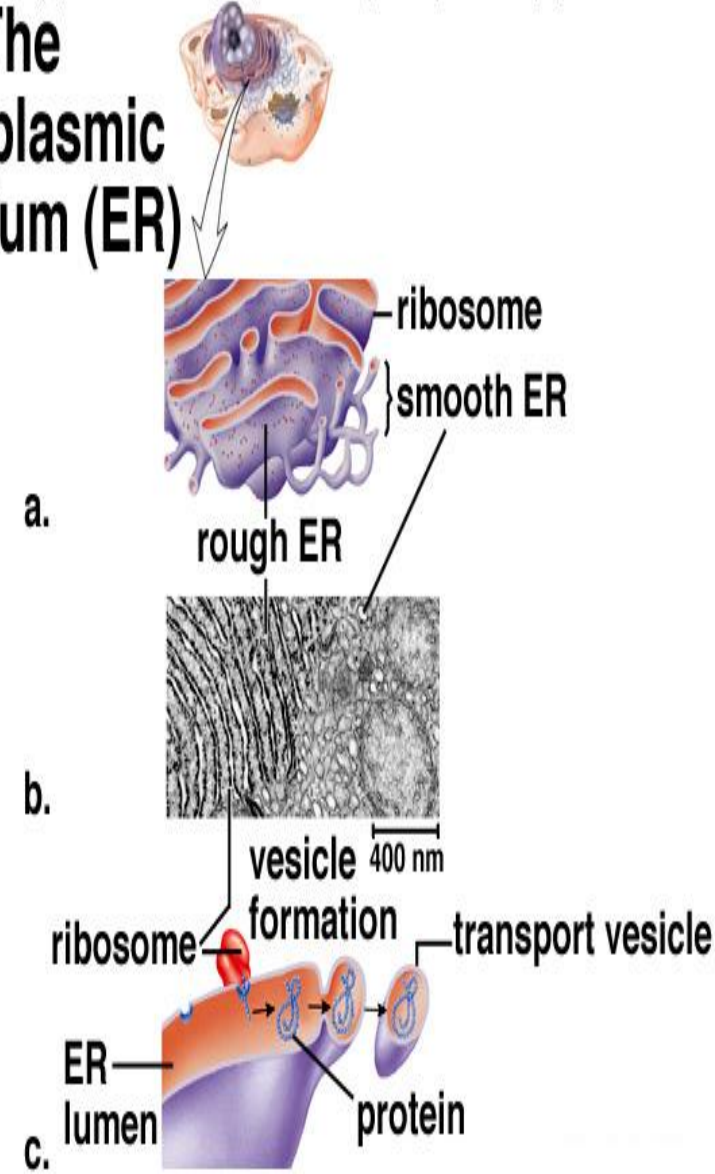


The Endoplasmic reticulum

- Proteins are made in the Rough ER lumen by an attached ribosome.
- Protein detaches from the ribosome
- The ER folds in on itself to form a **transport vesicle**
- This transport vesicle "buds off" and moves to the cytoplasm
- Either:
 - Fuses with plasma membrane
 - Fuses with **Golgi Apparatus**

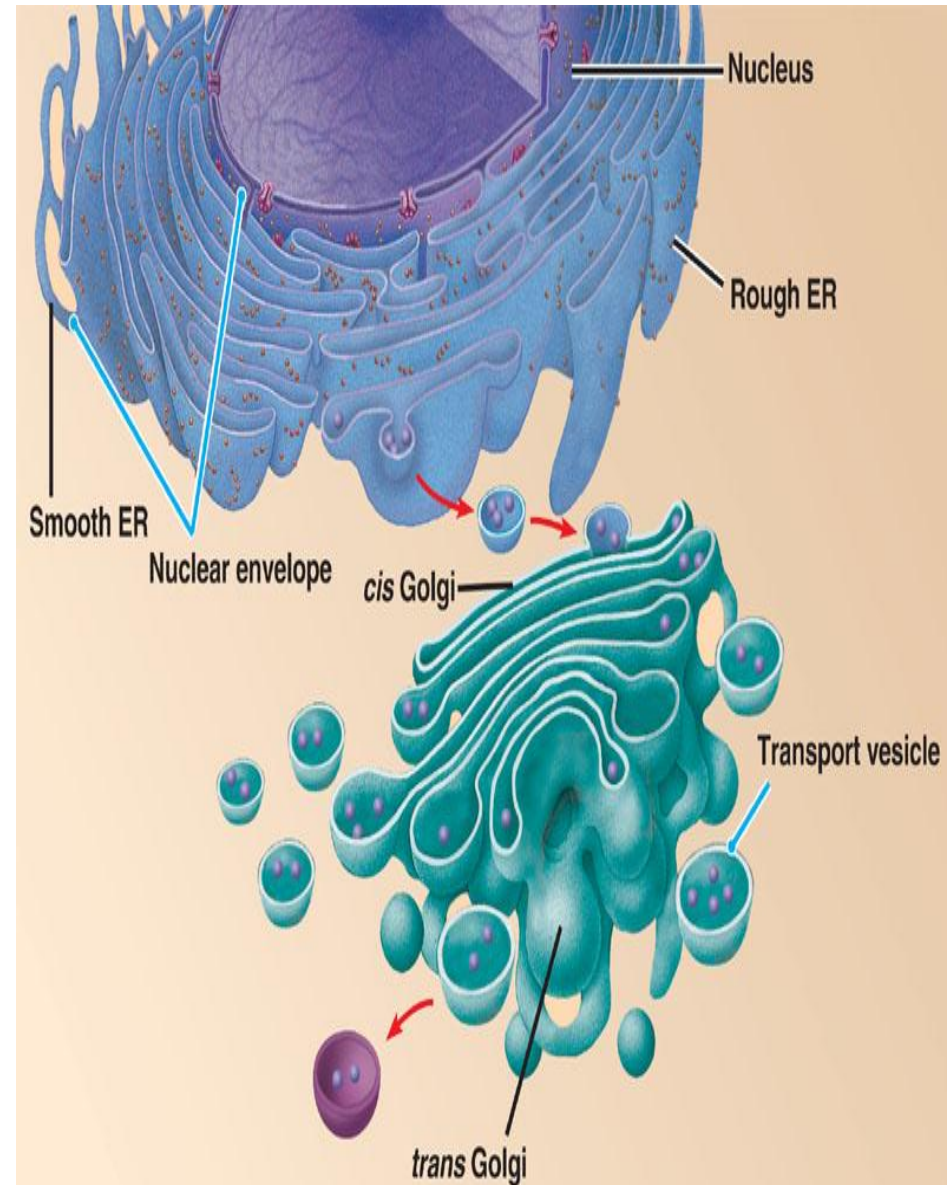
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The endoplasmic reticulum (ER)



The Golgi Network

- Proteins or lipids made in the ER contained in transport vesicles fuse with the Golgi.
- The Golgi modifies proteins and lipids from the ER, sorts them and packages them into **transport vesicles**.
- This transport vesicle "buds off" and moves to the cytoplasm.
- Fuse with plasma membrane.
-



The Golgi Network

Site of synthesis for:
Cellulose
Callose

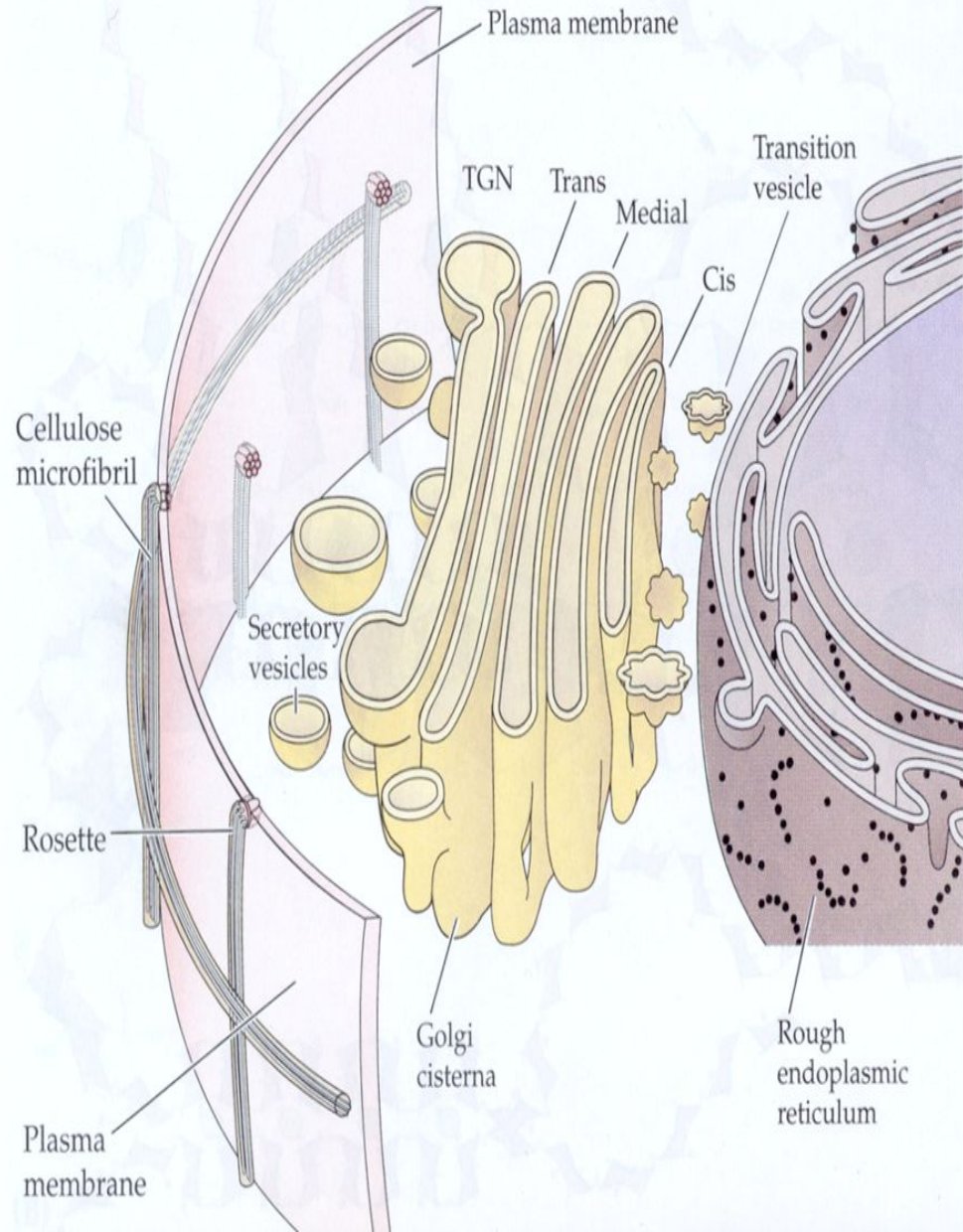
Site of synthesis for:
Pectins
HGA
RG I
RG II

Cross-linking glycans
Xyloglucan
Glucuronoarabinoxylan
 β -Glucan
Galactomannan

Site of glycosylation of:
HRGPs
AGPs
Modified glycoproteins

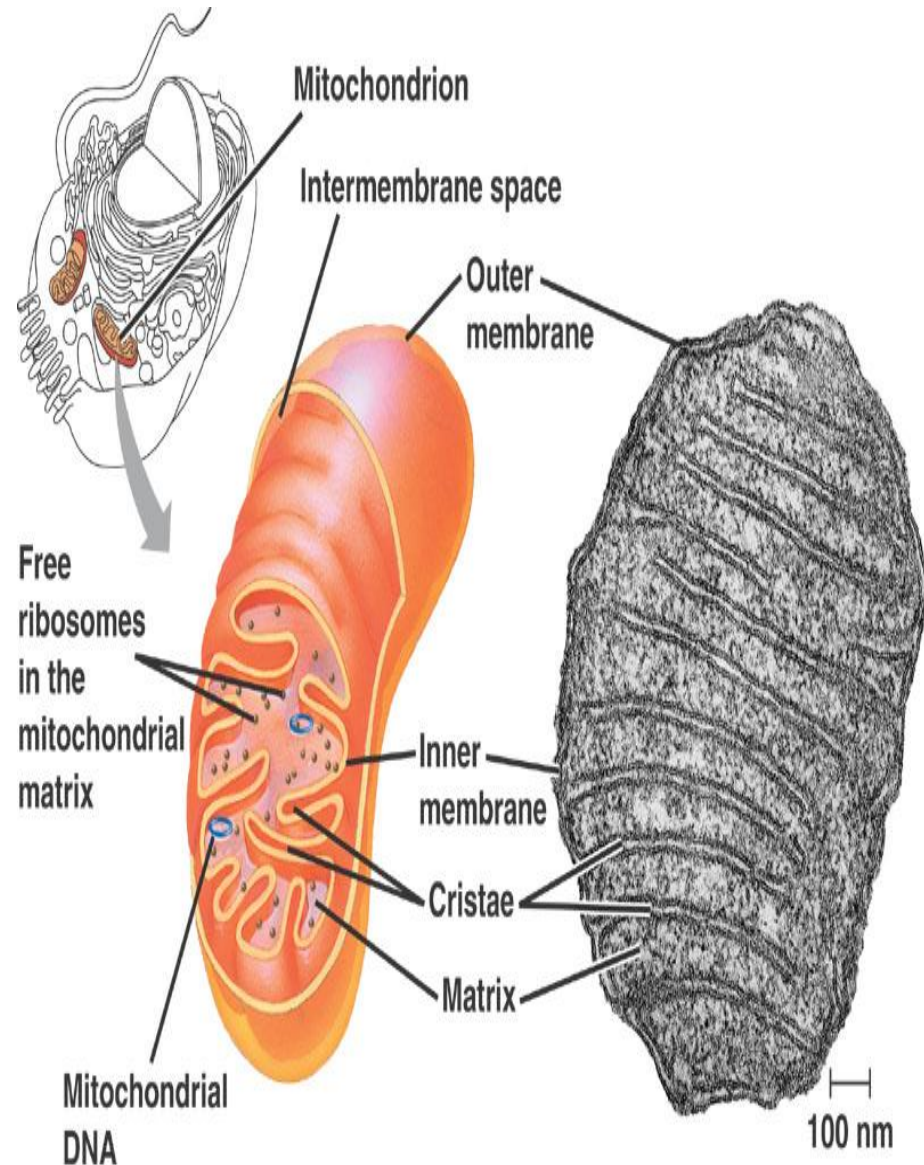
Site of synthesis for:
Cell wall proteins
HRGPs
PRPs
GRPs
AGPs

Enzymes
Hydrolases
Esterases
Peroxidases
Polysaccharide synthase



The Mitochondria

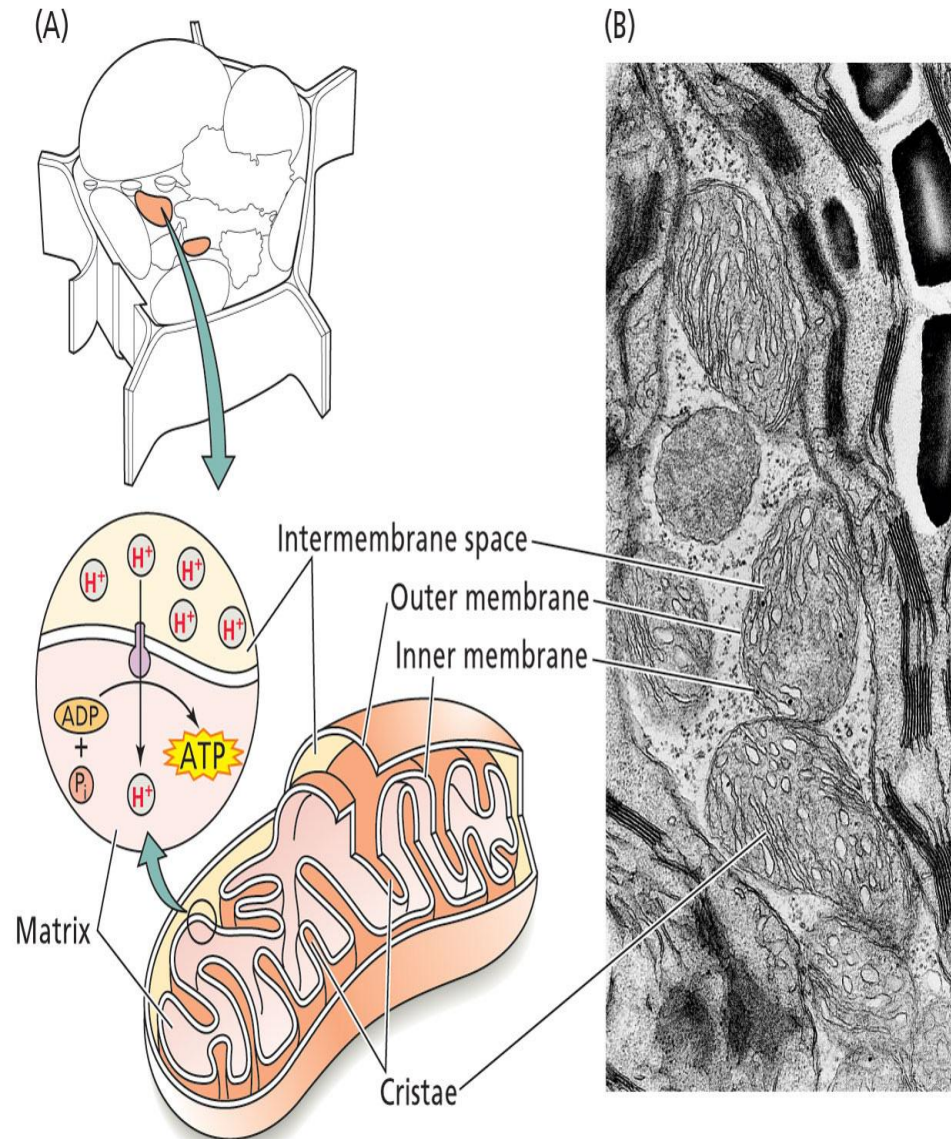
- Contain their own DNA and protein-synthesizing machinery
 - Ribosomes, transfer RNAs, nucleotides.
 - Thought to have evolved from **endosymbiotic bacteria**.
 - Divide by fusion
 - The DNA is in the form of circular chromosomes, like bacteria
 - DNA replication is independent from DNA replication in the nucleus



The Mitochondria

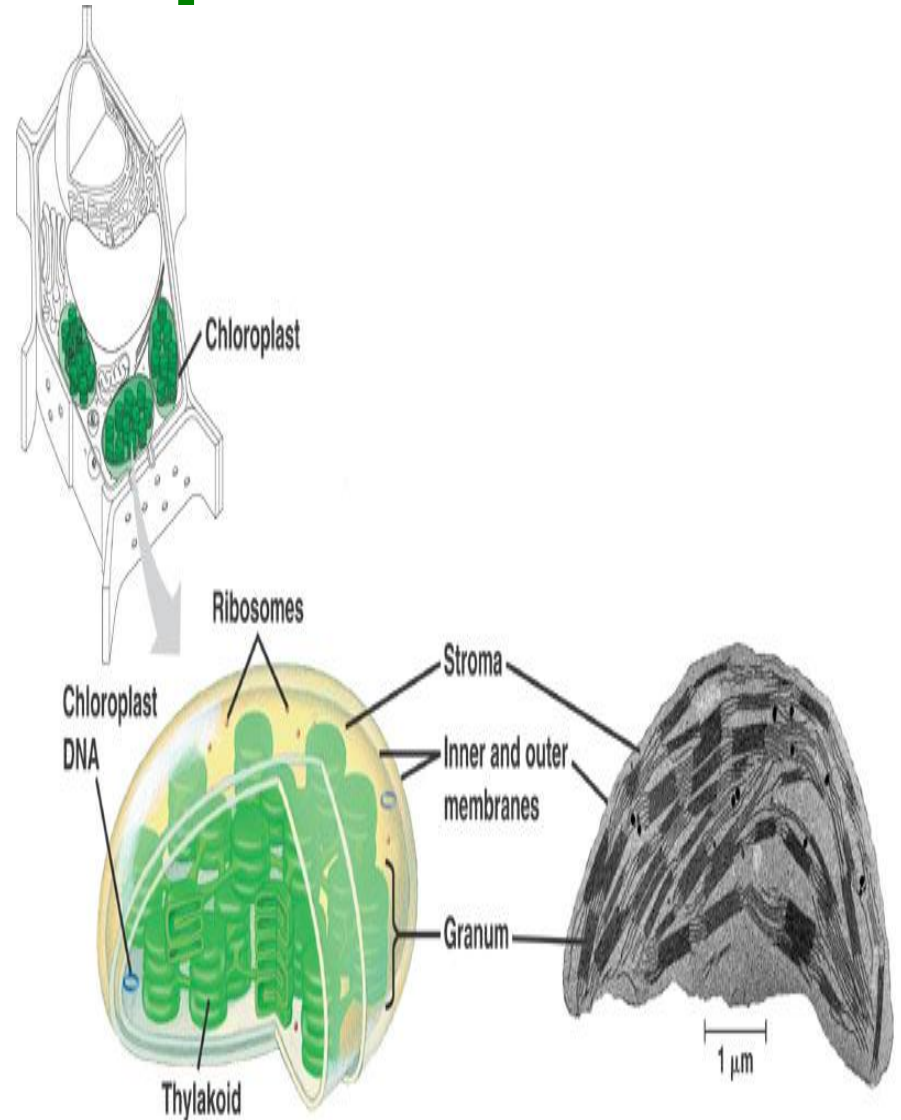
Site of Cellular Respiration

- This process requires oxygen.
- Composed of three stages:
 - **Glycolysis**--glucose splitting, occurs in the cell. Glucose is converted to Pyruvate.
 - **Krebs cycle**--Electrons are removed--carriers are charged and CO_2 is produced. This occurs in the mitochondrion.
 - **Electron transport**--electrons are transferred to oxygen. This produces H_2O and ATP. Occurs in the mito.



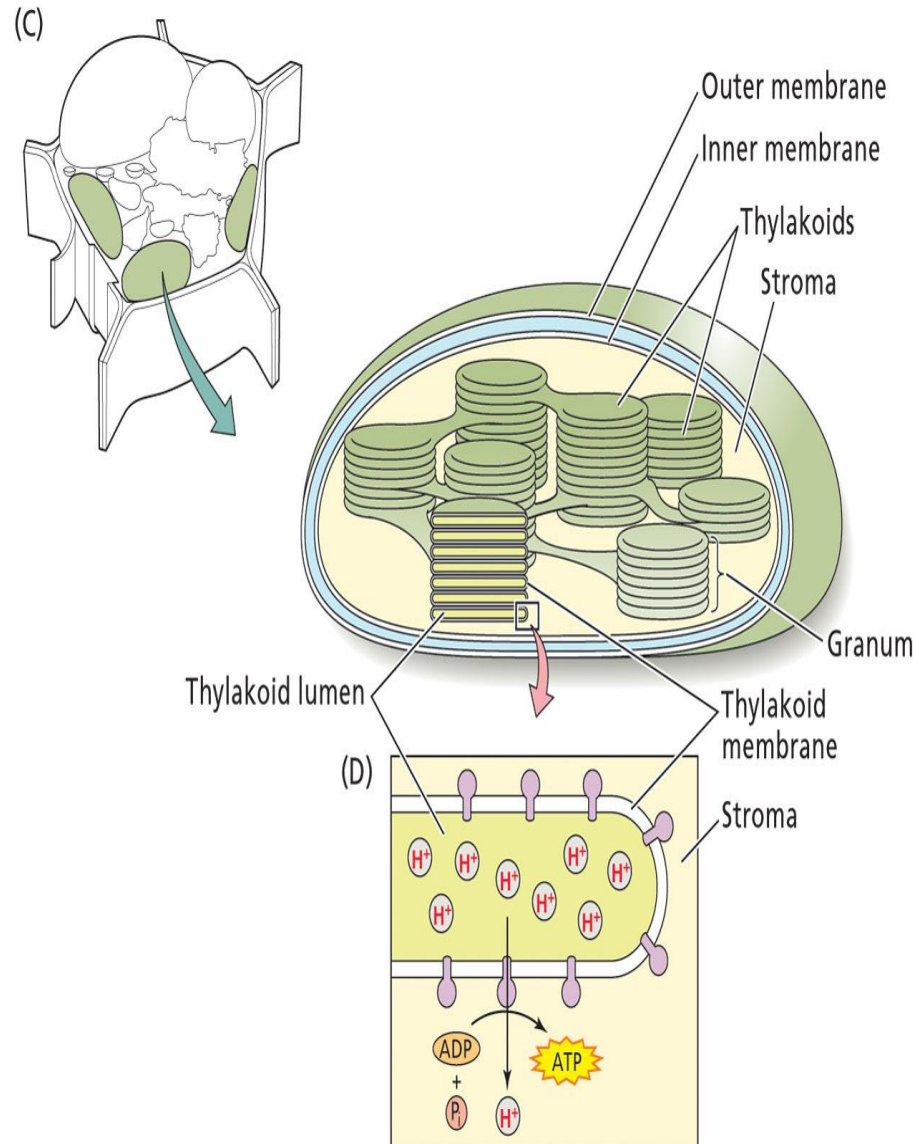
The Chloroplast

- Contain their own DNA and protein-synthesizing machinery
 - Ribosomes, transfer RNAs, nucleotides.
 - Thought to have evolved from **endosymbiotic bacteria**.
 - Divide by fusion
 - The DNA is in the form of circular chromosomes, like bacteria
 - DNA replication is independent from DNA replication in the nucleus



The Chloroplast

- Membranes contain chlorophyll and its associated proteins
 - **Site of photosynthesis**
- Have inner & outer membranes
- 3rd membrane system
 - **Thylakoids**
- Stack of Thylakoids = **Granum**
- Surrounded by **Stroma**
 - Works like mitochondria
- During photosynthesis, ATP from stroma provide the energy for the production of sugar molecules

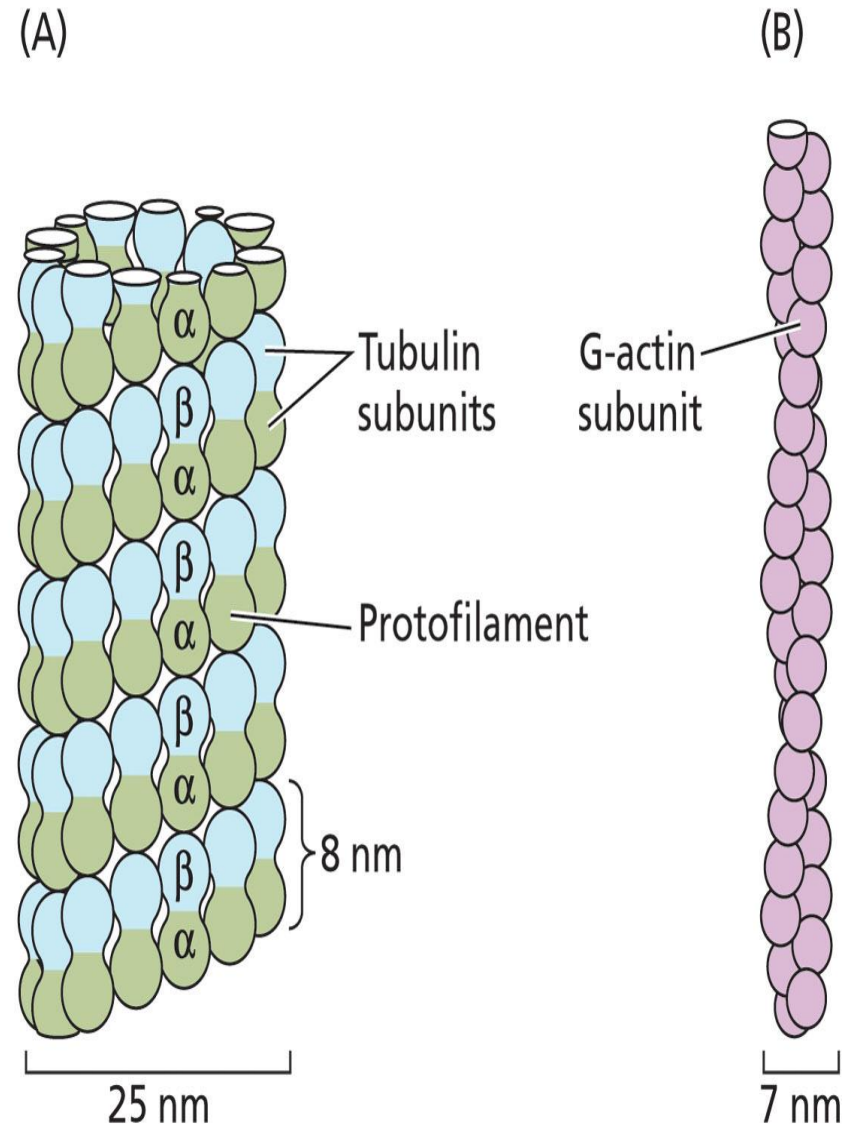


The Vacuole

- Can be 80 - 90% of the plant cell
- Contained within a vacuolar membrane (*Tonoplast*)
- Contains:
 - Water, inorganic ions, organic acids, sugars, enzymes, and secondary metabolites.
- Required for plant cell enlargement
- The turgor pressure generated by vacuoles provides the structural rigidity needed to keep herbaceous plants upright.

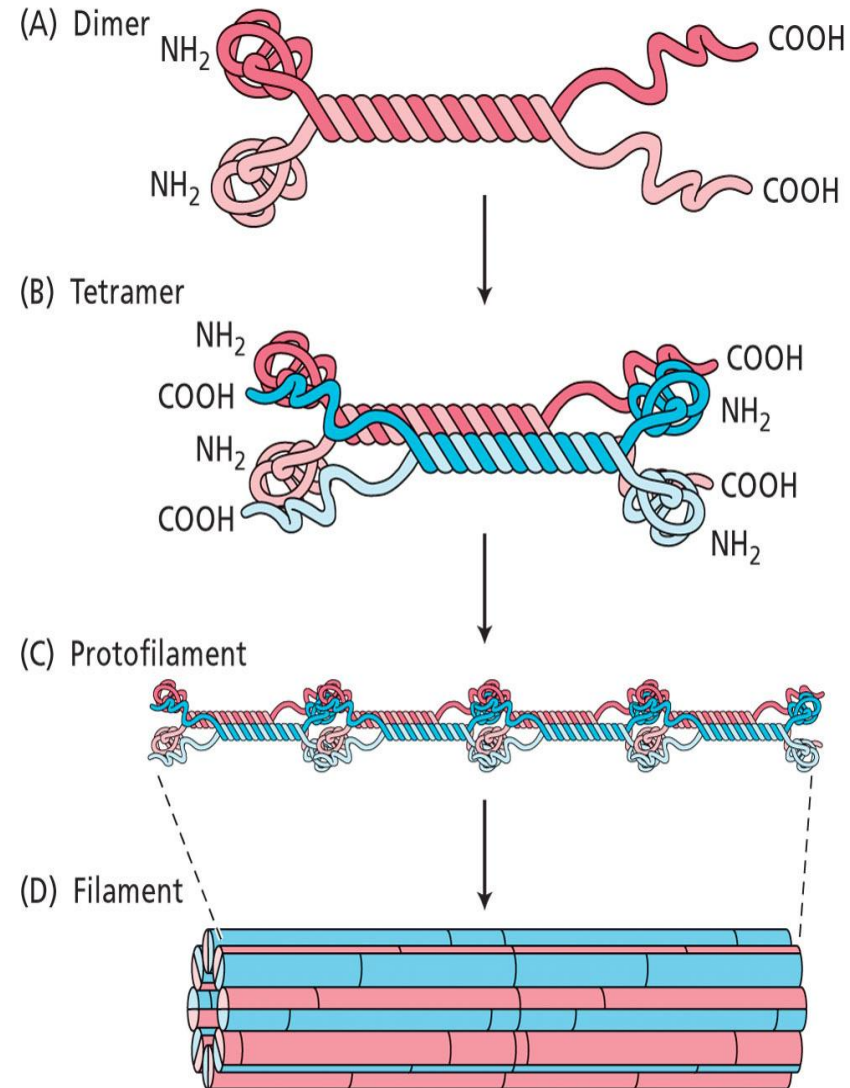
The cytoskeleton

- **Three main components:**
- **Microtubules:** are α and β proteins that create scaffolding in a cell. MTs are formed from the protein tubulin. **13 rows of tubulin = 1 microtubule**
- **Microfilaments:** solid (7 nm) made from **G-actin** protein. Consists of 2 chains of actin subunits that intertwine in a helical fashion



The cytoskeleton

- **Intermediate filaments:** a diverse group of helically wound linear proteins.
- Dimers line up parallel to each other
- These form anti-parallel Tetramers
- These join together to form a filament

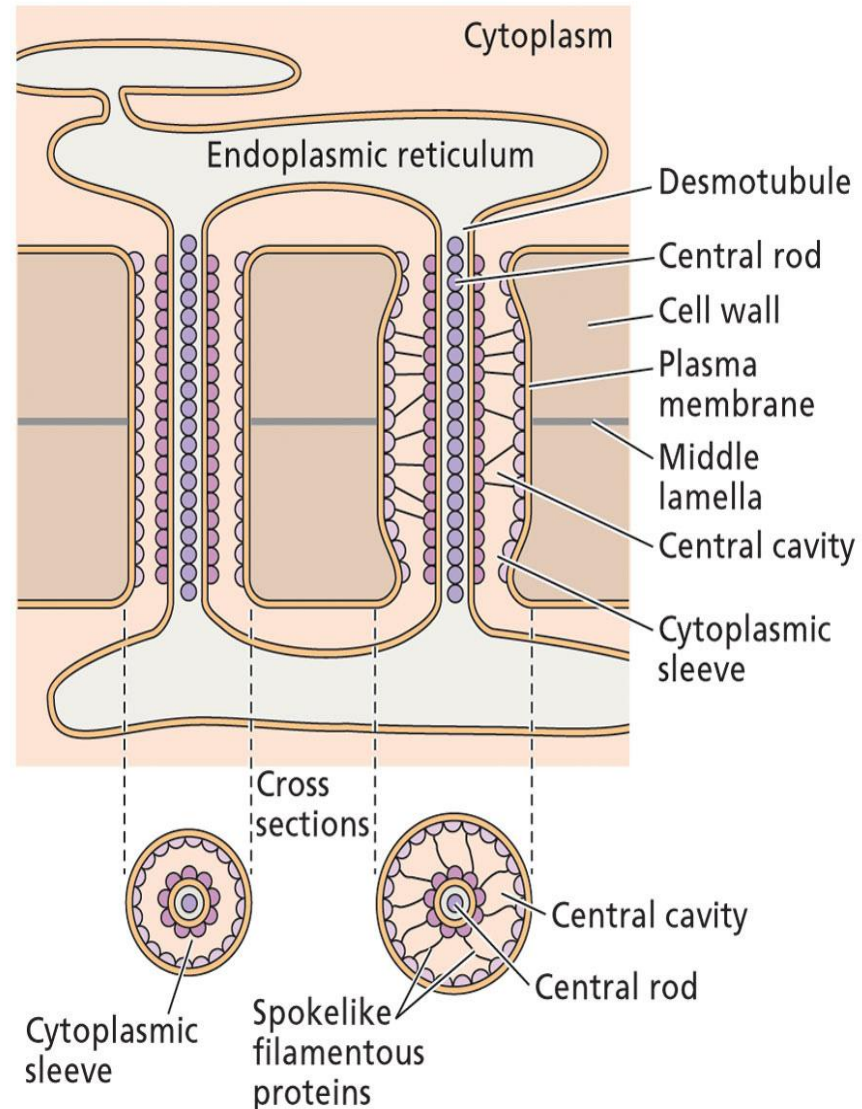


The cytoskeleton

- All these elements can assemble and disassemble
- Involved in plant cell division
 - During mitosis
 - *Process of division that produces two daughter cells with identical chromosomal content of parent cell*

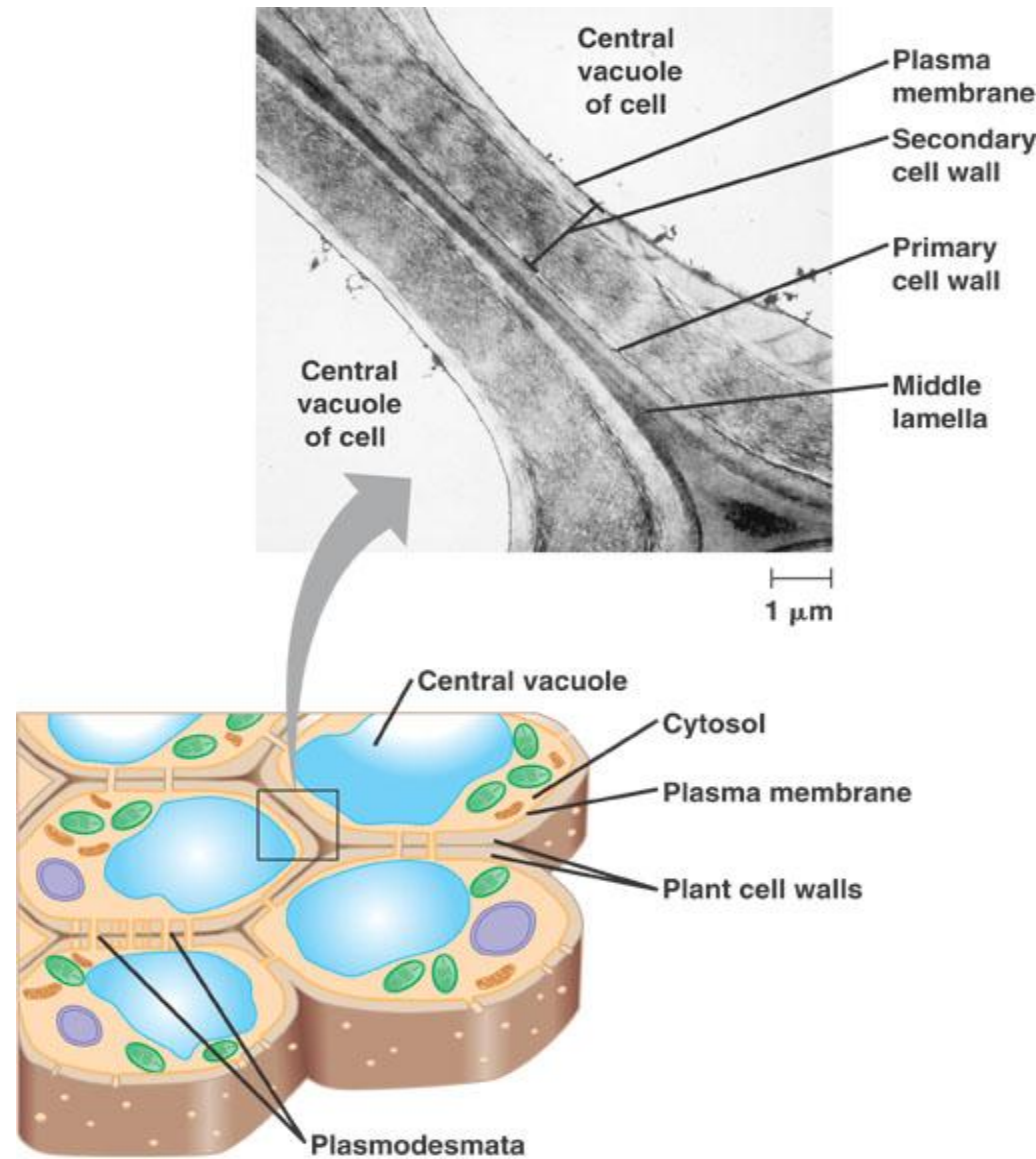
Plasmodesmata

- Each contains a tube called a **Desmotubule**, which is part of the ER.
- This is what connects adjacent cells and allows chemical communication and transport of material throughout the whole plant.
- The restriction acts to control the size of the molecules which pass through.



The Plant Cell wall

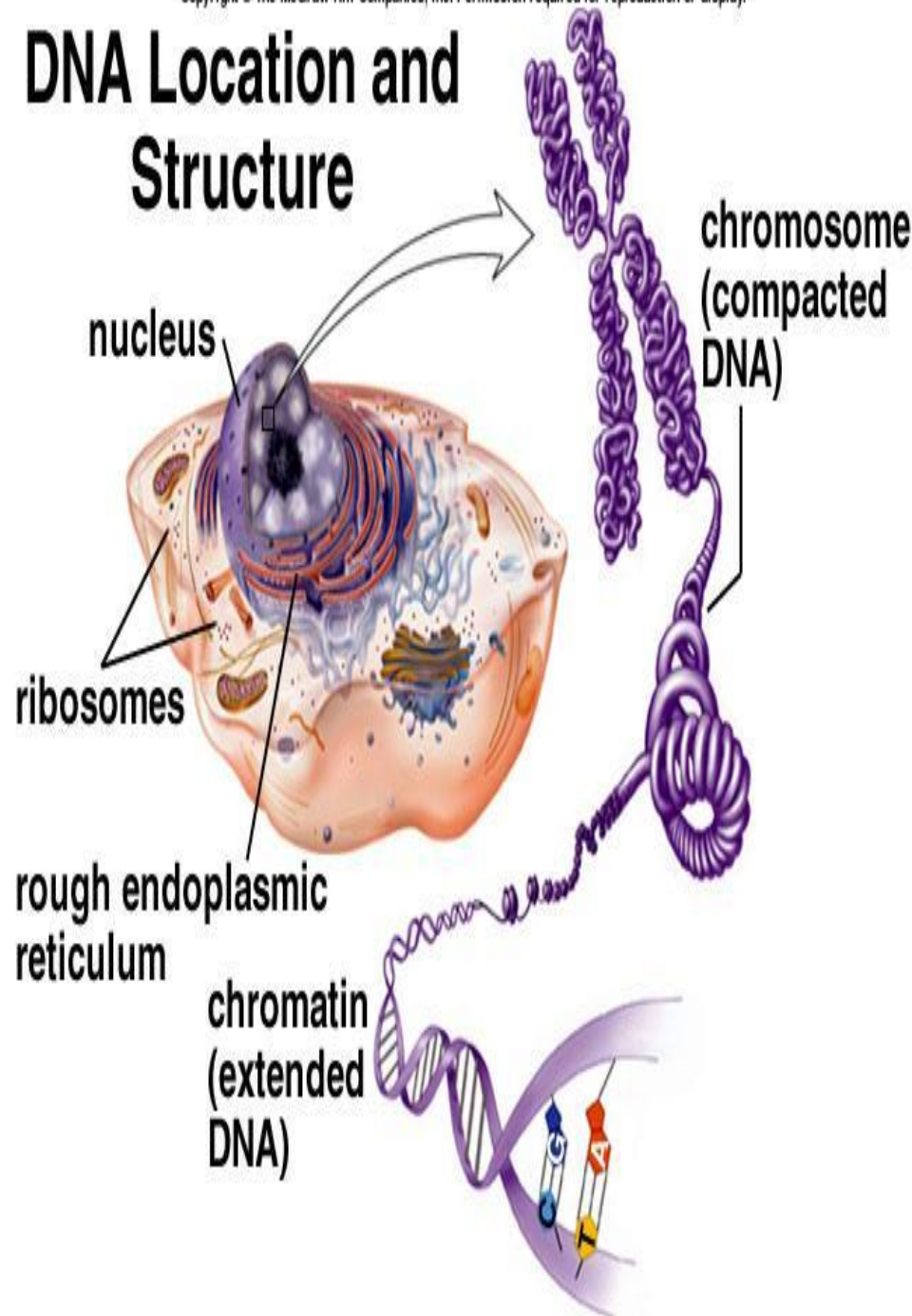
- Cell walls are held together by the **middle Lamella**.
- Made up of:
 - Cellulose
 - Xyloglucan
 - Pectin
 - Proteins
 - Ca ions
 - Lignin
 - other ions
 - Water



Replication of DNA

- Composed of 4 nucleotide bases, 5 carbon sugar and phosphate.
- Base pair = rungs of a ladder.
- Edges = sugar-phosphate backbone.
- Double Helix
- Anti-Parallel

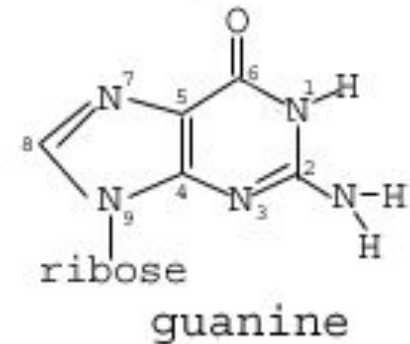
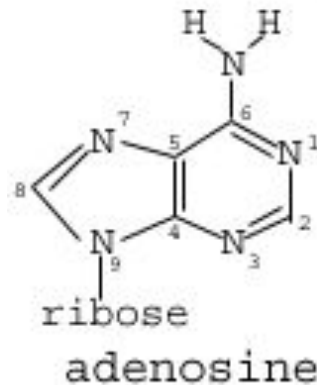
DNA Location and Structure



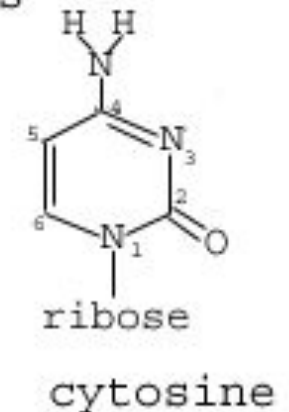
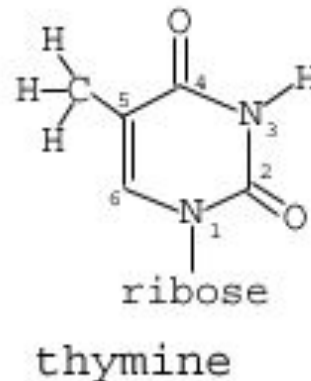
The bases

- Chargaff's Rules
- $A=T$
- $G=C$
- led to suggestion of a double helix structure for DNA

Purines



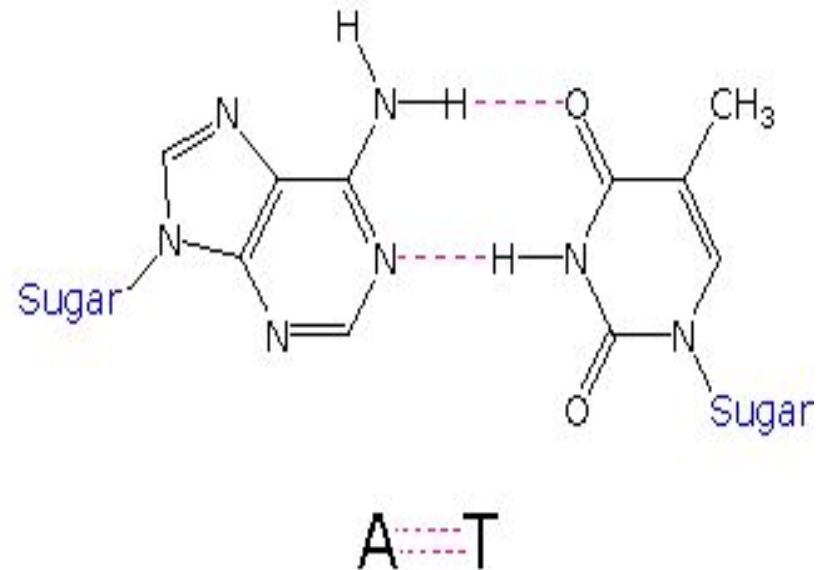
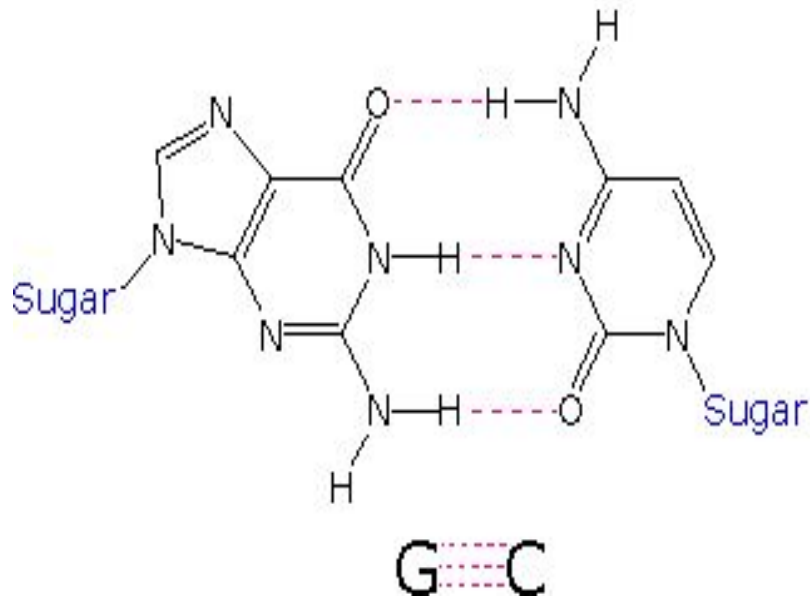
Pyrimidines



The Bases

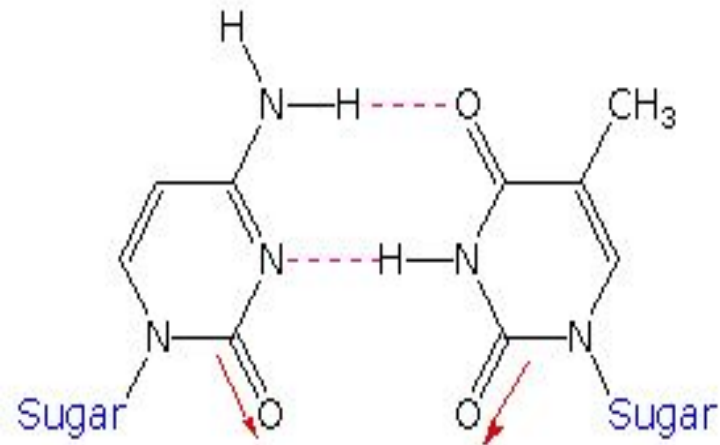
- **Adenine (A)** always base pairs with **thymine (T)**
- **Guanine (G)** always base pairs with **Cytosine (C)**

Hydrogen Bonded Base Pairs

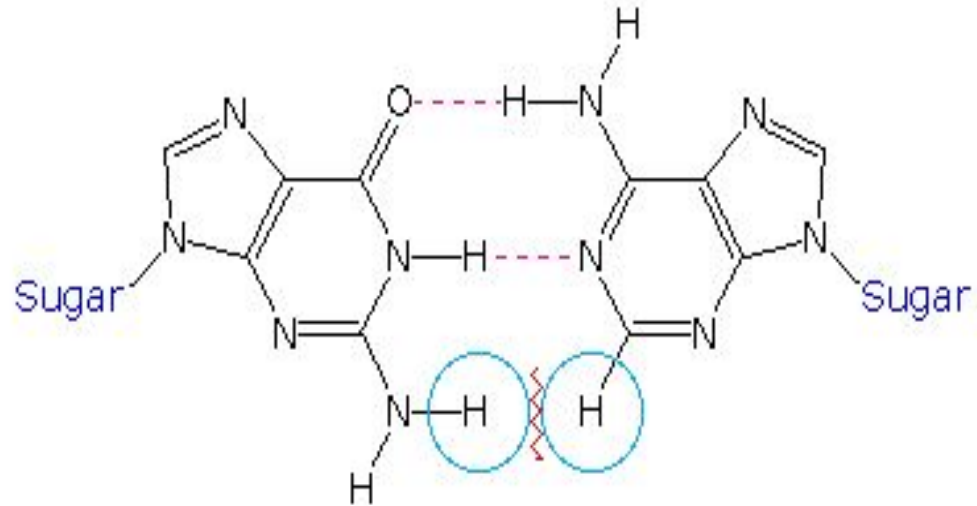


The Bases

- The C#T pairing on the left suffers from *carbonyl dipole repulsion*, as well as *steric crowding of the oxygens*. The G#A pairing on the right is also destabilized by *steric crowding* (circled hydrogens).



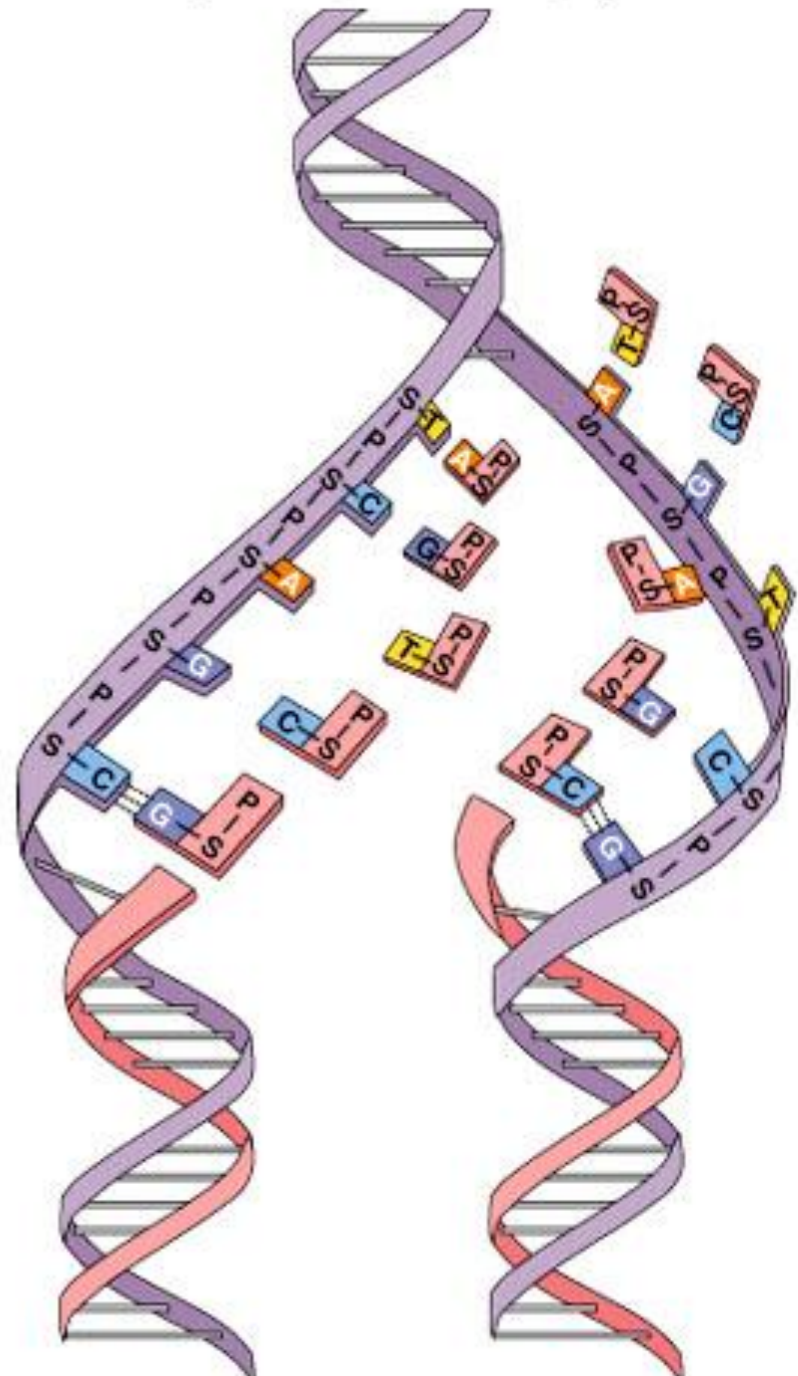
cytosine : thymine



guanosine : adenosine

Unfavorable Interactions

DNA Replication



DNA Replication

- **Adenine** (A) always base pairs with **thymine** (T)
- **Guanine** (G) always base pairs with **Cytosine** (C)
- ALL Down to **HYDROGEN** Bonding
- Requires steps:
 - H bonds break as enzymes unwind molecule
 - New nucleotides (always in nucleus) fit into place beside old strand in a process called **Complementary Base Pairing**.
 - New nucleotides joined together by enzyme called **DNA Polymerase**

DNA Replication

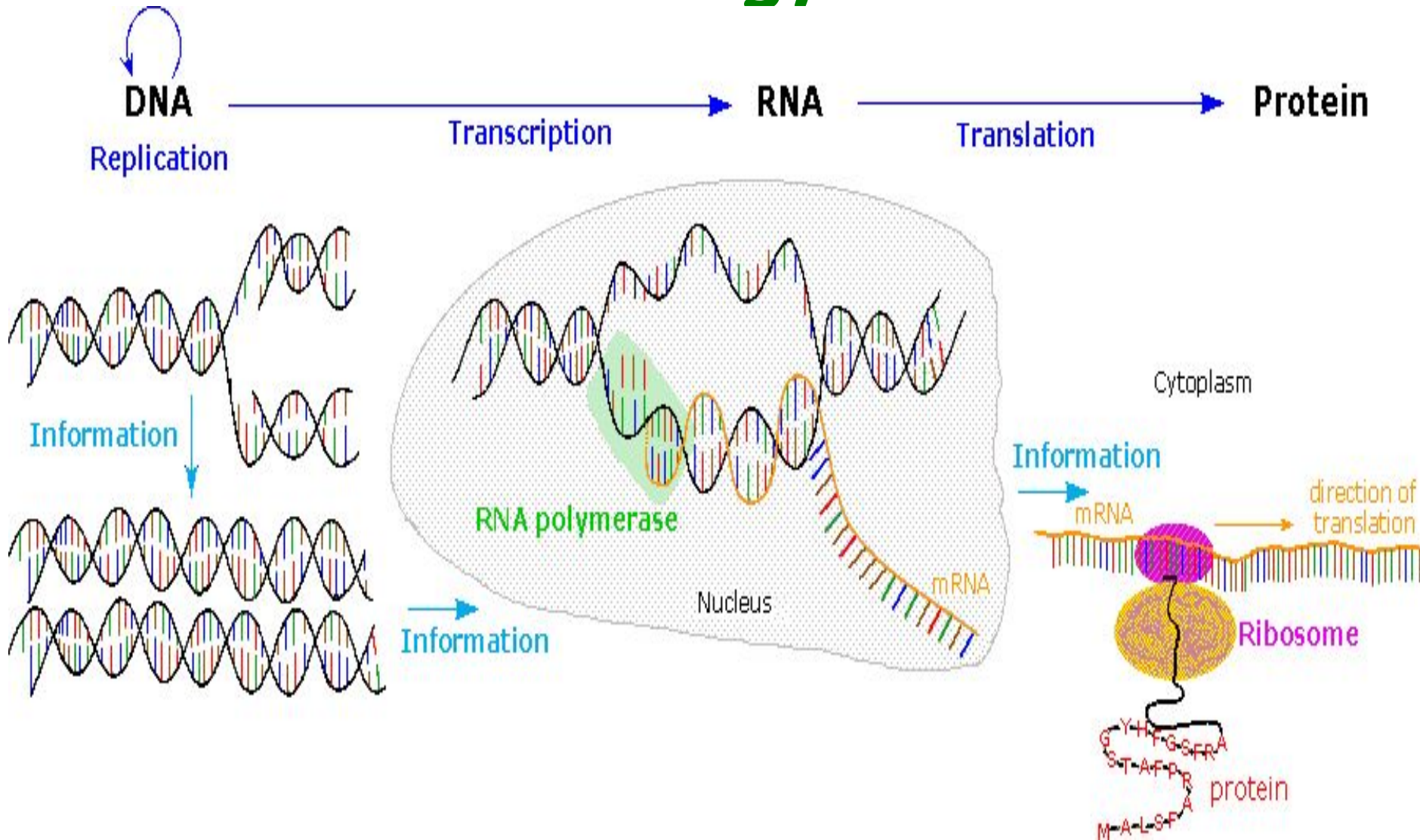
- Each new double helix is composed of an old (parental) strand and a new (daughter) strand.
- As each strand acts as a template, process is called *Semi-conservative Replication*.
- Replication errors can occur. Cell has repair enzymes that usually fix problem. An error that persists is a **mutation**.
- This is permanent, and alters the **phenotype**.

Protein synthesis in Plants

Central Dogma of Molecular Biology

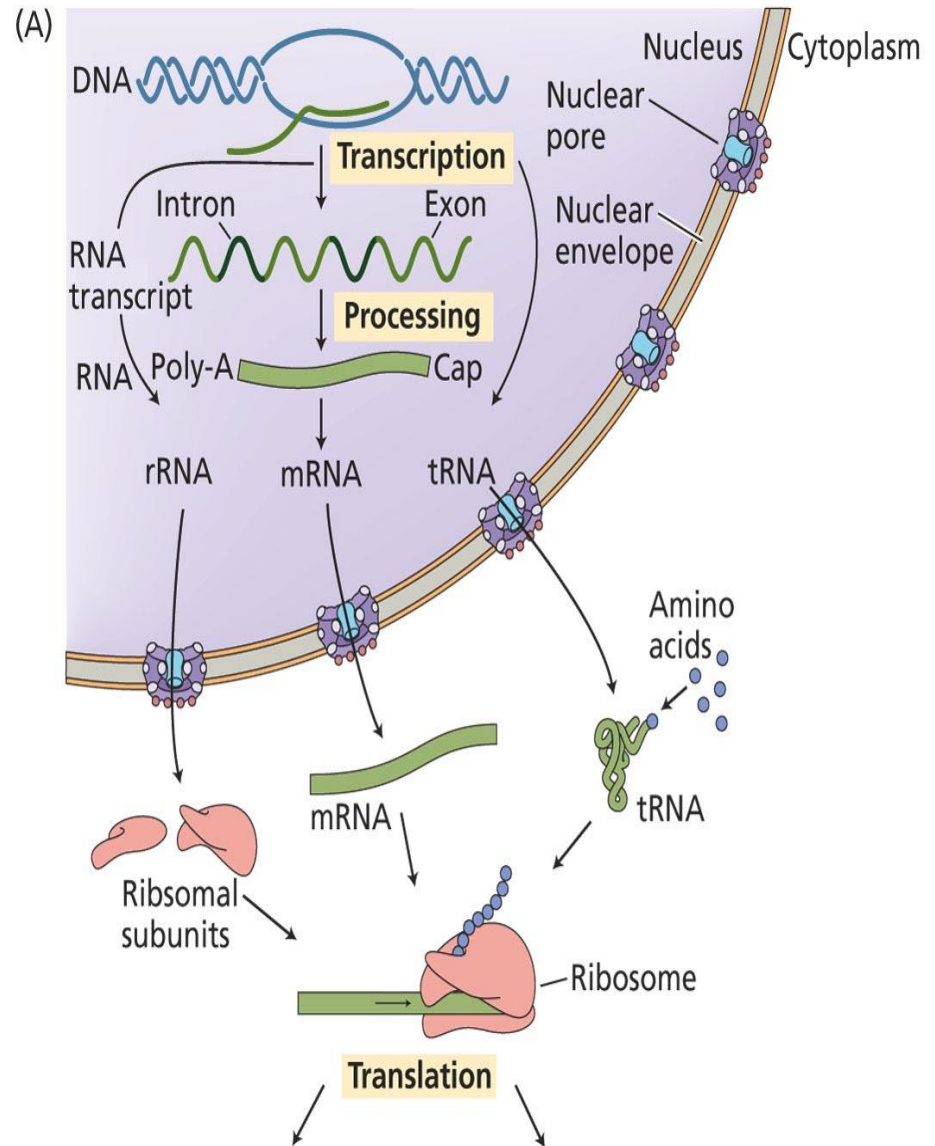
- DNA holds the code
- DNA makes RNA
- RNA makes Protein
- DNA to DNA is called **REPLICATION**
- DNA to RNA is called **TRANSCRIPTION**
- RNA to Protein is called **TRANSLATION**

Central Dogma of Molecular Biology

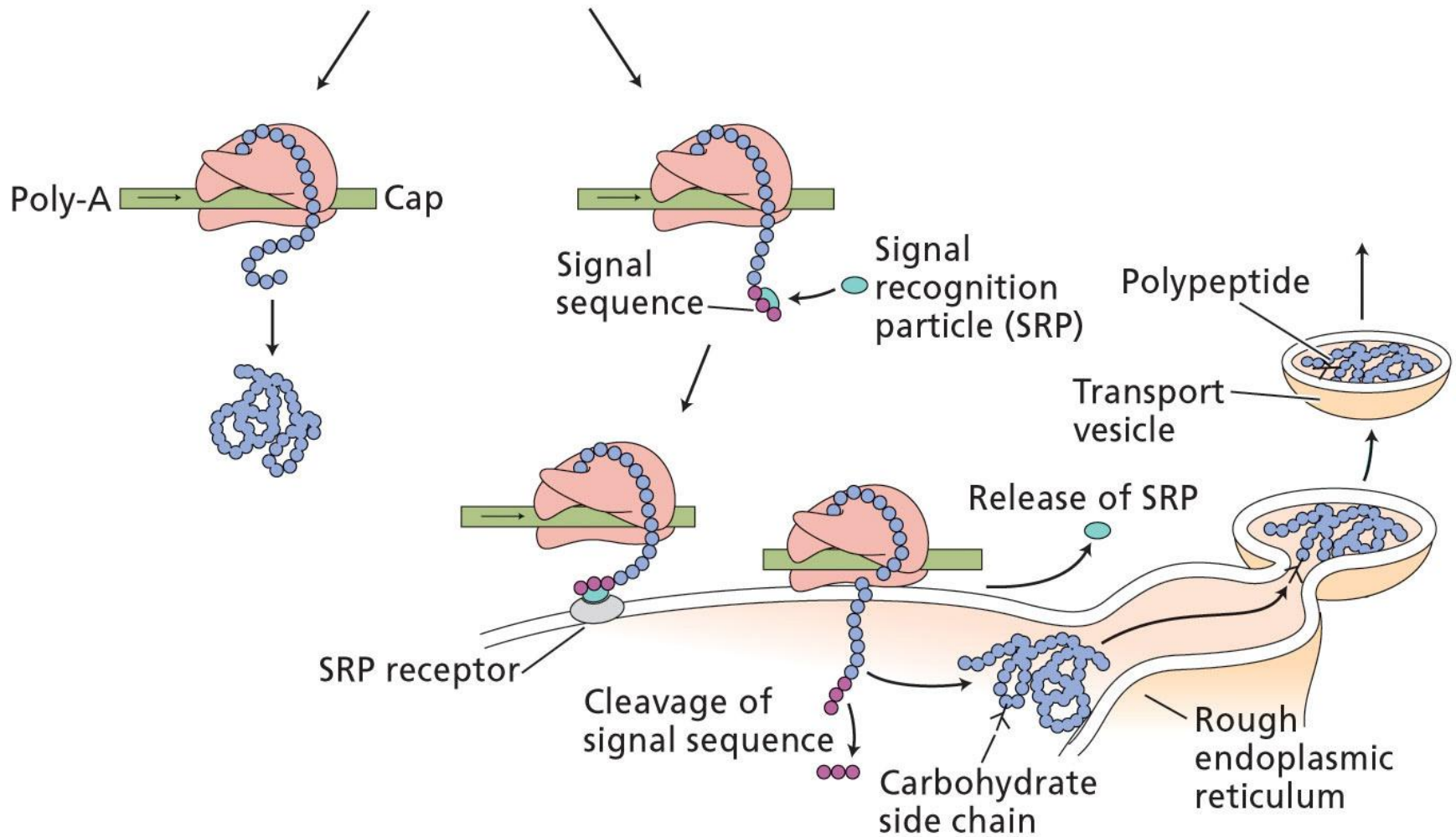


Summary of protein synthesis

- **Proteins:**
- Chains of Amino Acids
- Three nucleotide base pairs code for one amino acid.
- Proteins are formed from RNA
- The nucleotide code must be translated into an amino acid code.

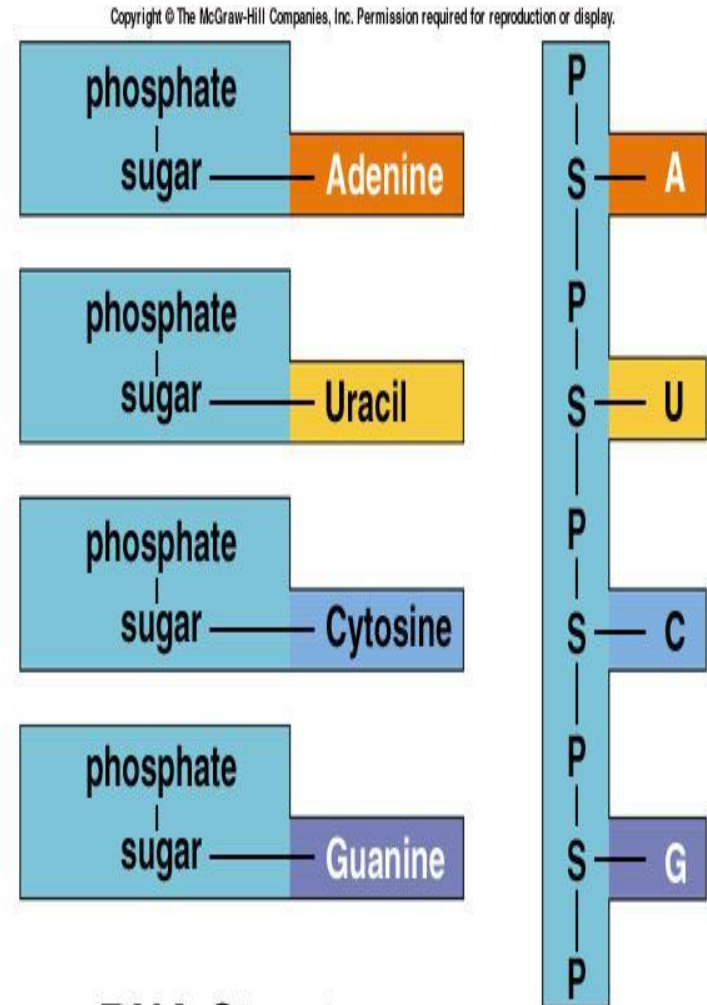


Occurs in the cytoplasm or on Rough ER



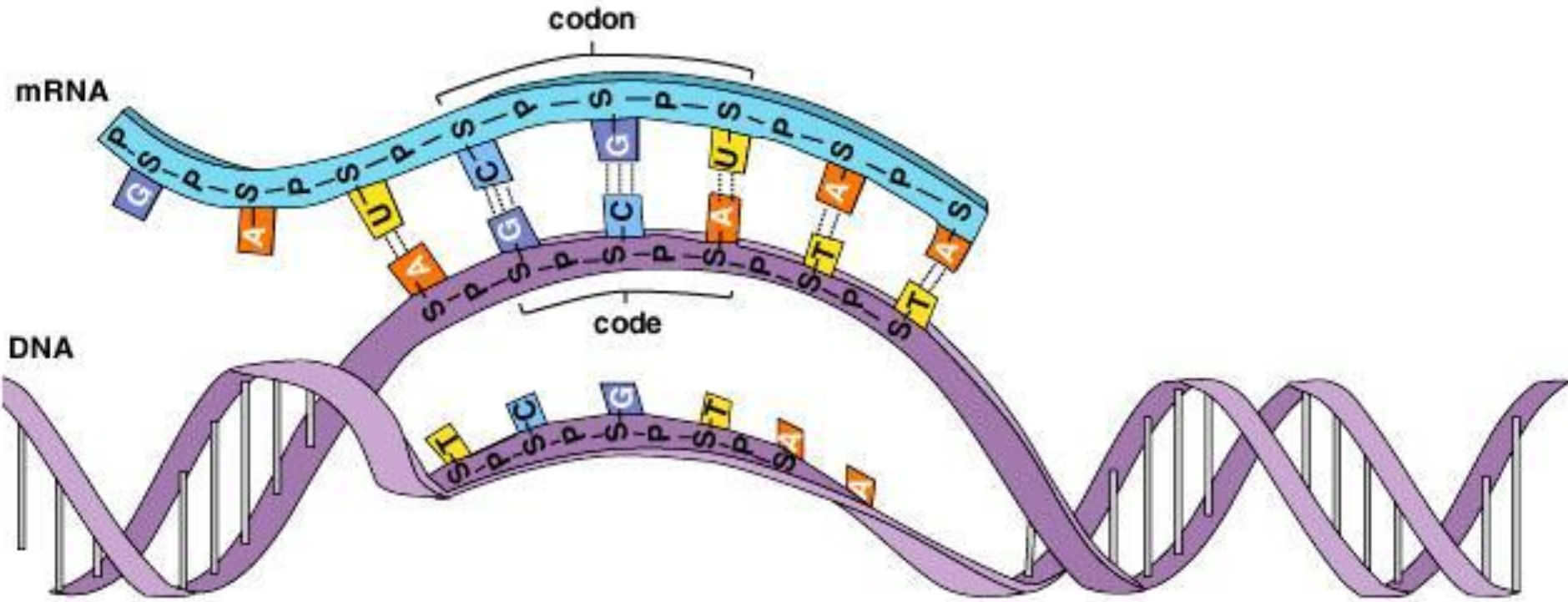
RNA

- Formed from 4 nucleotides, 5 carbon sugar, phosphate.
- **Uracil is used in RNA.**
 - *It replaces Thymine*
- The 5 carbon sugar has an extra oxygen.
- RNA is single stranded.



RNA Structure

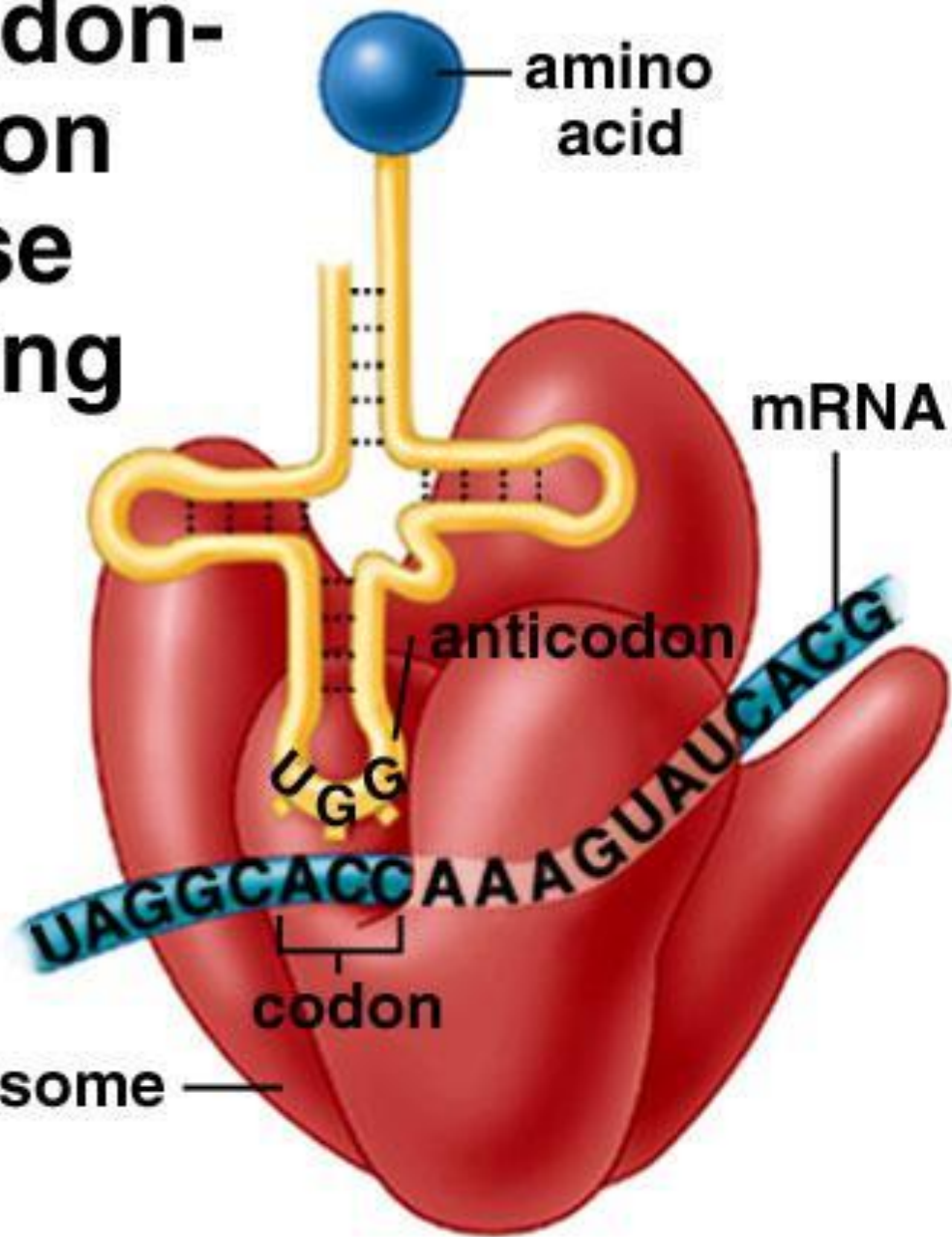
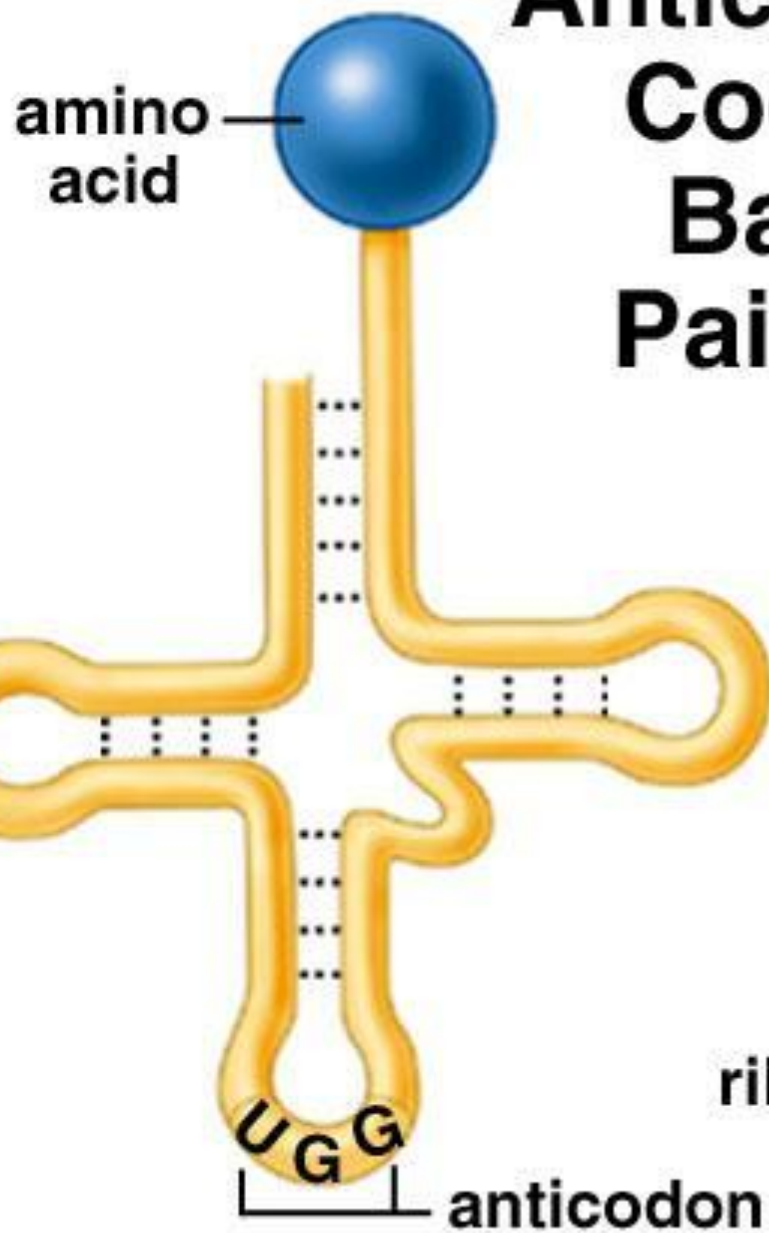
Transcription



Translation

- Translation requires:
 - Amino acids
 - **Transfer RNA: (tRNA)** Appropriate to its time, transfers AAs to ribosomes. The AA's join in cytoplasm to form proteins. 20 types.
Loop structure
 - **Ribosomal RNA: (rRNA)** Joins with proteins made in cytoplasm to form the subunits of ribosomes. *Linear molecule.*
 - **Messenger RNA: (mRNA)** Carries genetic material from DNA to ribosomes in cytoplasm. *Linear molecule.*

Anticodon-Codon Base Pairing



Translation

- **Initiation**—

- mRNA binds to smaller of ribosome subunits, then, small subunit binds to big subunit.
- **AUG** start codon--complex assembles

- **Elongation**—

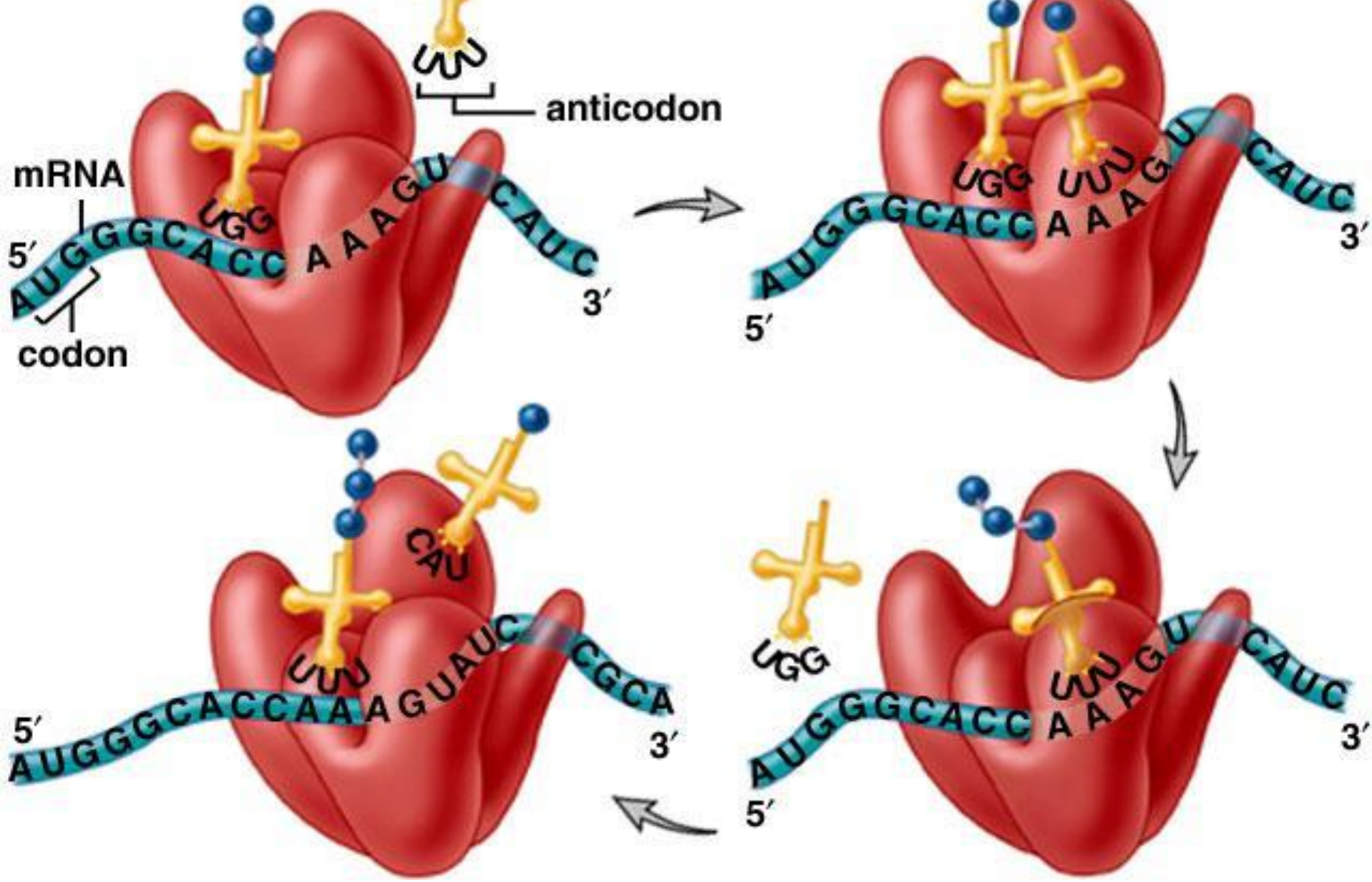
- add AAs one at a time to form chain.
- Incoming tRNA receives AA's from outgoing tRNA. Ribosome moves to allow this to continue

- **Termination**—

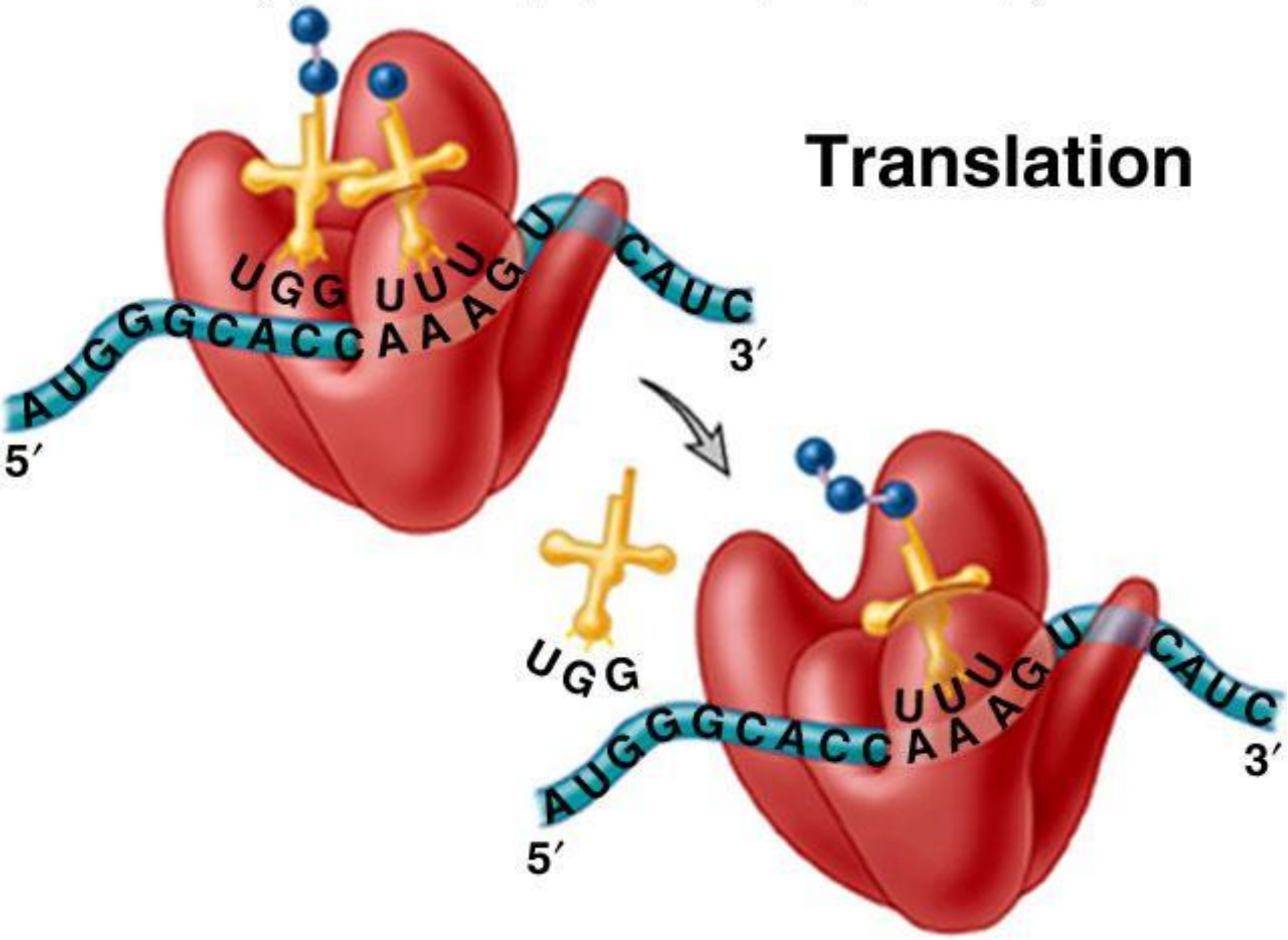
Stop codon--complex falls apart

Translation

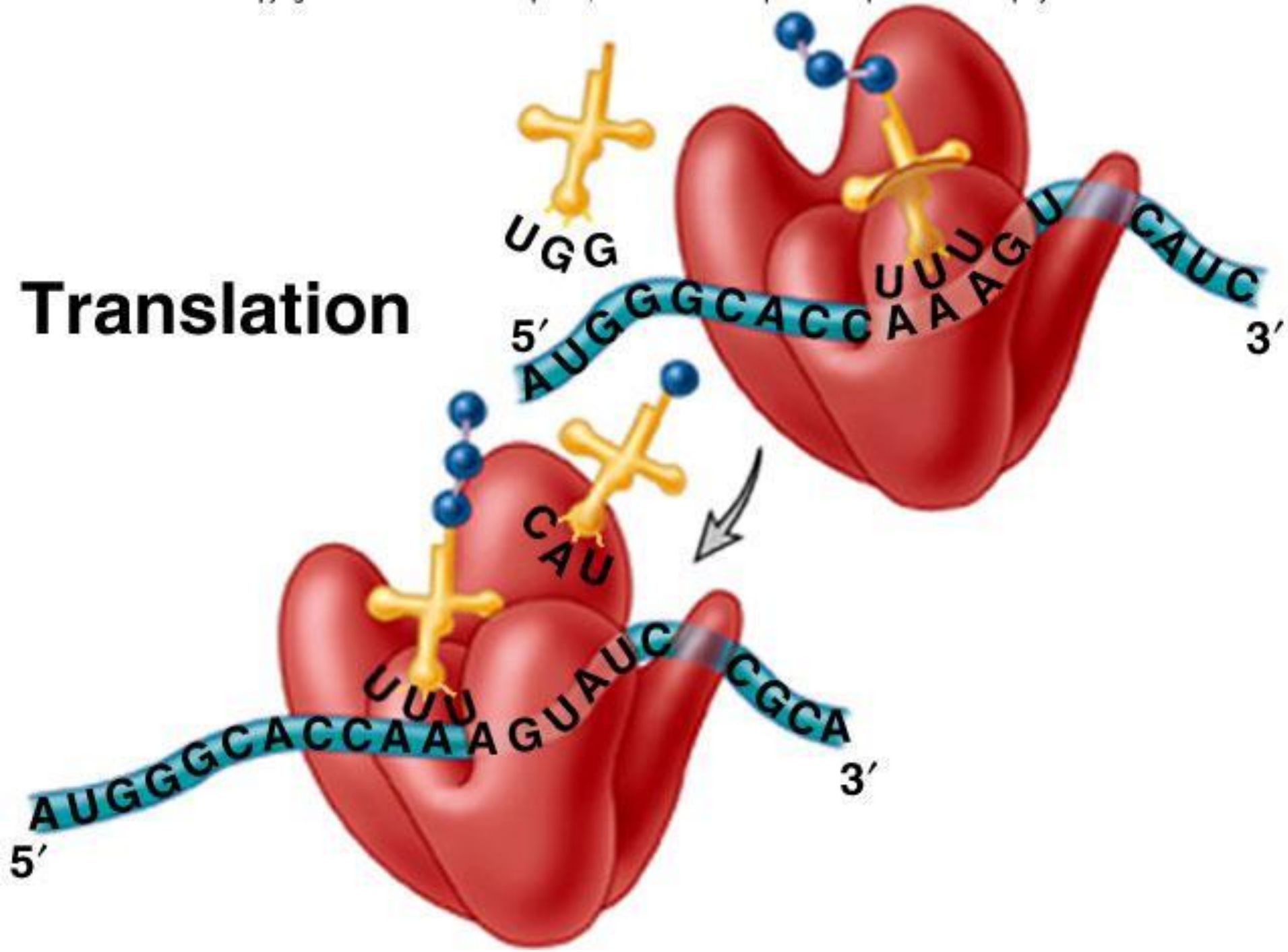
amino acid —●—
tRNA —■—



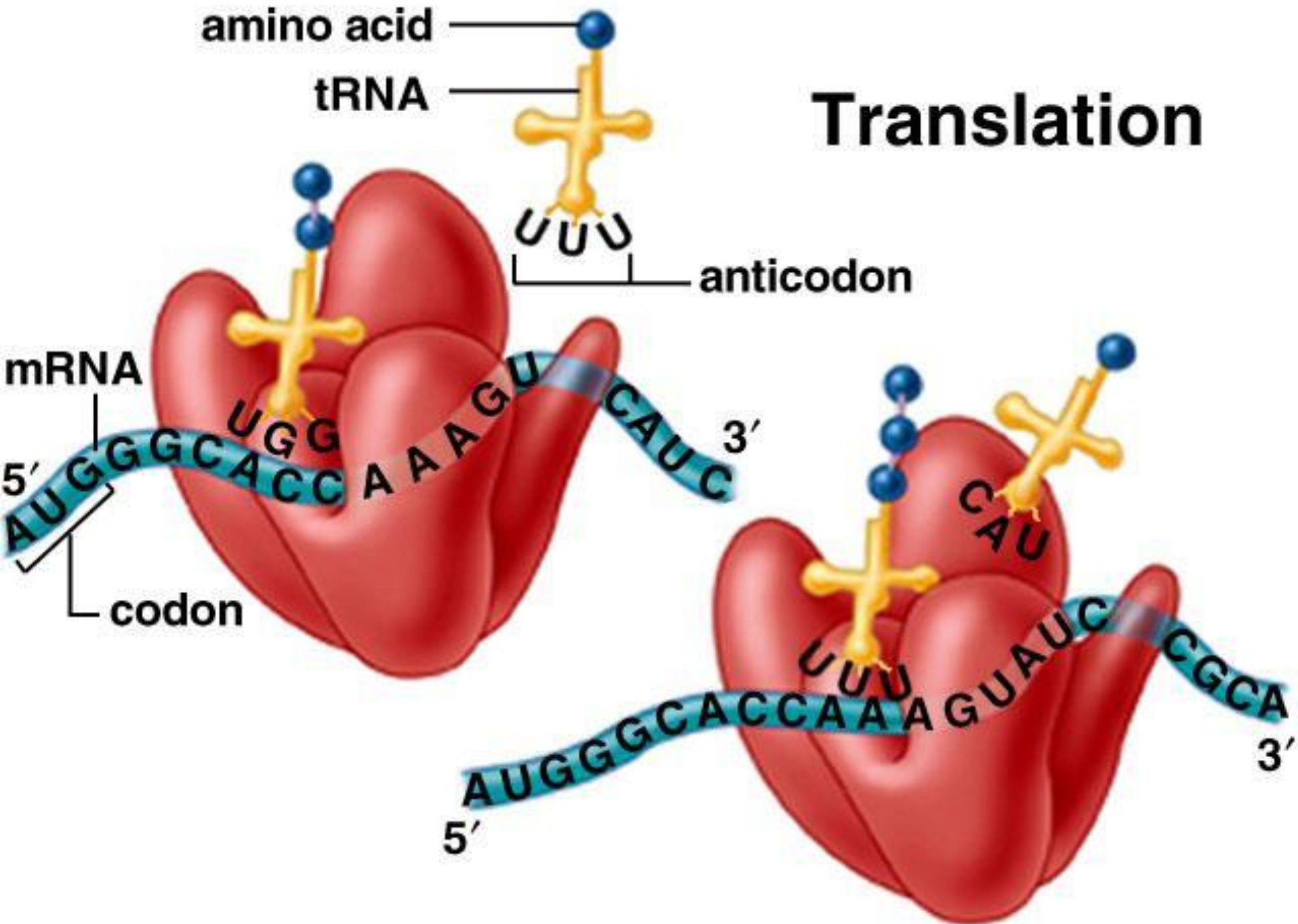
Translation



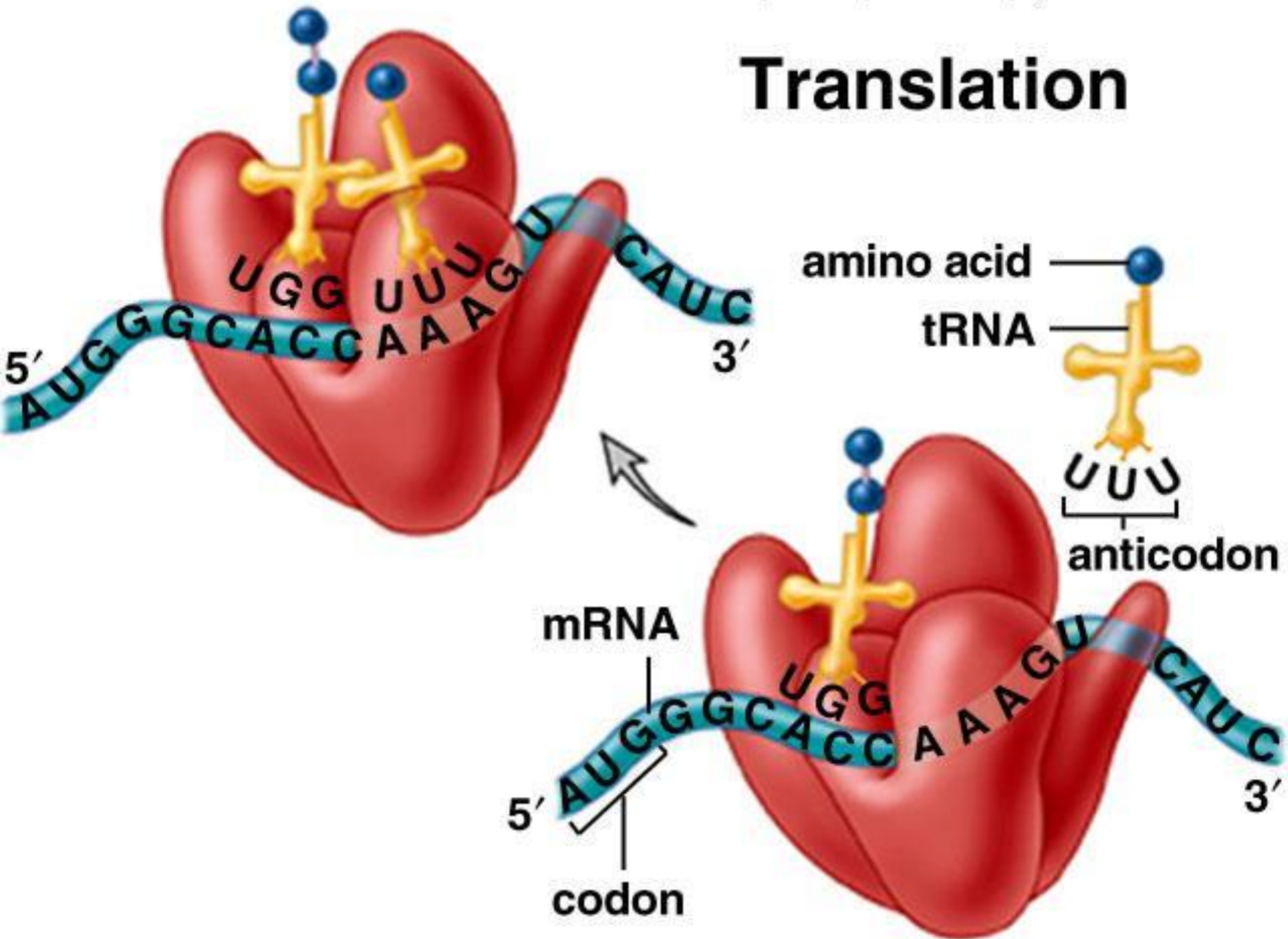
Translation



Translation

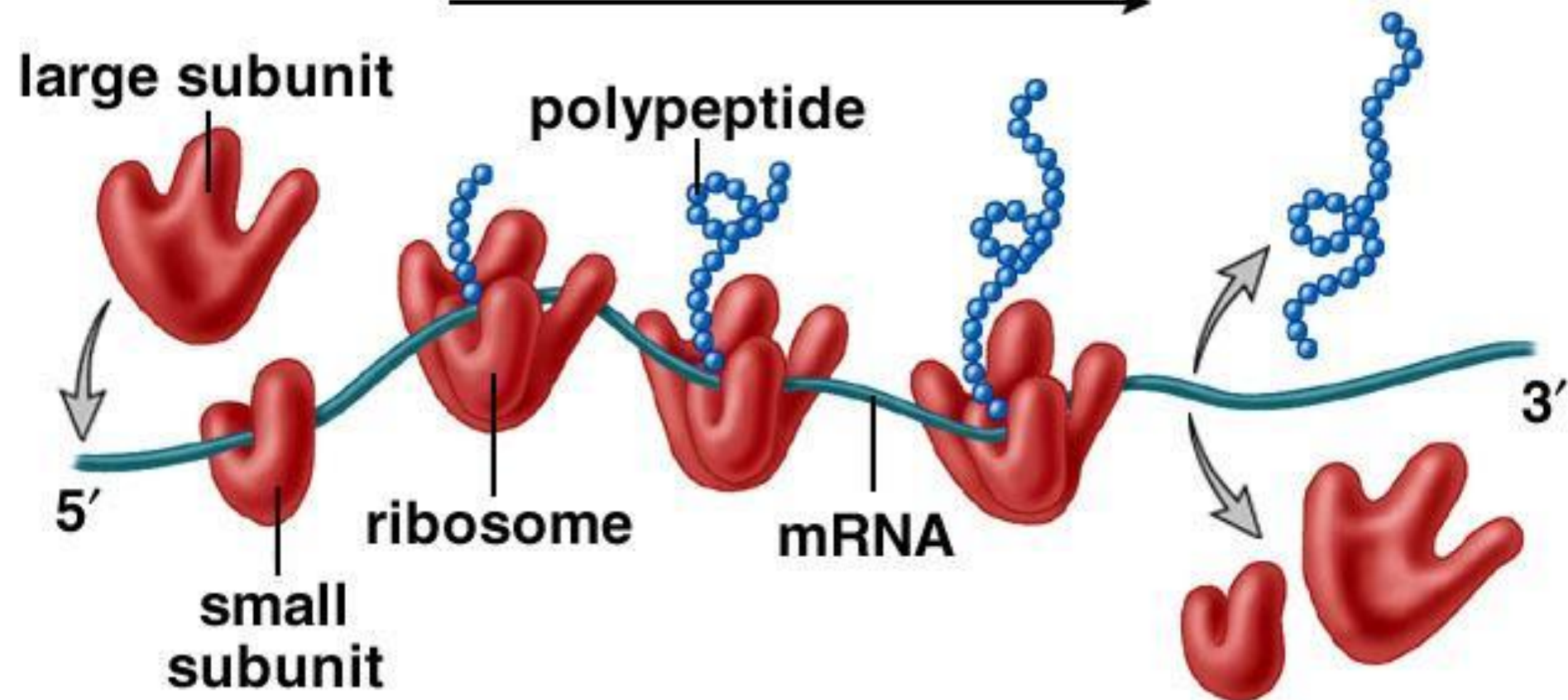


Translation



Polyribosome Structure

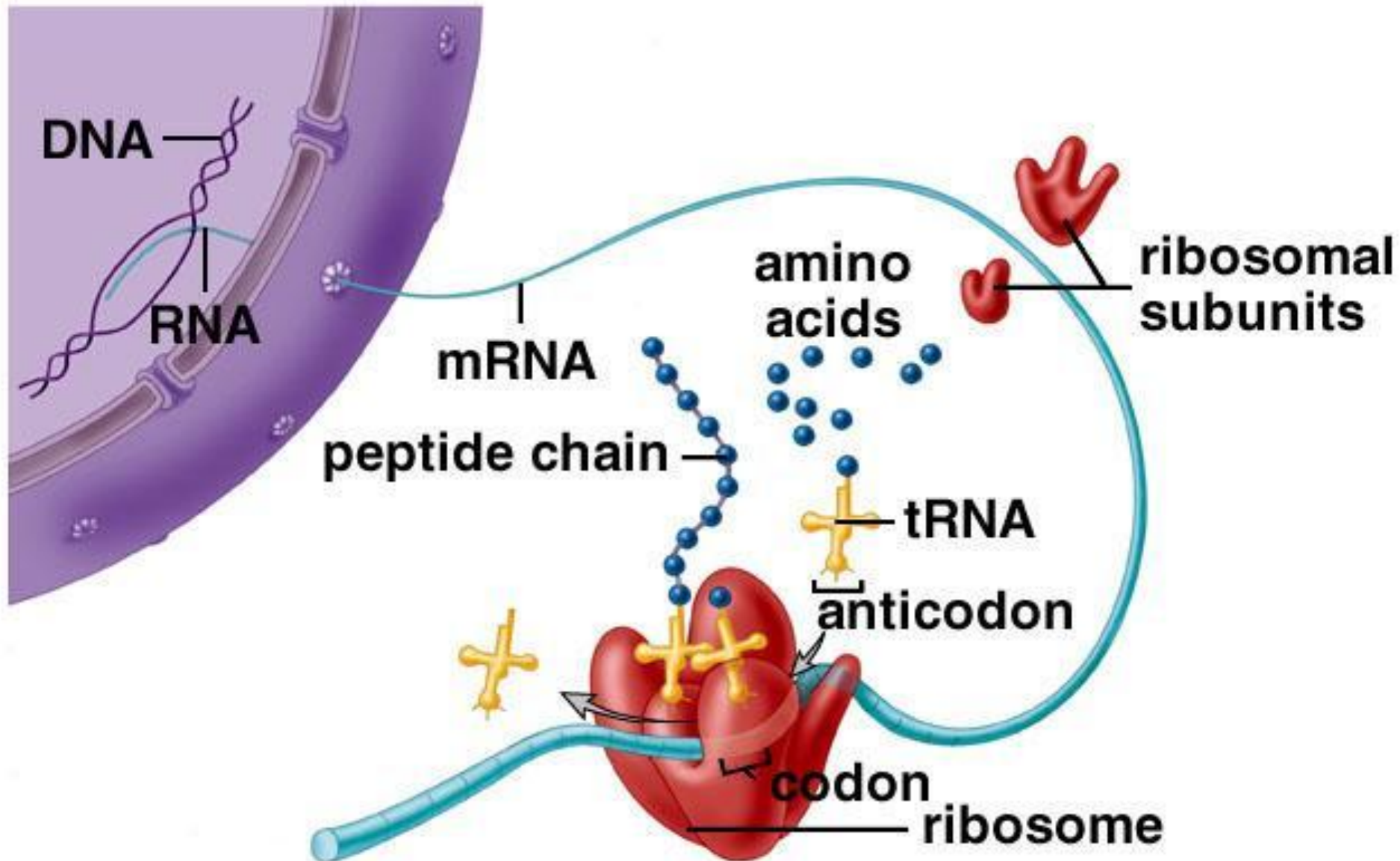
direction of transcription



Translation

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Loop structure
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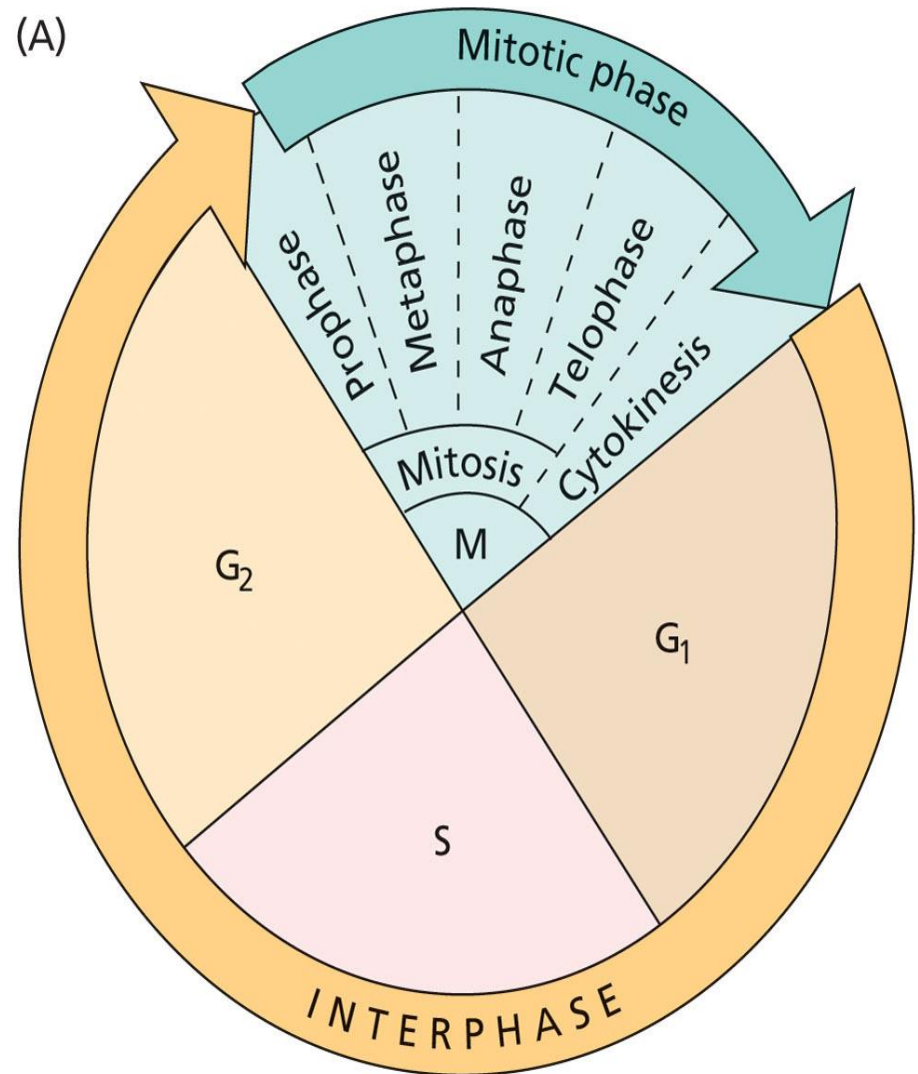
Summary of Gene Expression



Cell Division in Plants

Most plant cells divide by Mitosis

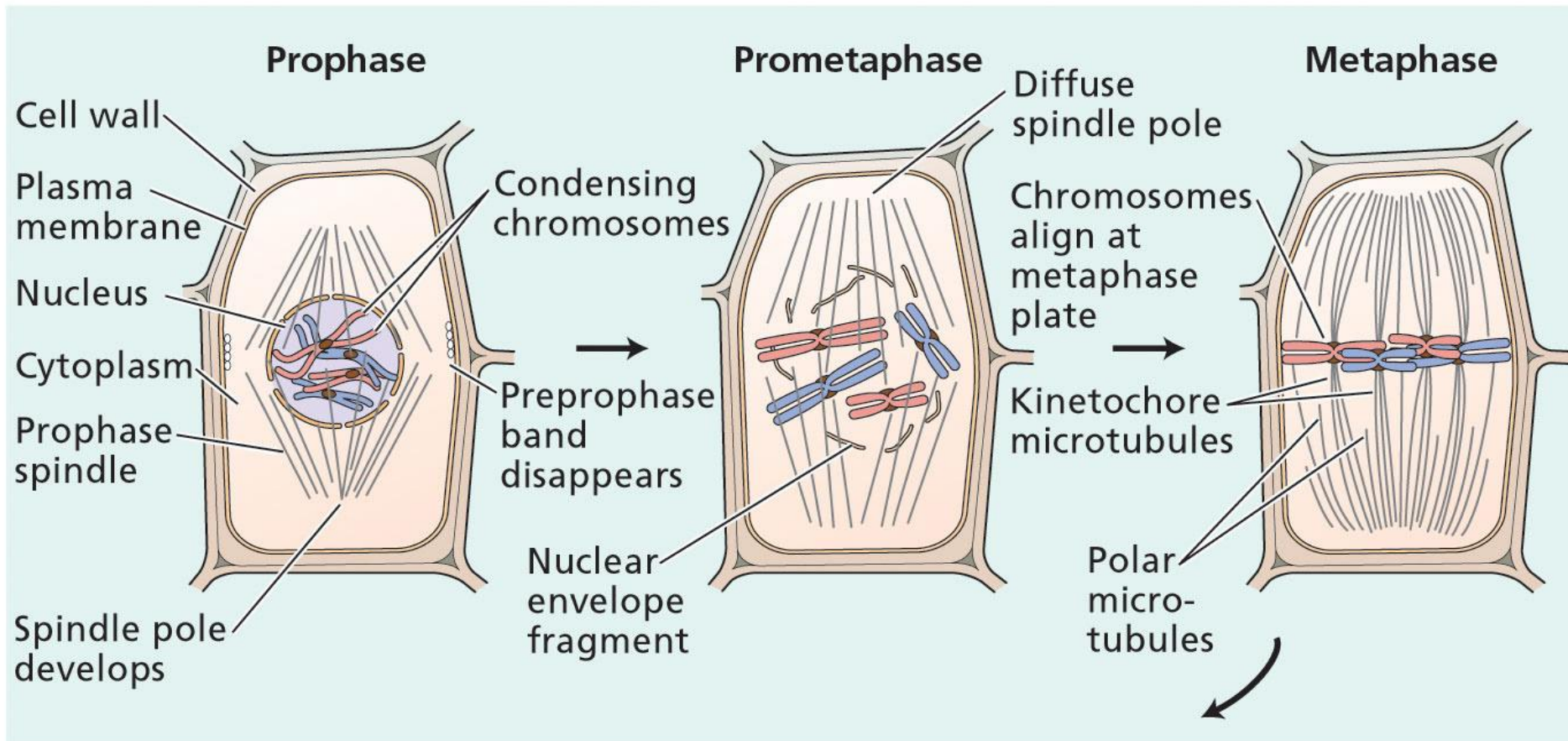
- **Mitosis:** Process of division that produces two daughter cells with identical chromosomal content of parent cell.
- Mitosis is one stage of the cell cycle.
- Cell cycle--cycle of stages a cell goes through in order to grow and divide.



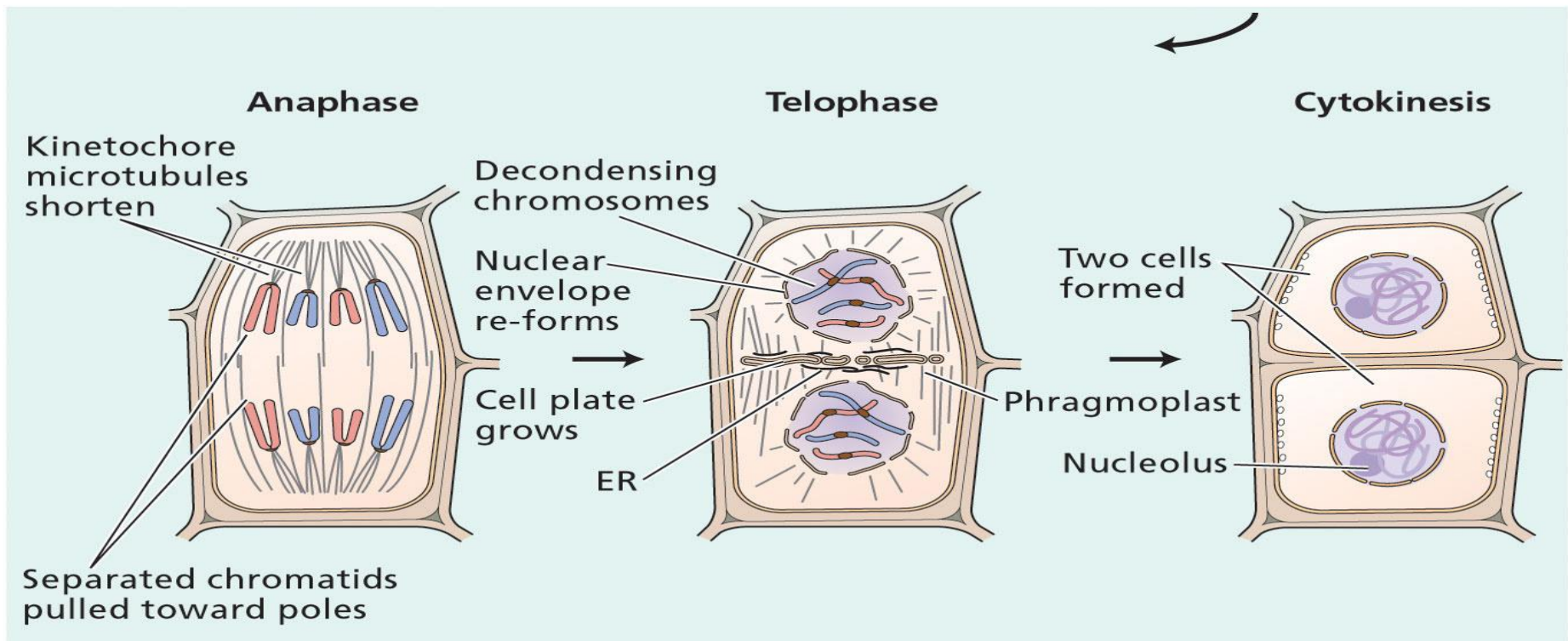
Stages of Division

- **Prophase**--nuclear envelope breakdown, chromosome condensation, spindle formation.
- **Metaphase**--chromosomes are lined up precisely on the metaphase plate, or middle of the cell.
- **Anaphase**--spindle pulls sister chromatids apart.
- **Telophase**--chromatids begin to decondense and become chromatin. Spindle disappears.
- **Cytokinesis**--divide cell and organelles. Actin ring, or cleavage furrow splits cell.

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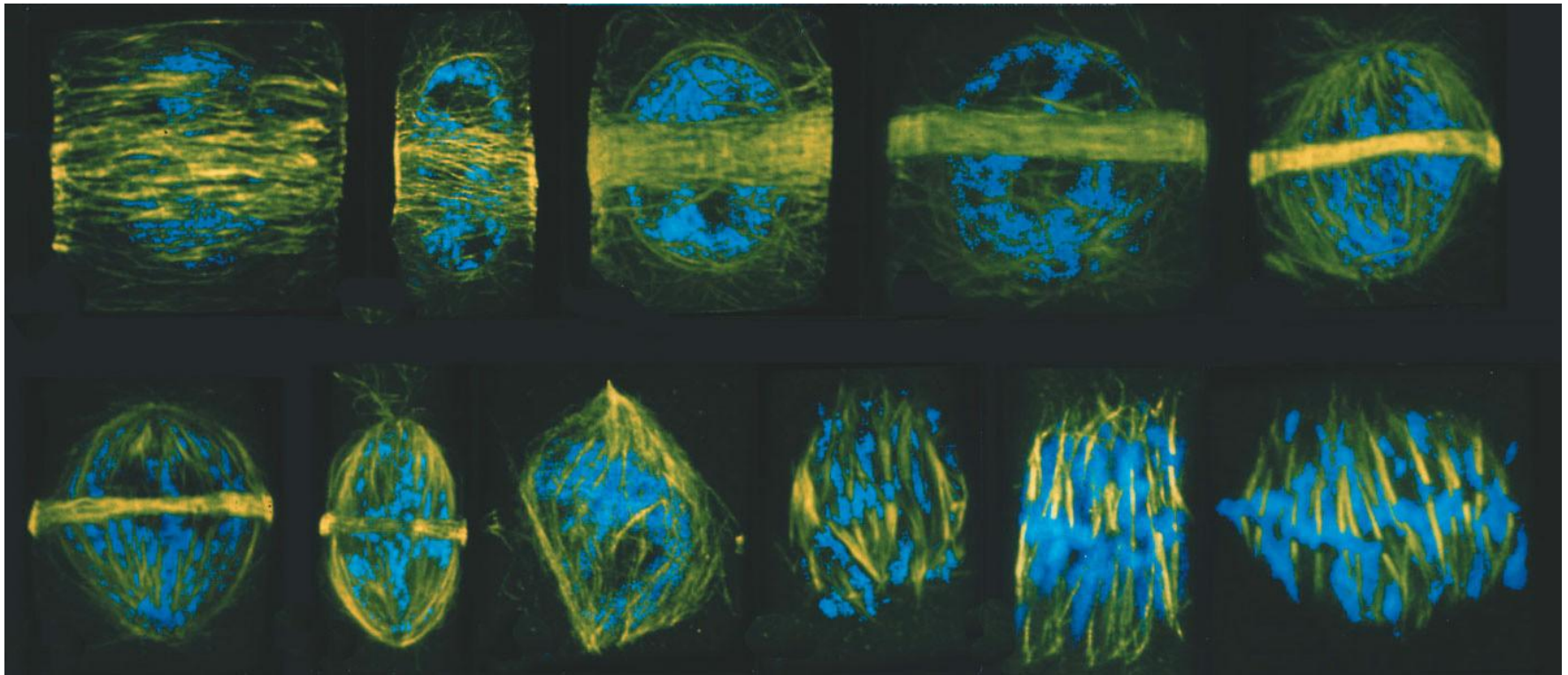


- **Anaphase**--spindle pulls sister chromatids apart.
- **Telophase**--chromatids begin to decondense and become chromatin. Spindle disappears.
 - **NEW CELL WALL IS FORMED**
- **Cytokinesis**--divide cell and organelles. Actin ring, or cleavage furrow splits cell.



Remember the cytoskeleton?

- Changes in microtubule arrangements (yellow) during different stages of the cell cycle of wheat root cells. DNA is shown in blue.



ANY
QUESTIONS?