Leaves,steams,flowers,seeds and fruits:

Form and structure

Dr. Haitham Kurbaj

Plant Cells

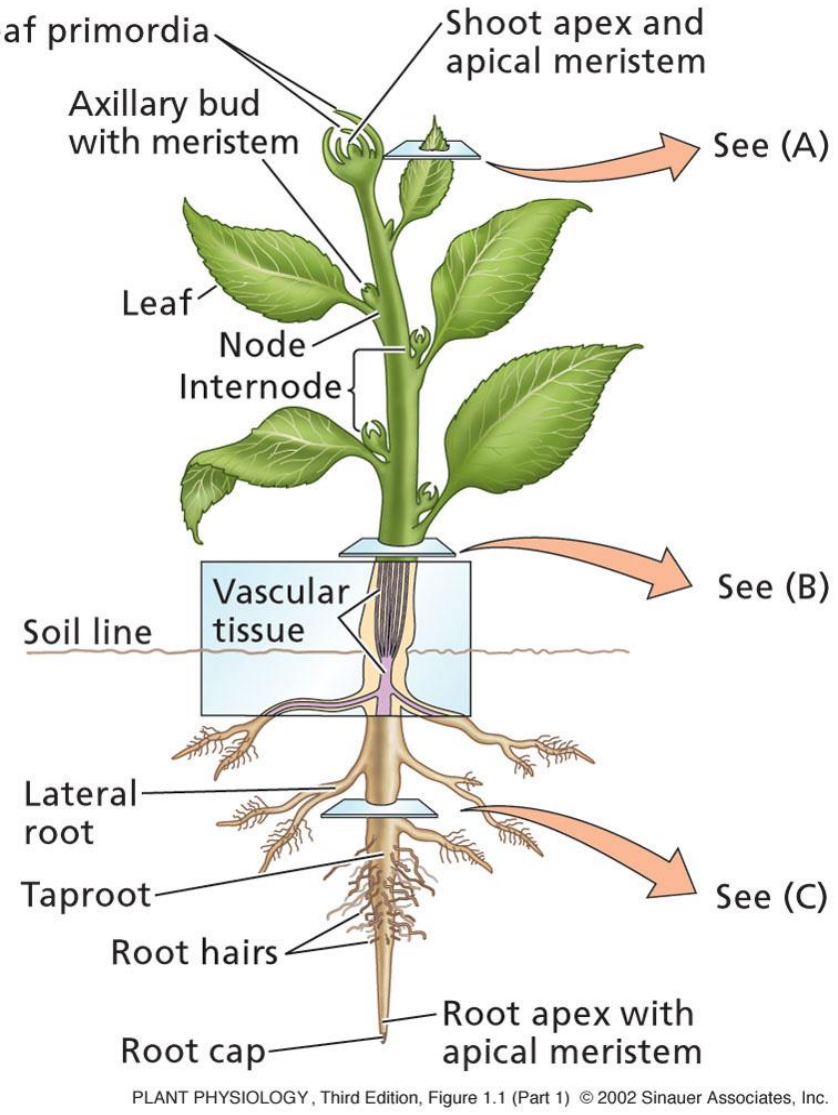
Overview of Plant Structure

- 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 the 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 tc stem.
- **Internode:** Region of stem between two nodes



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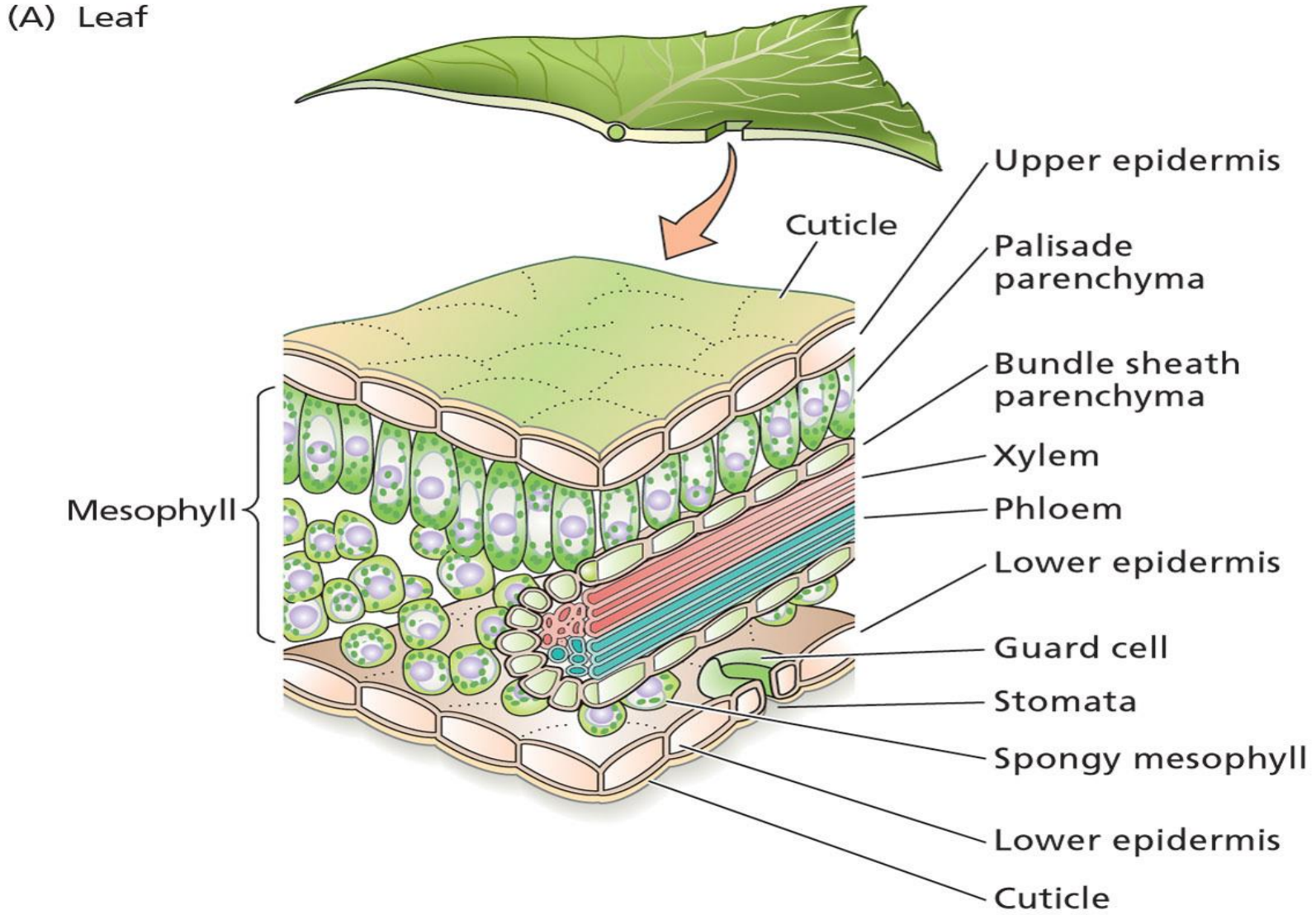
THE LEAF



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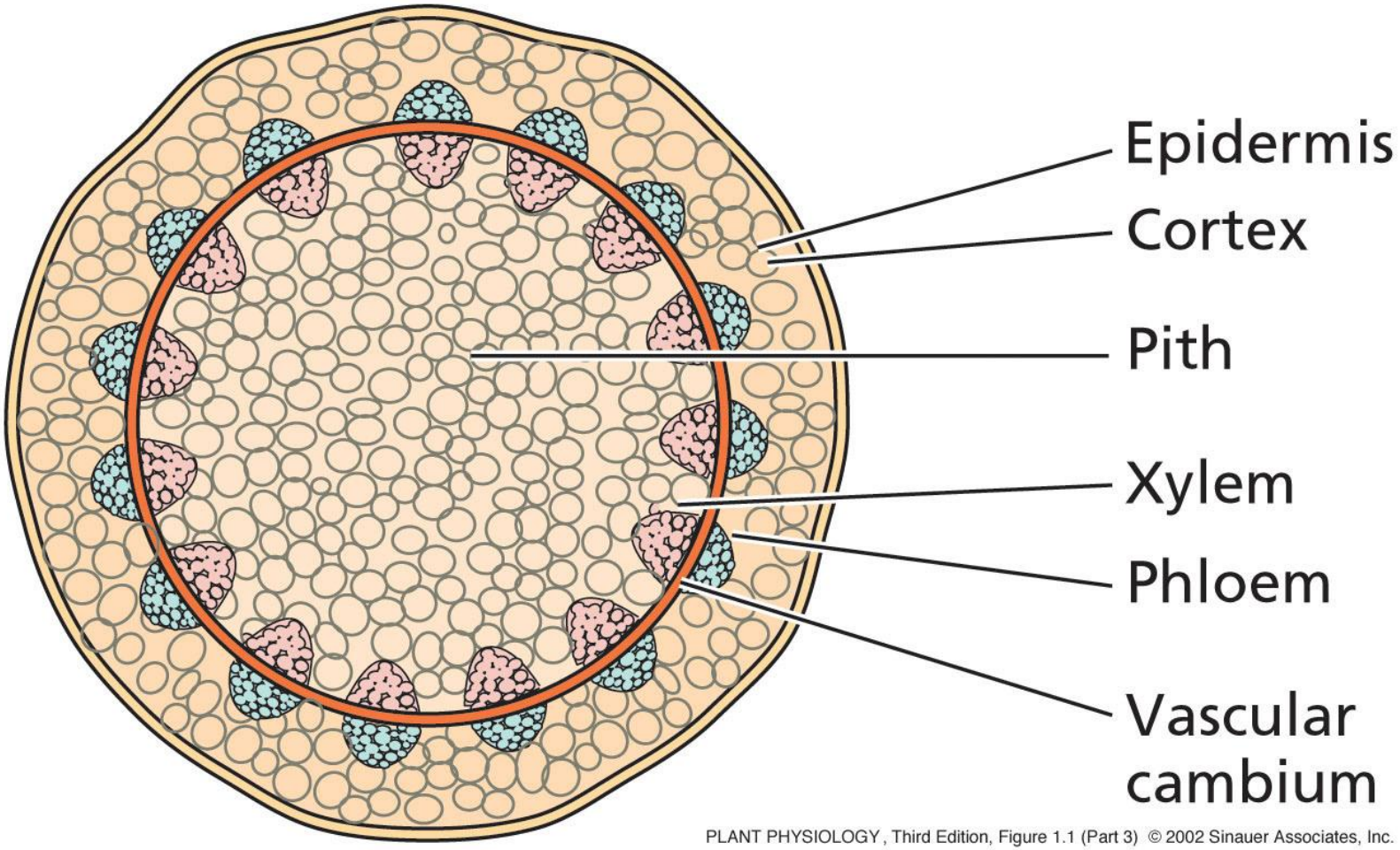
THE STEM

(B) Stem



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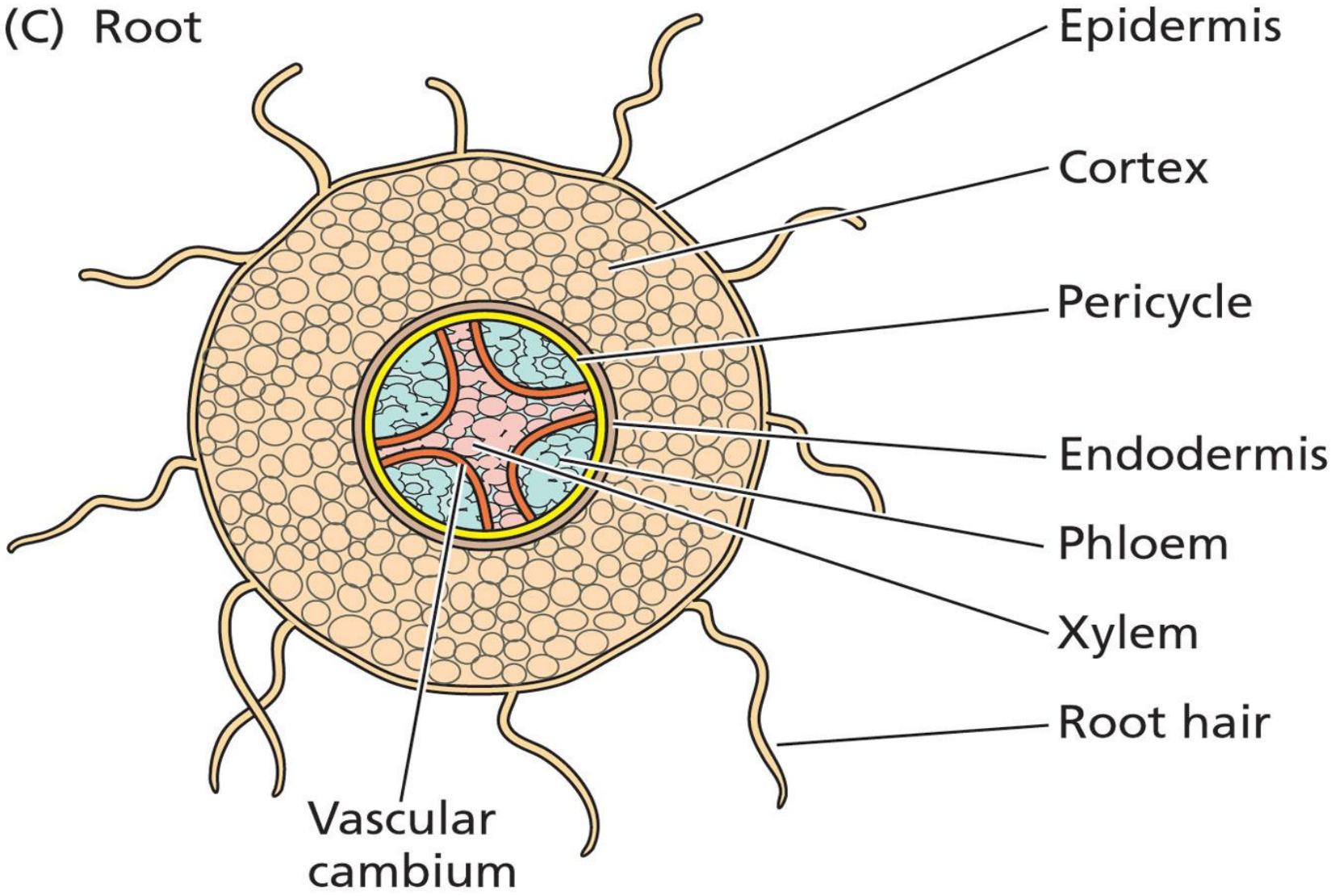
THE ROOT

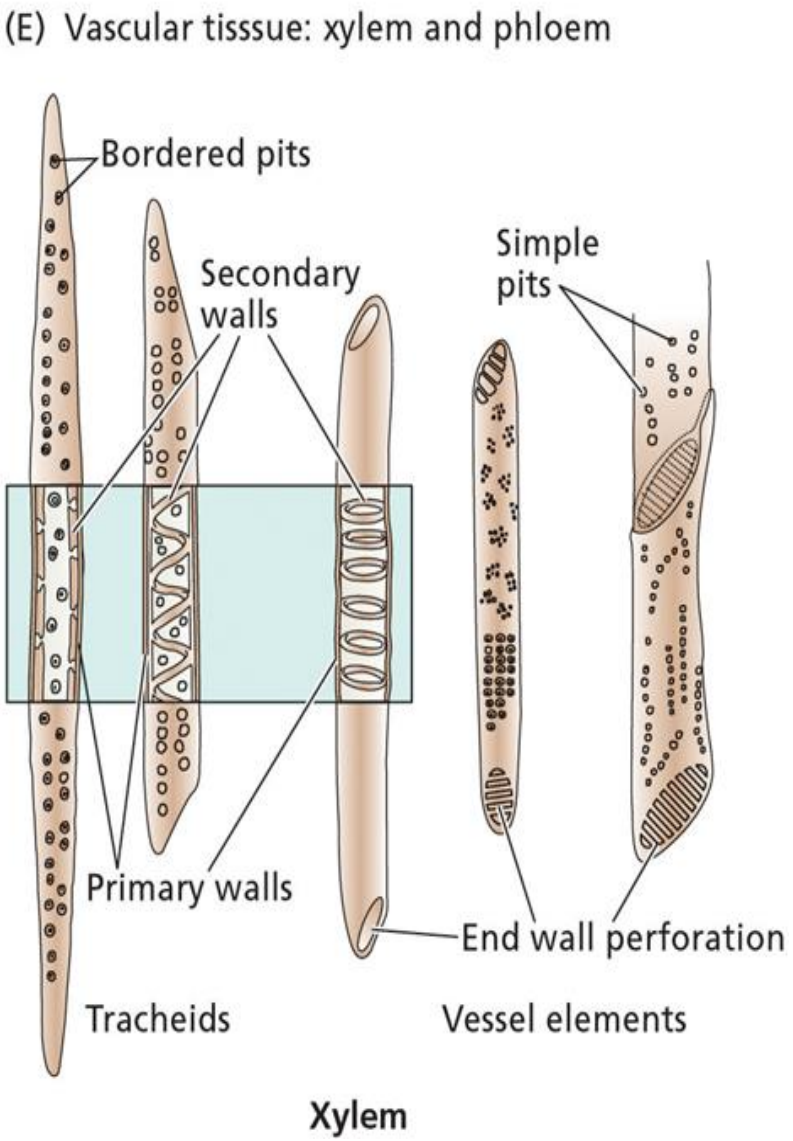


Overview of Plant Structure

- 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 flowing plants!
- ***Gymnosperms***:
  - Less advanced than angiosperms
    - About 700 species known
    - Largest group is the conifer (cone bearer)
      - ie, pine, fir, spruce, and redwood

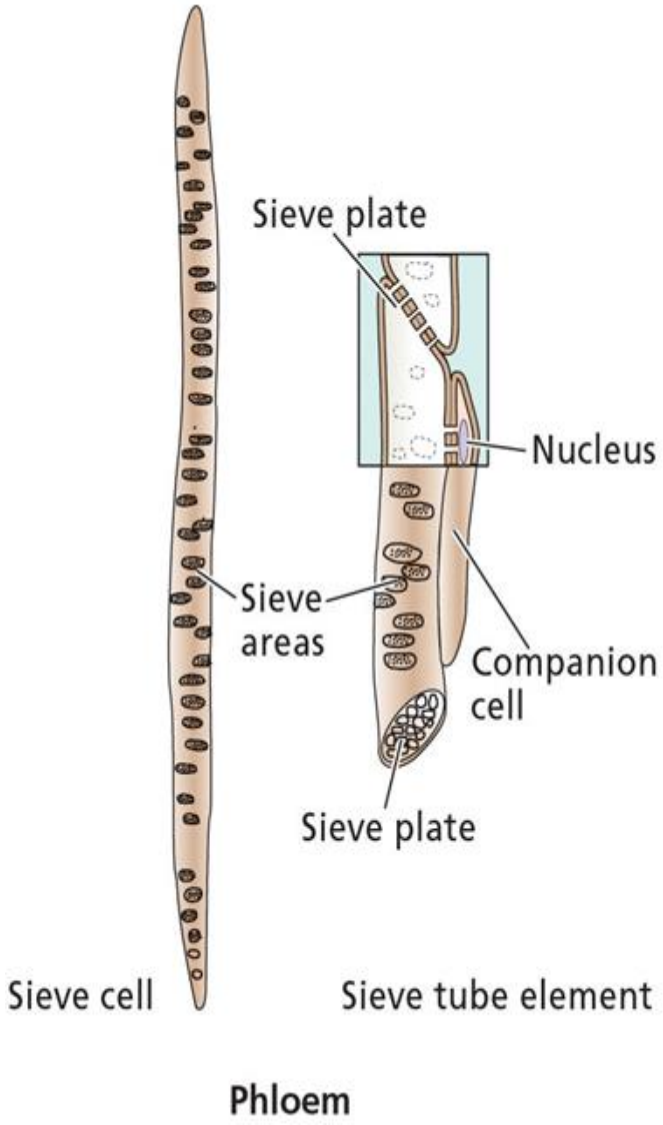
Overview of Plant Structure

- ***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

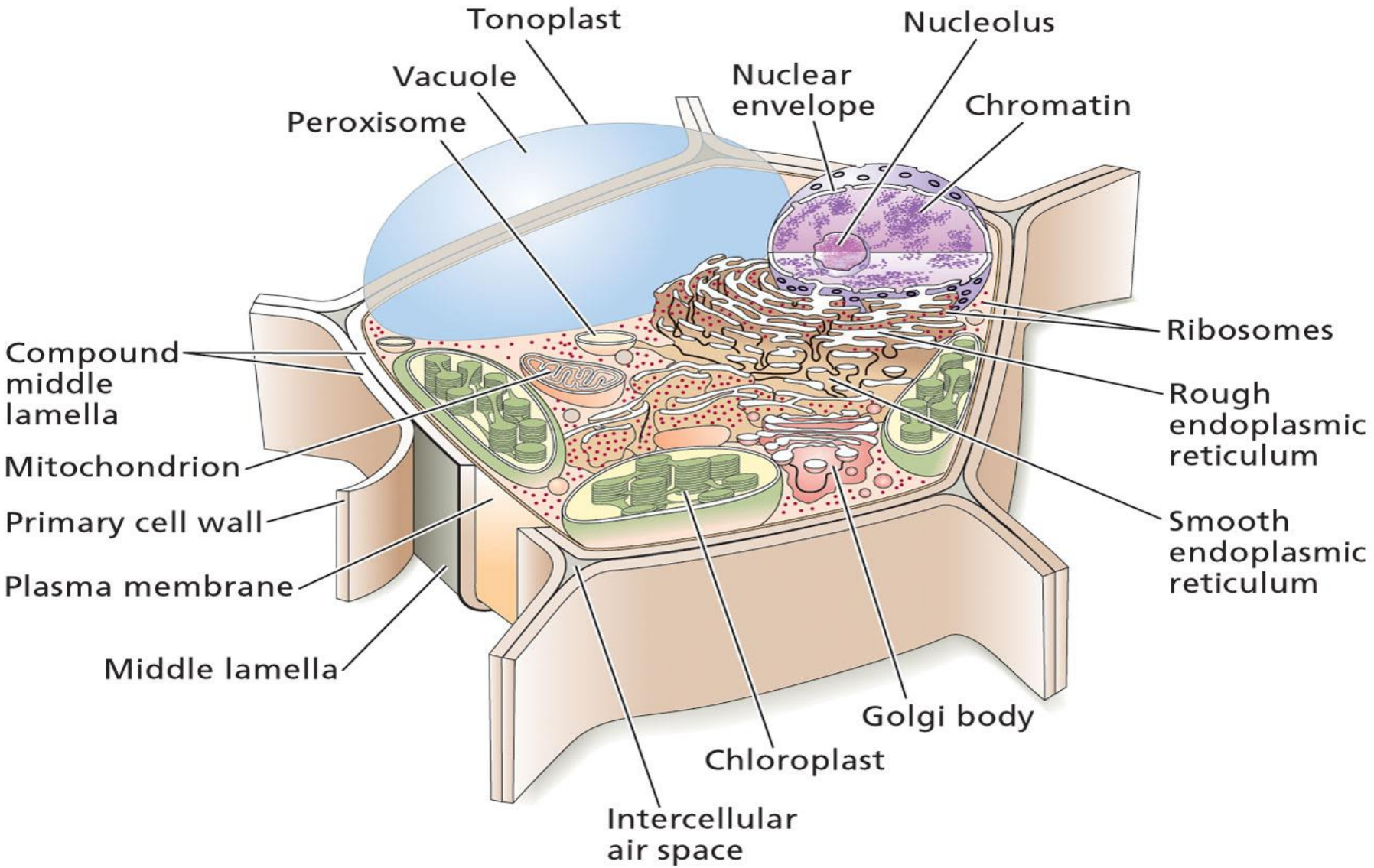


Overview of Plant Structure

- ***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



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The Plant Cell

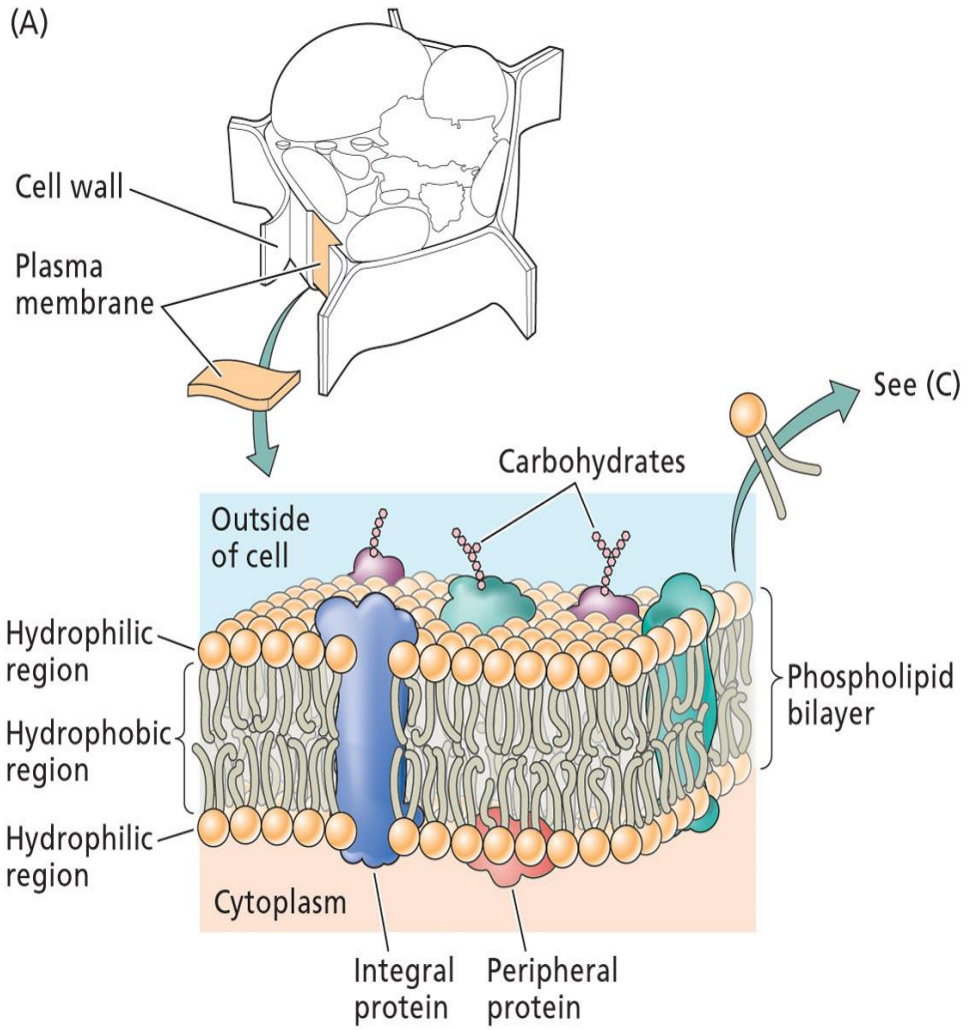
- All plant cells have the same basic eukaryotic organization
  - ***However***, at maturity when they become specialized, plant cells may differ greatly from one another in their structures and functions
    - ***Even those physically next to each other.***
    - ***Even the nucleus can be lost in some plant cells***

- Contains many organelles with specific functions

- Enclosed by a membrane which defines their boundaries

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



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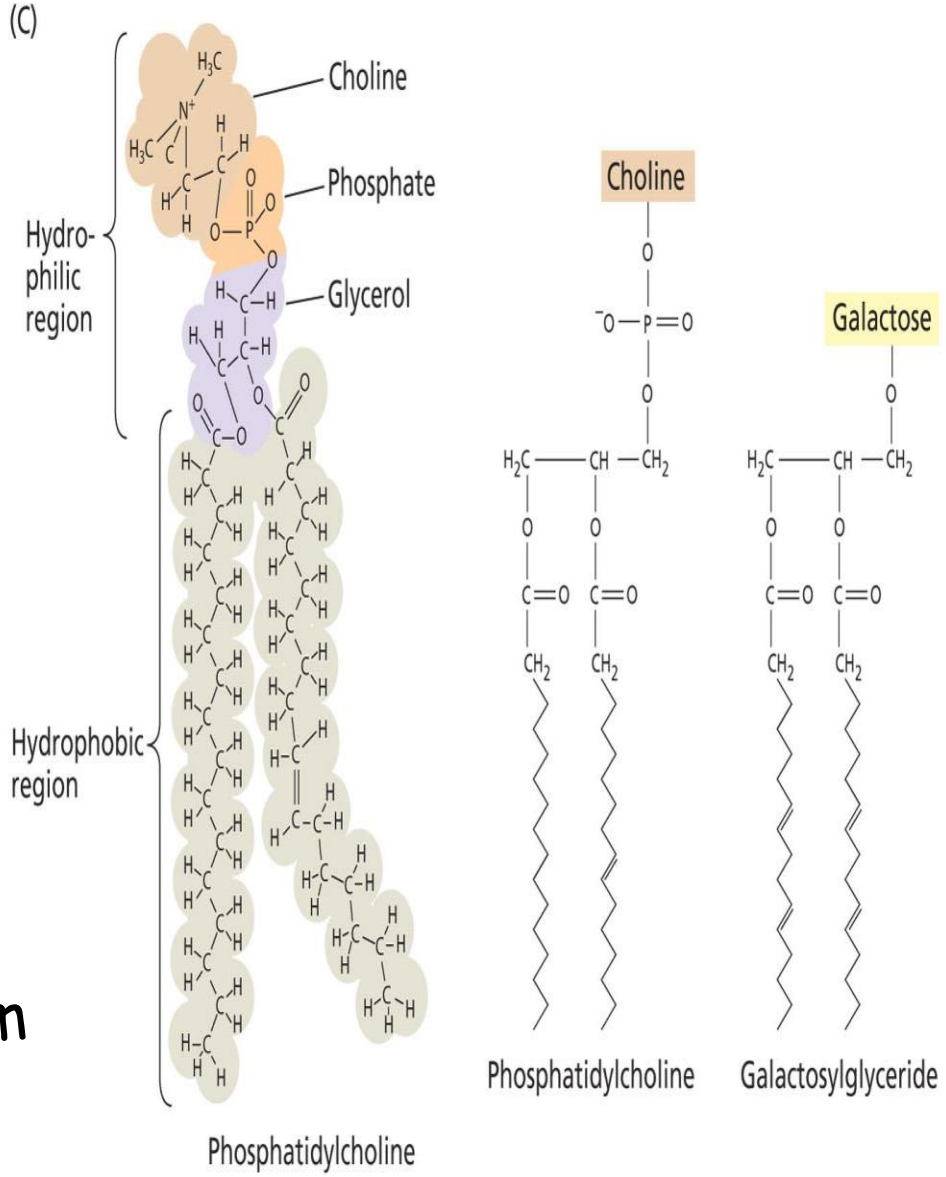
The Plasma Membrane

- ***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.

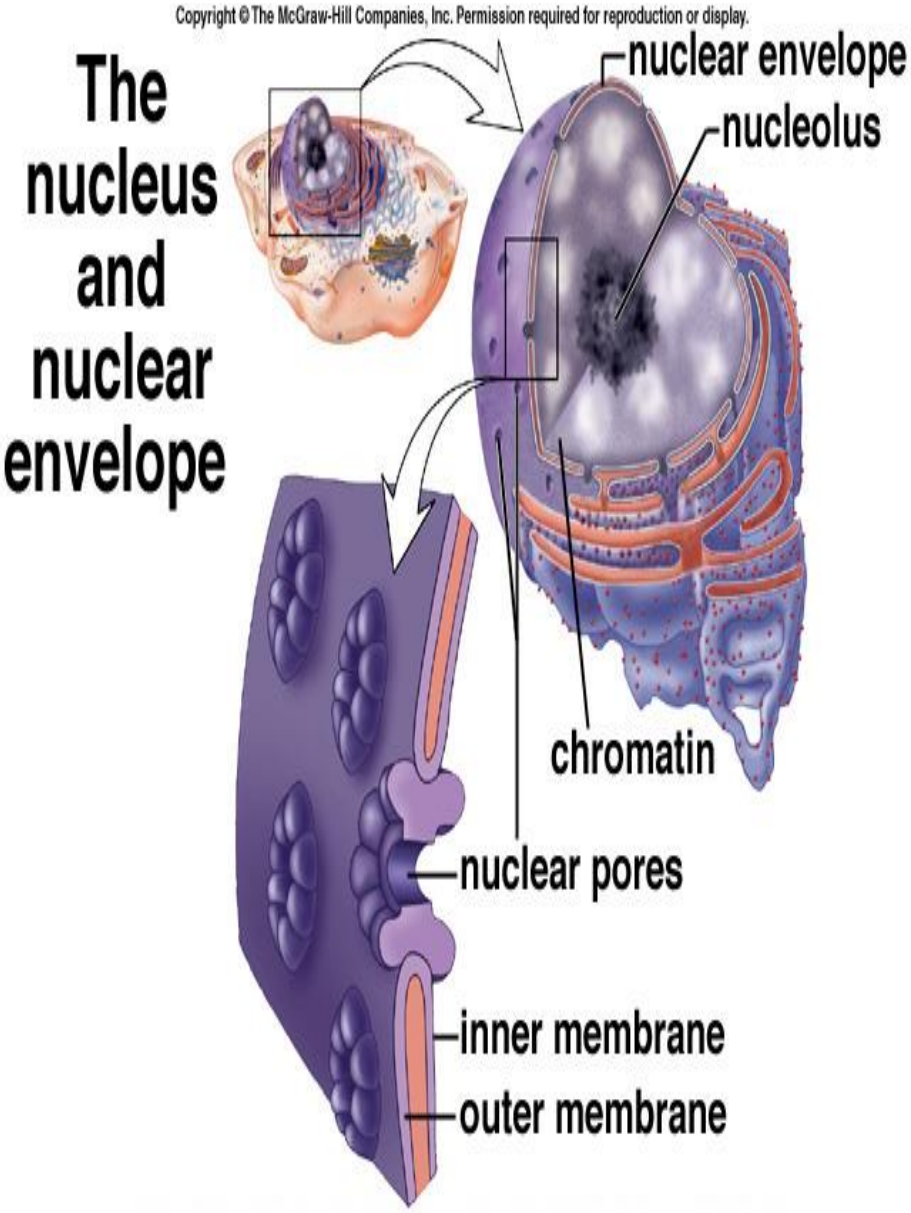


The Plasma Membrane

- ***Proteins***:
- ***Integral proteins***:
  - Embedded in lipid bylayer – 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

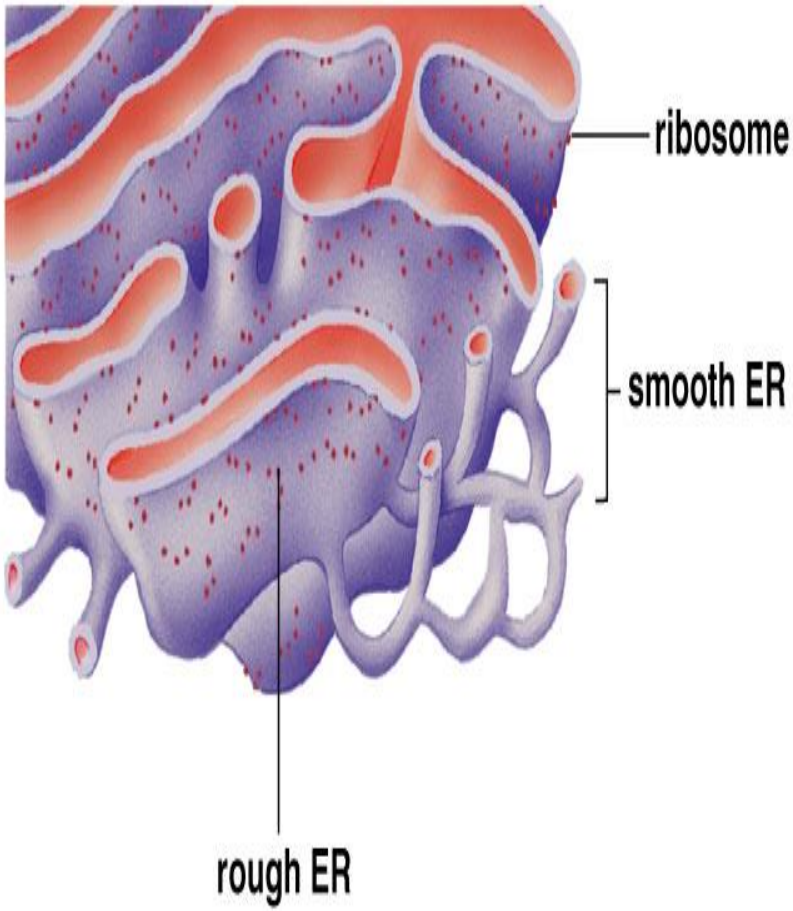
- Contains ***almost all*** of the genetic material
- What it contains is called the ***nuclear genome*** – this varies greatly between plant species.
- Surrounded by ***nuclear envelope-*** double membrane - ***same as the plasma membrane***.
- The ***nuclear pores*** allow for the passage of macromolecules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



The Endoplasmic reticulum

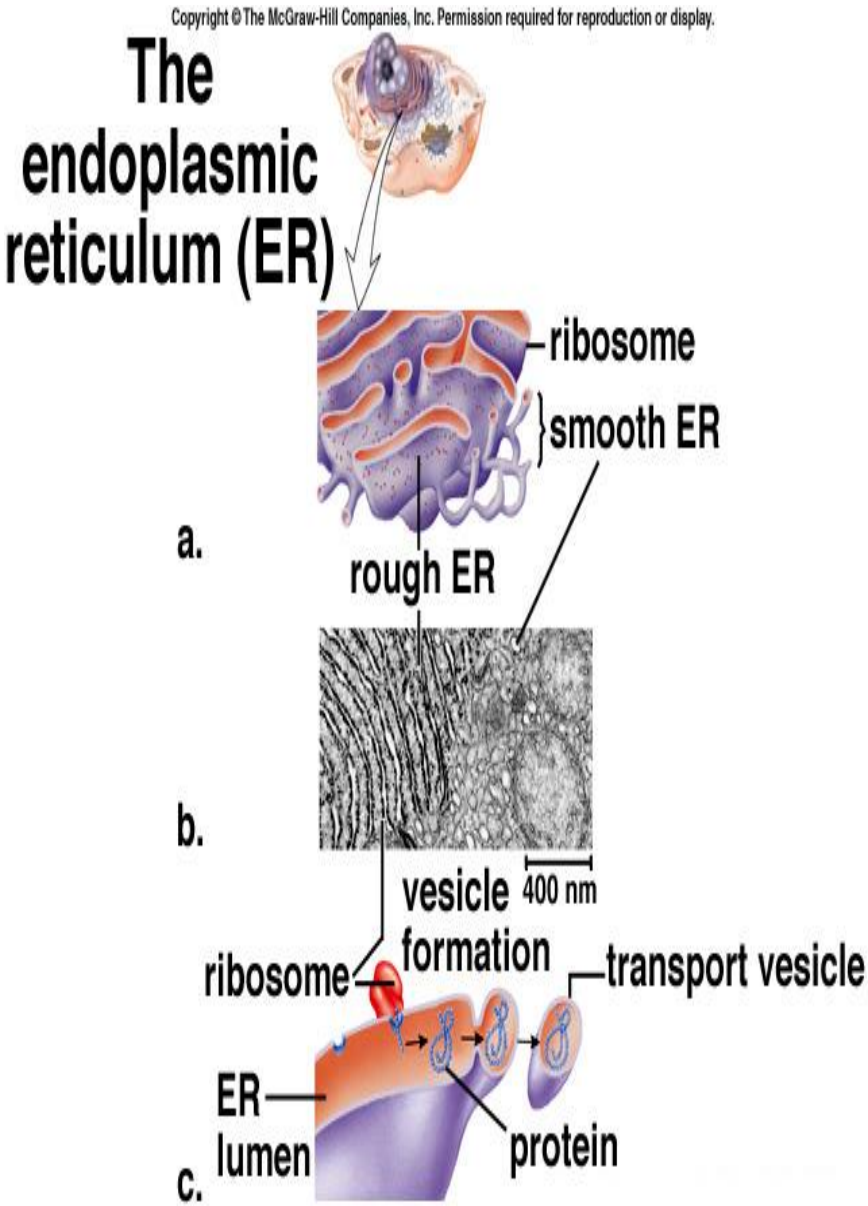
- Connected to the nuclear envelope
- 3D-network of continuous tubules that course through the cytoplasm.

- ***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



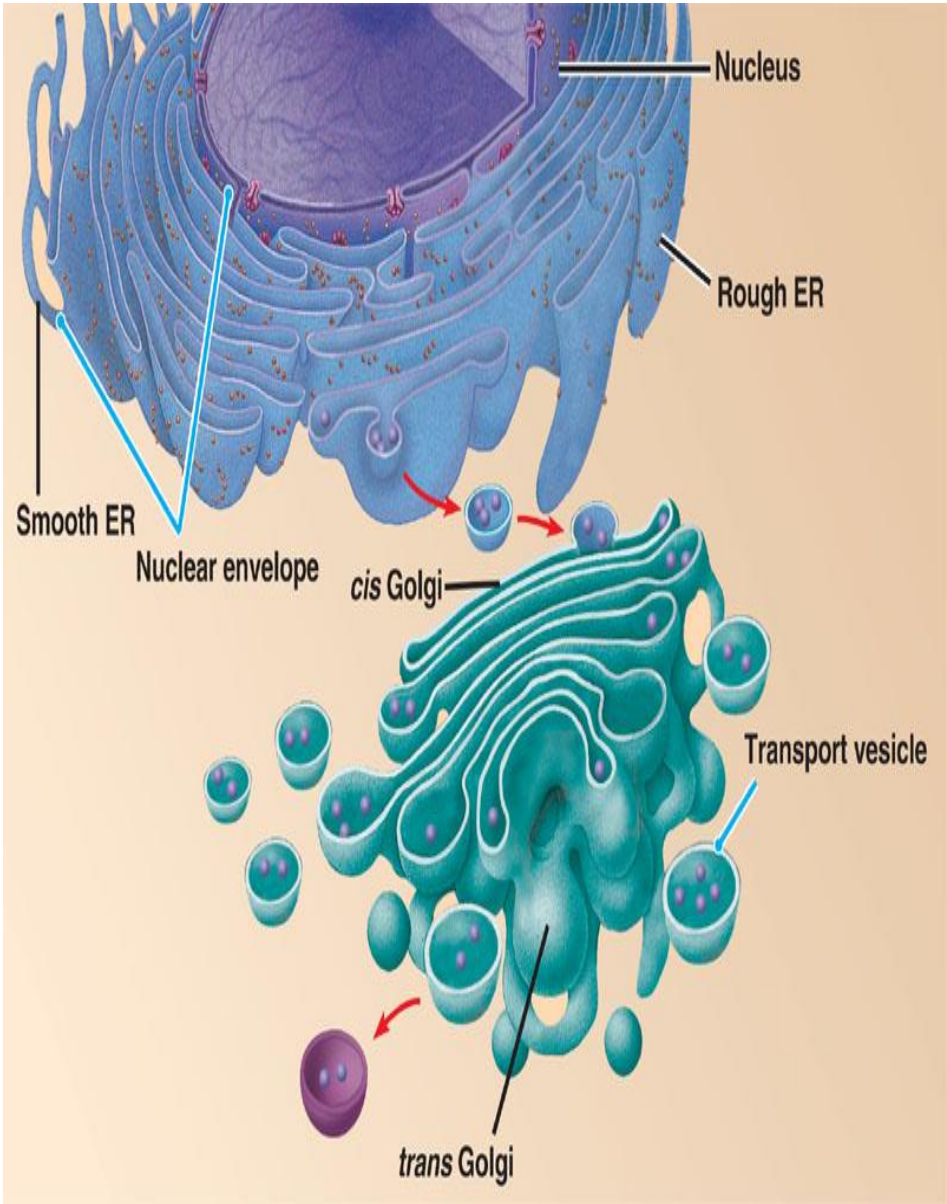
The Endoplasmic reticulum

- 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***



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:

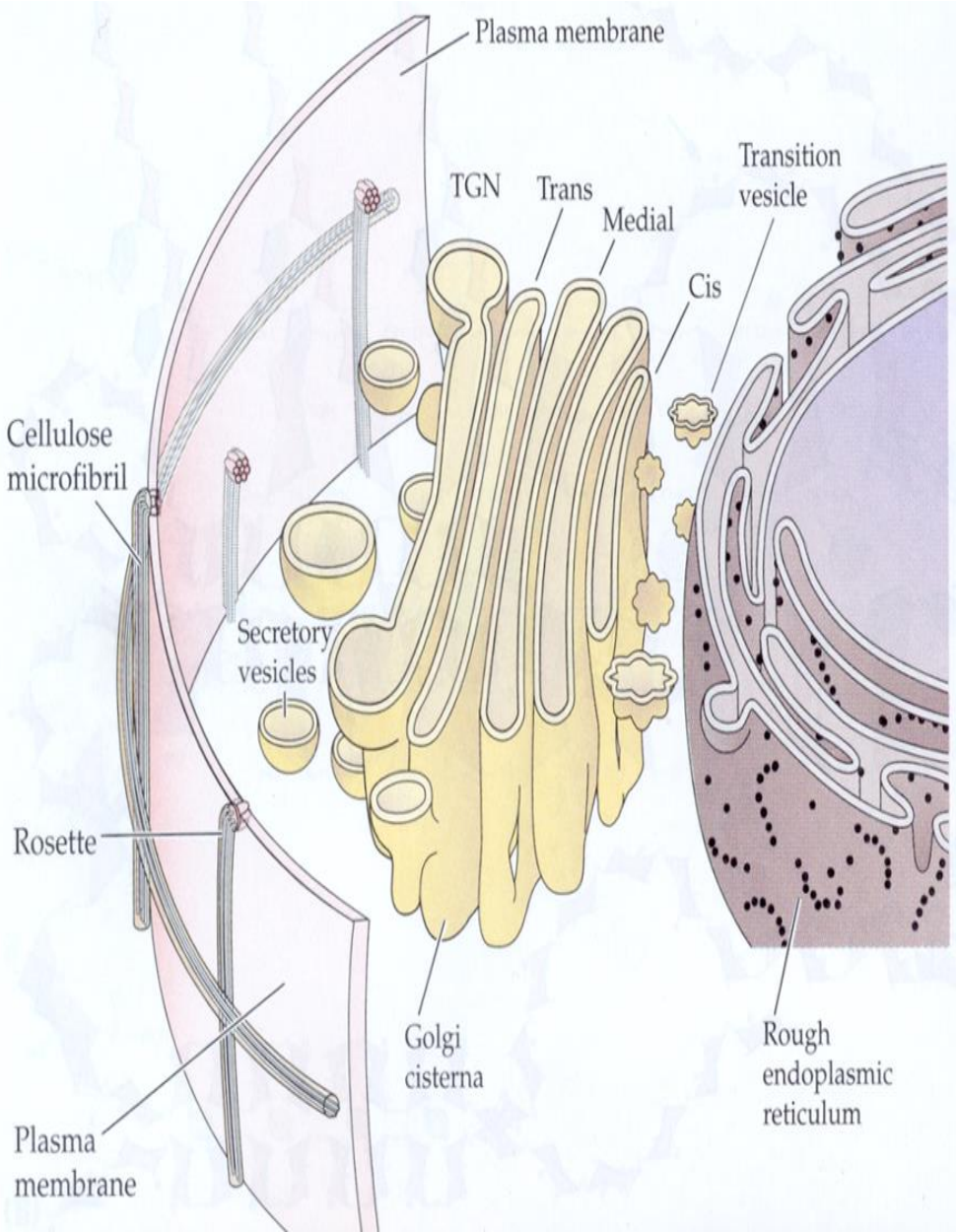
- Pectins
  - HGA
  - RG I
  - RG II
- Cross-linking glycans
  - Xyloglucan
  - Glucuronoarabinoxylan
  - β-Glucan
  - Galactomannan

Site of glycosylation of:

- HRGPs
- AGPs
- Modified glycoproteins

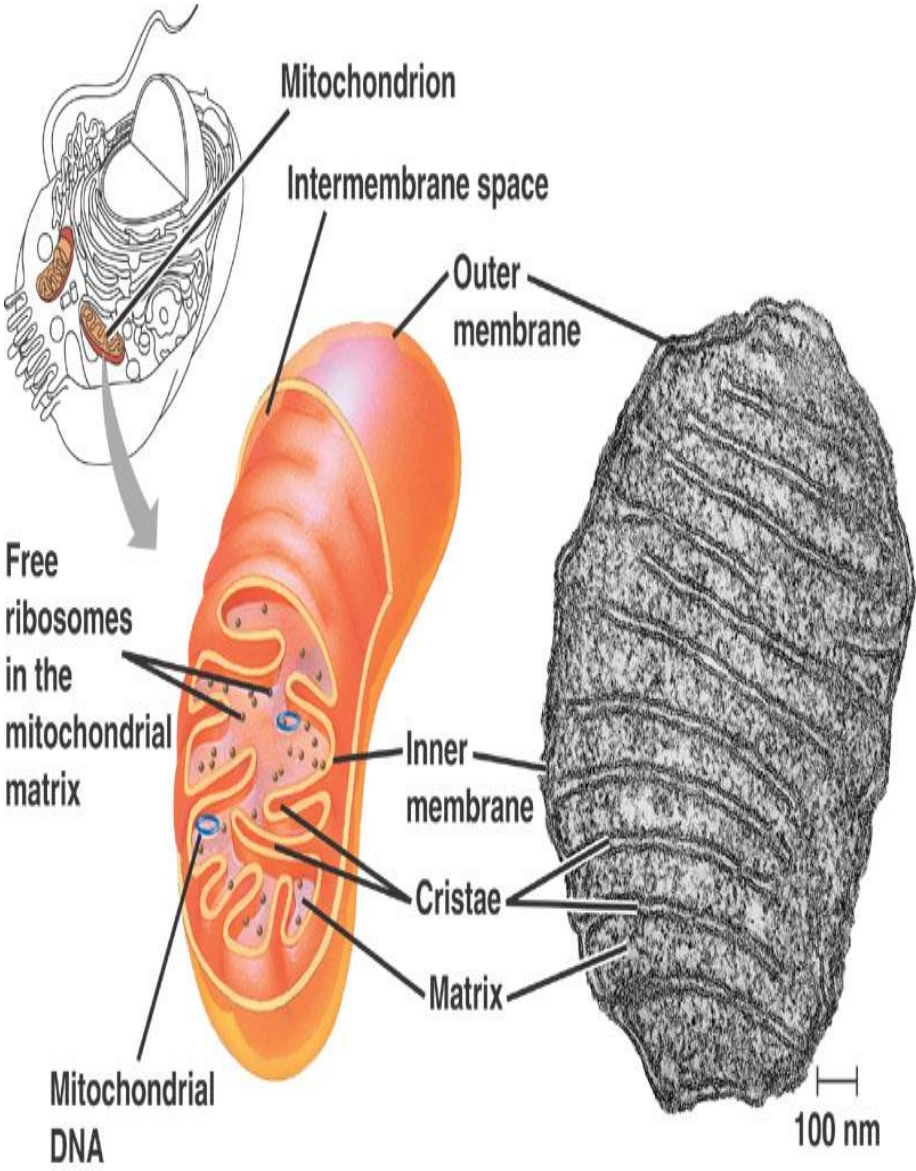
Site of synthesis for:

- 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

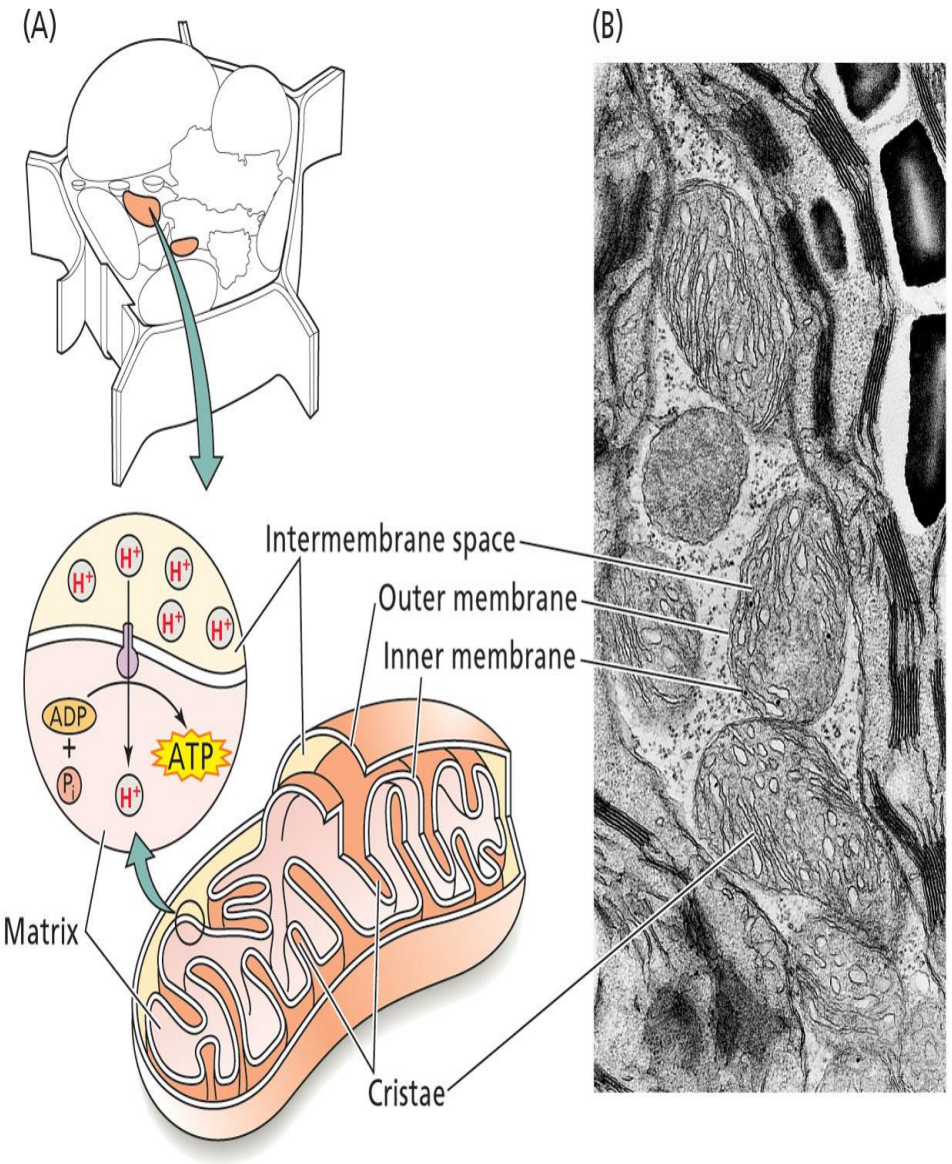
Site of Cellular Respiration

- 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 CO2 is produced. This occurs in the mitochondrion.

  - ***Electron transport-***--electrons are transferred to oxygen. This produces H2O and ATP. Occurs in the mito.



The Chloroplast

- Contain their own DNA and protein-synthesizing machinery
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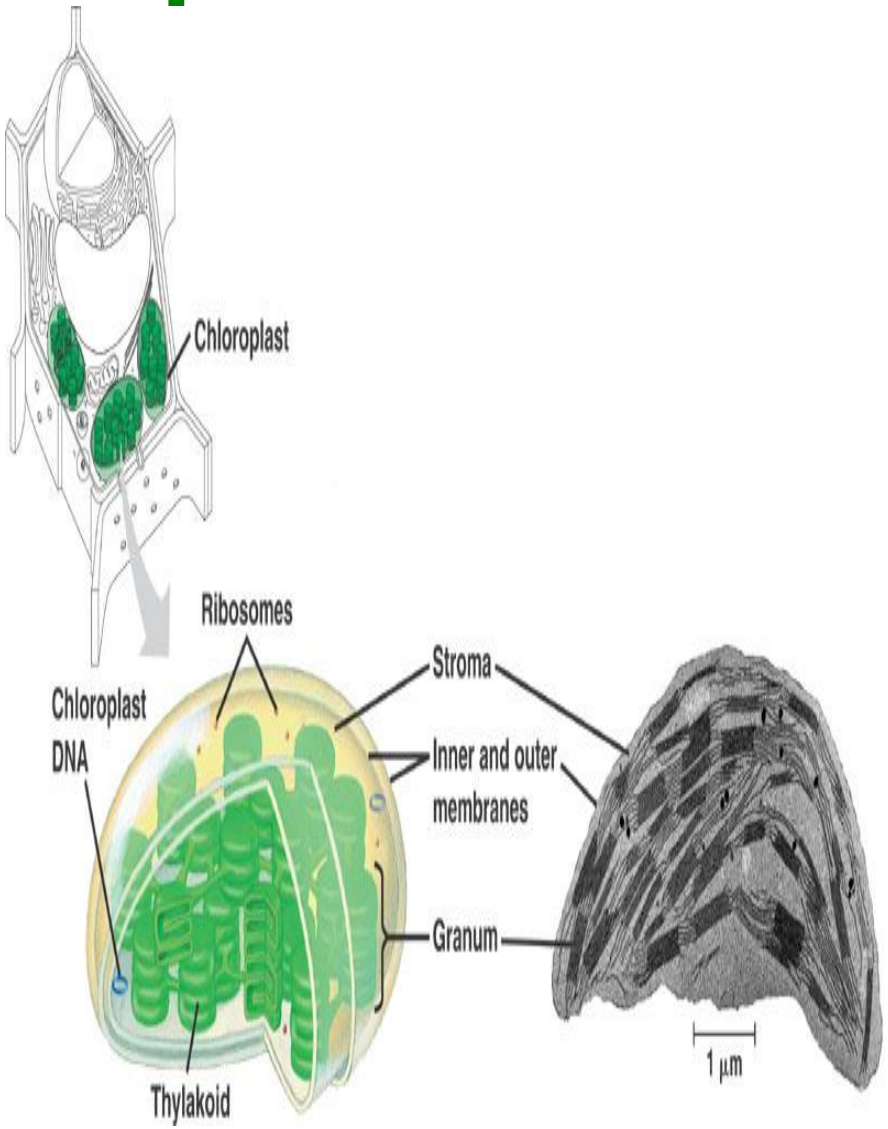
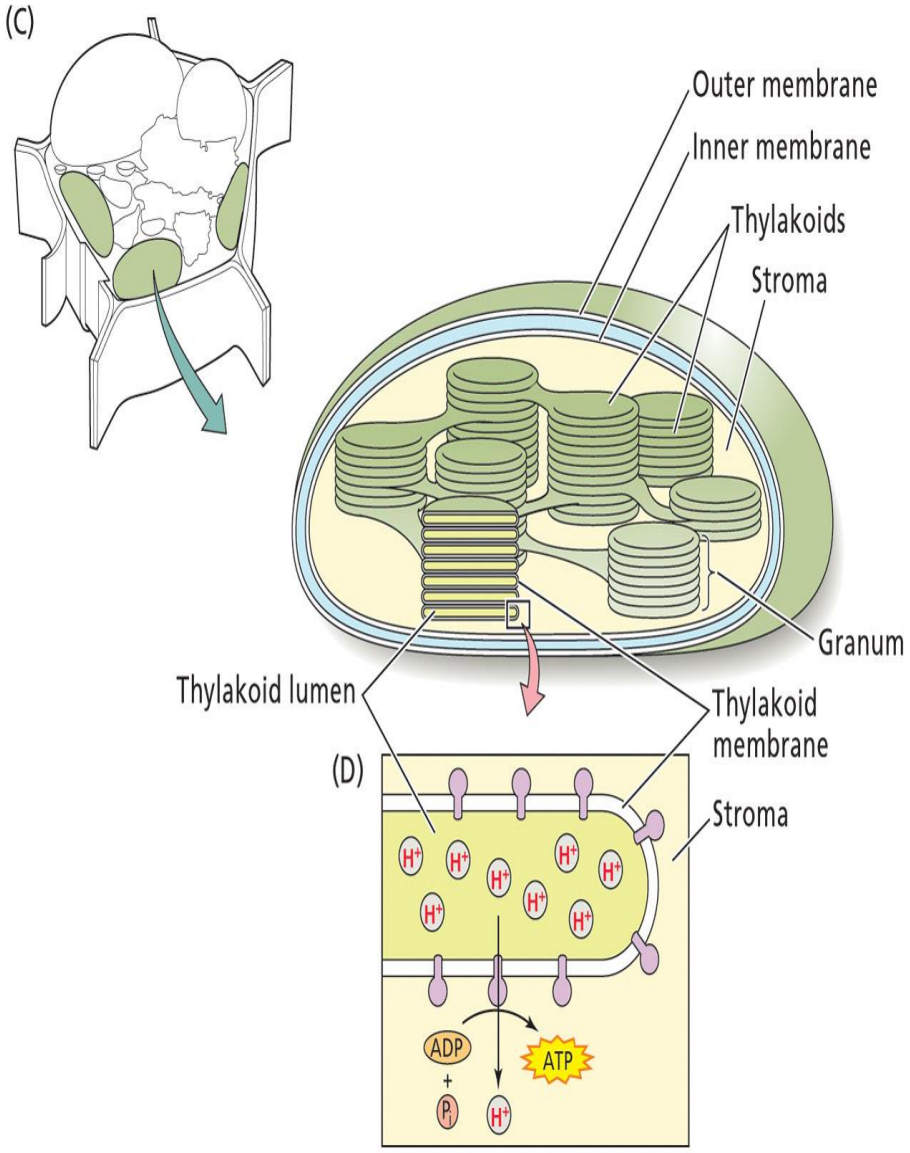
  - Divide by fusion
  - The DNA is in the form of circular chromosomes, like bacteria
  - DNA replication is independent from DNA replication in the nucleus



The Chloroplast

- Membranes contain chlophyll and it's 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



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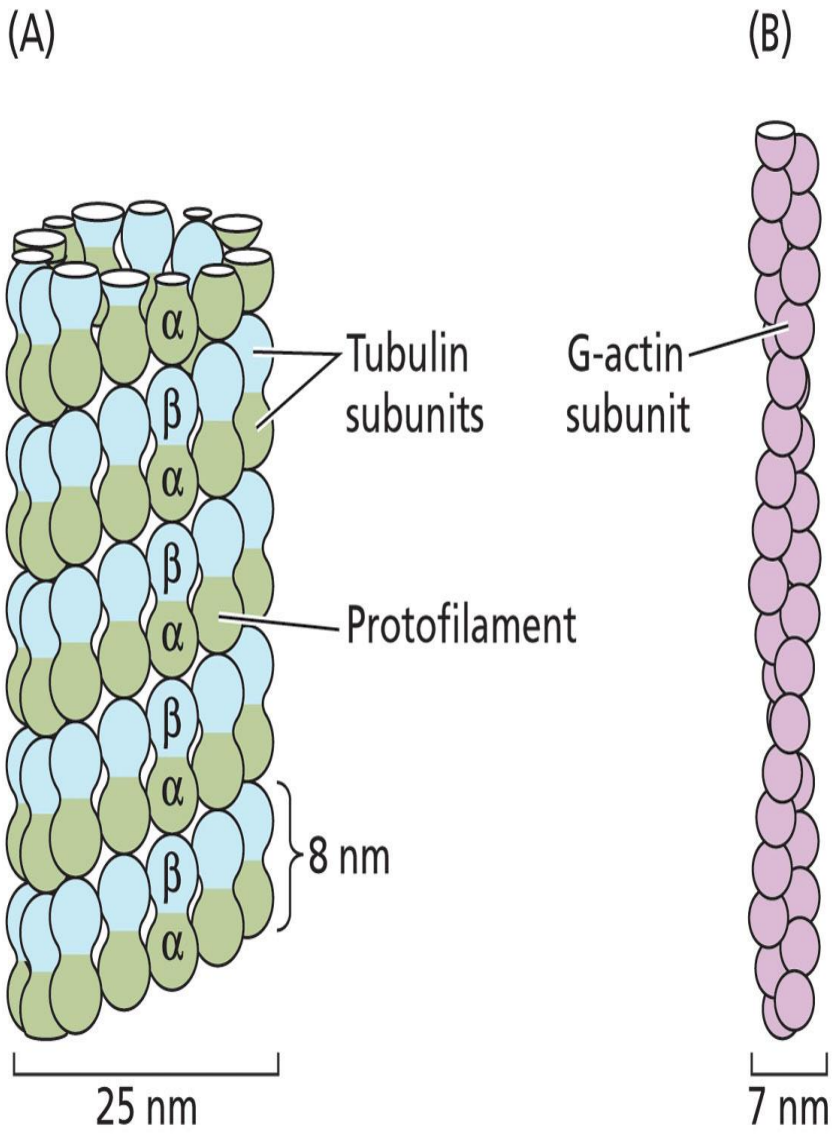
The Vacuole

- 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



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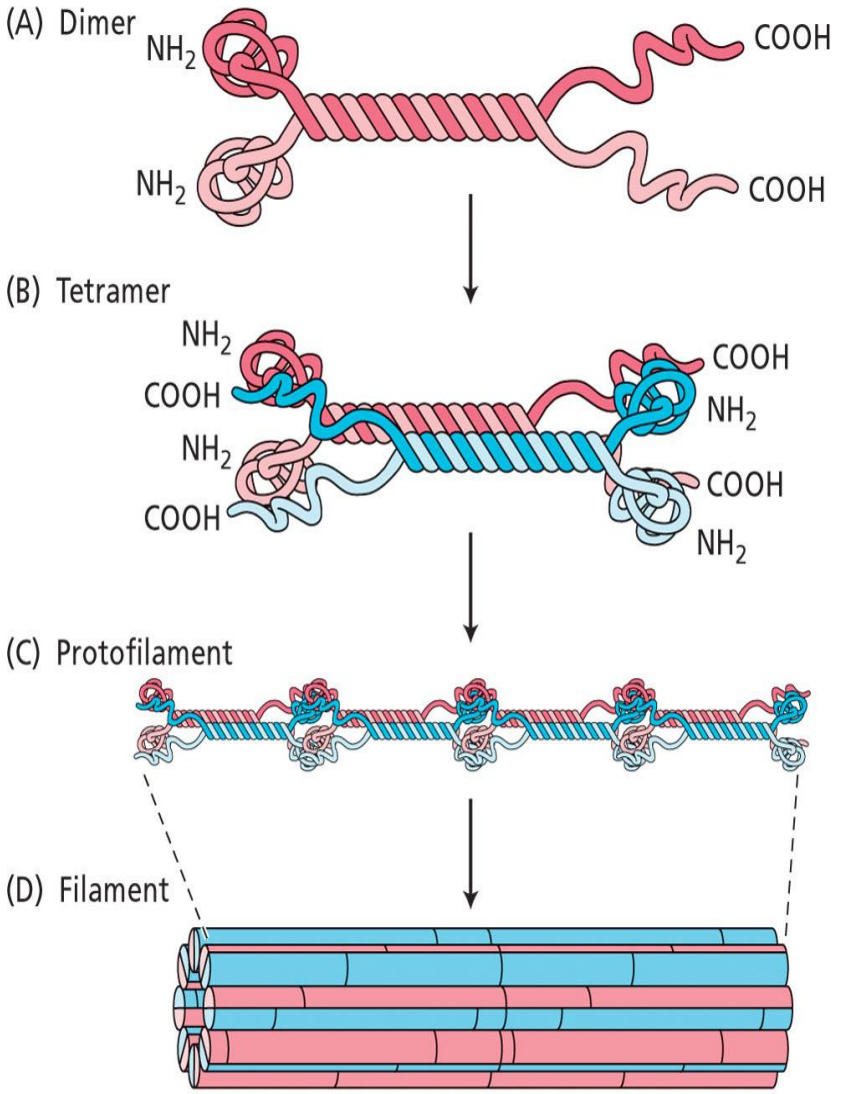
The cytoskeleton

- ***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



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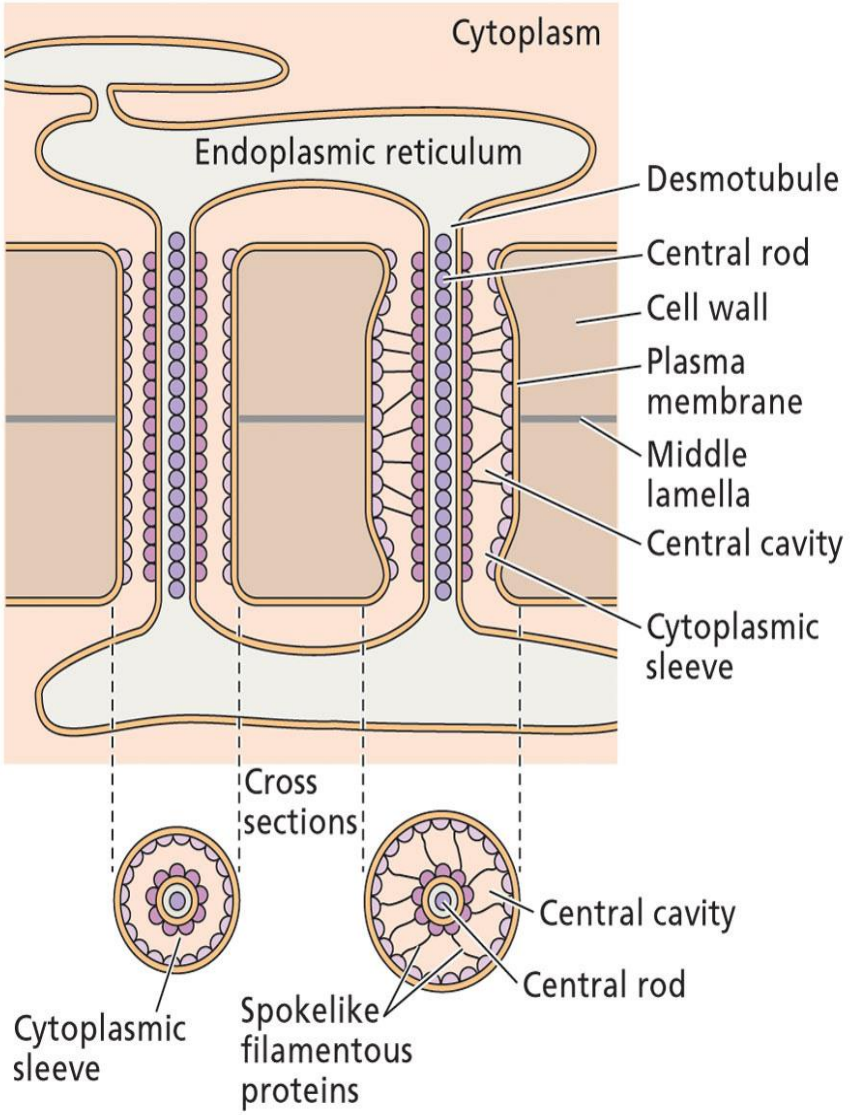
The cytoskeleton

- 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***

Plamodesmarta

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



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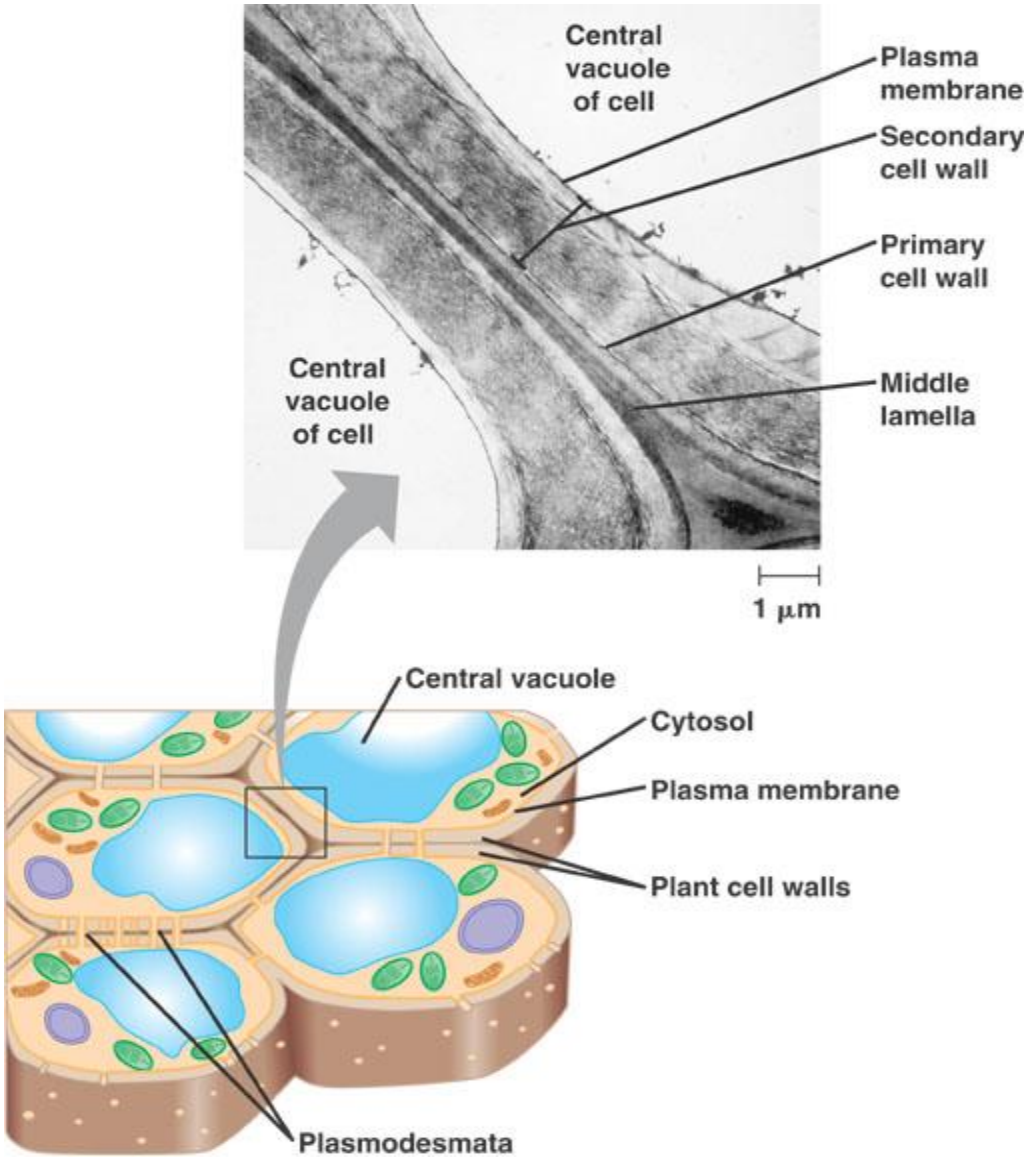
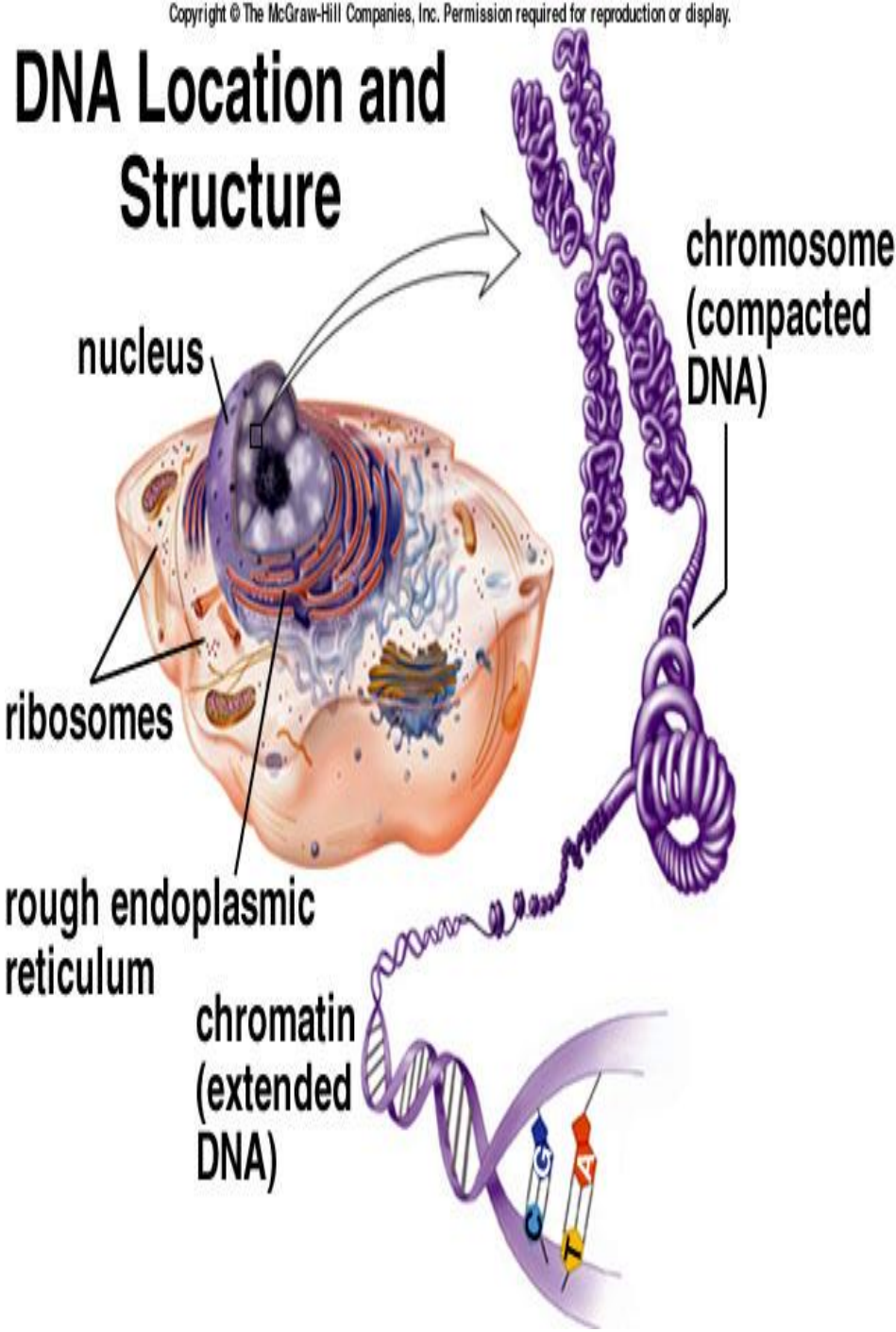
The Plant Cell wall

- 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

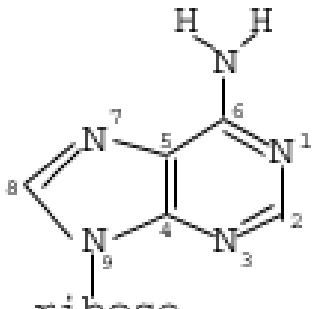
- Composed of 4 nucleotide bases, 5 carbon sugar and phosphate.
- Base pair = rungs of a ladder.
- Edges = sugar-phosphate backbone.
- Double Helix
- Anti-Parallel



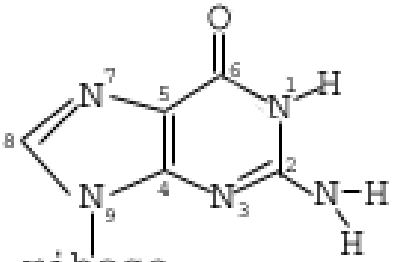
The bases

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

Purines

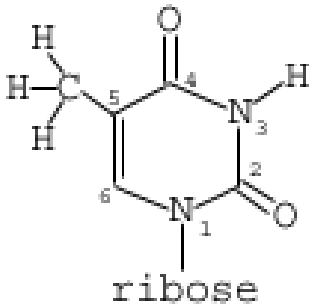


adenosine

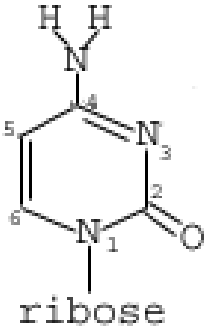


guanine

Pyrimidines



thymine

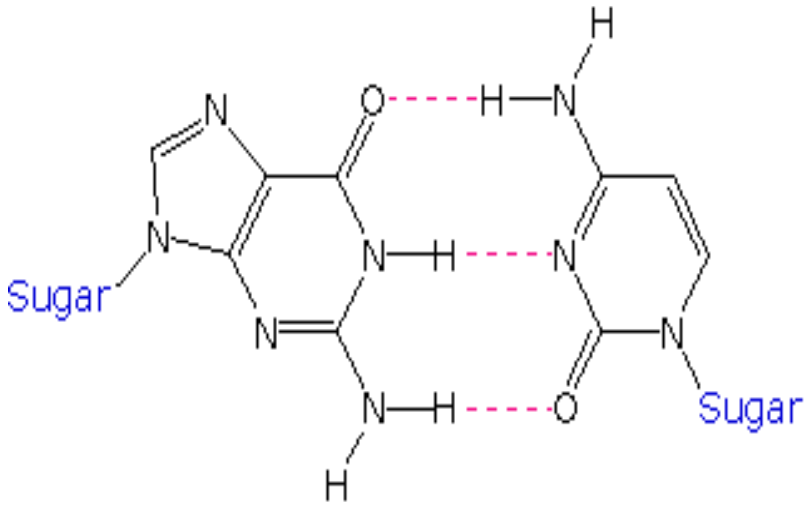


cytosine

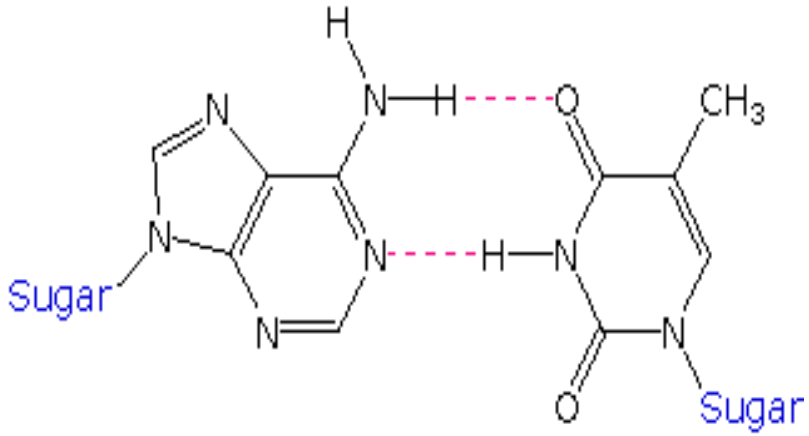
The Bases

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

Hydrogen Bonded Base Pairs



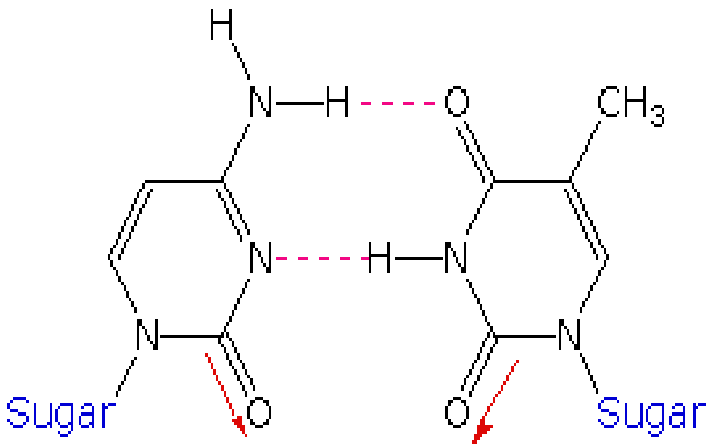
G C



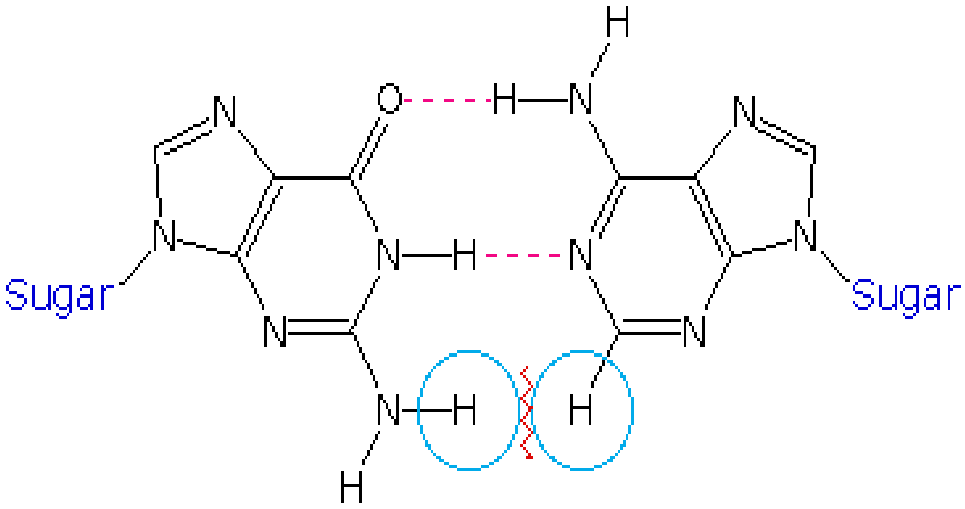
A T

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).



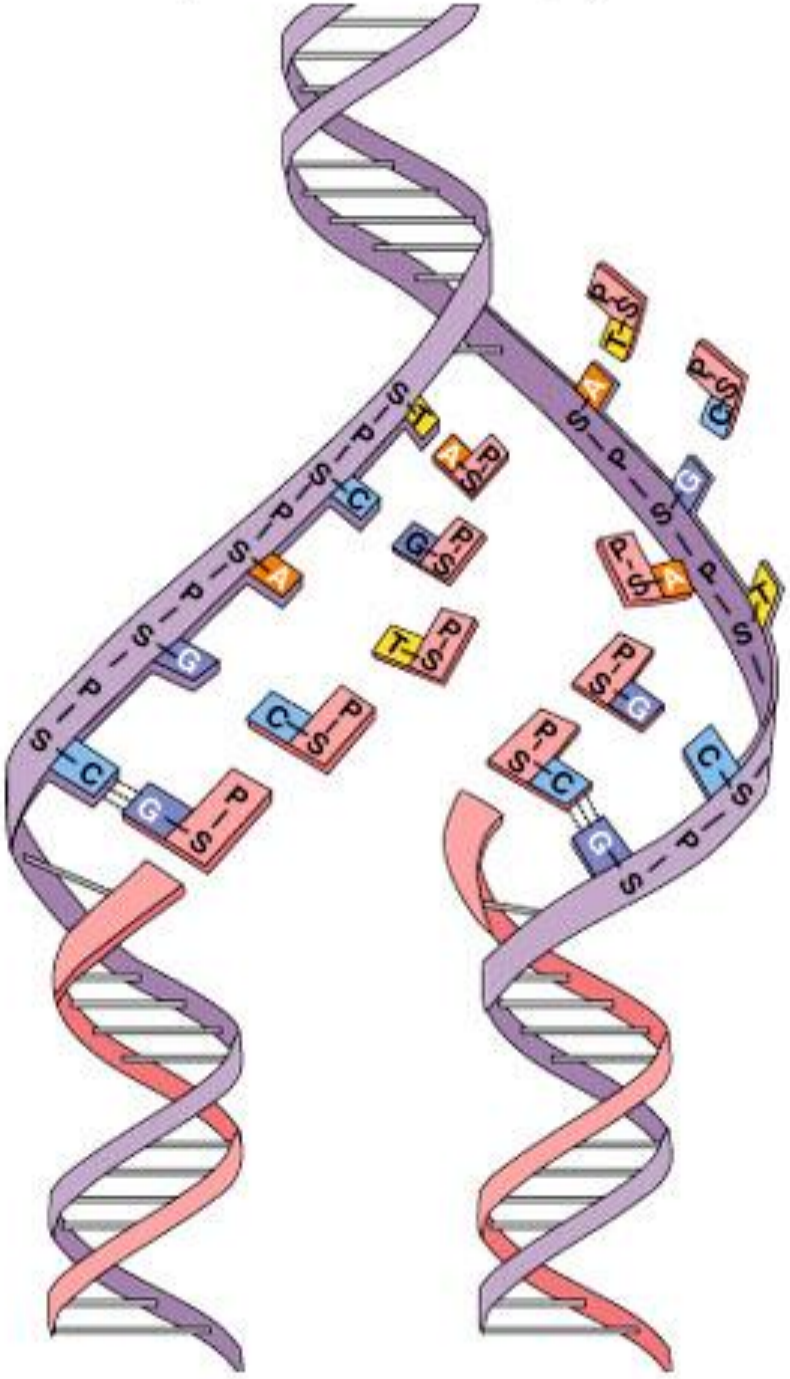
cytidine : thymidine



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***.

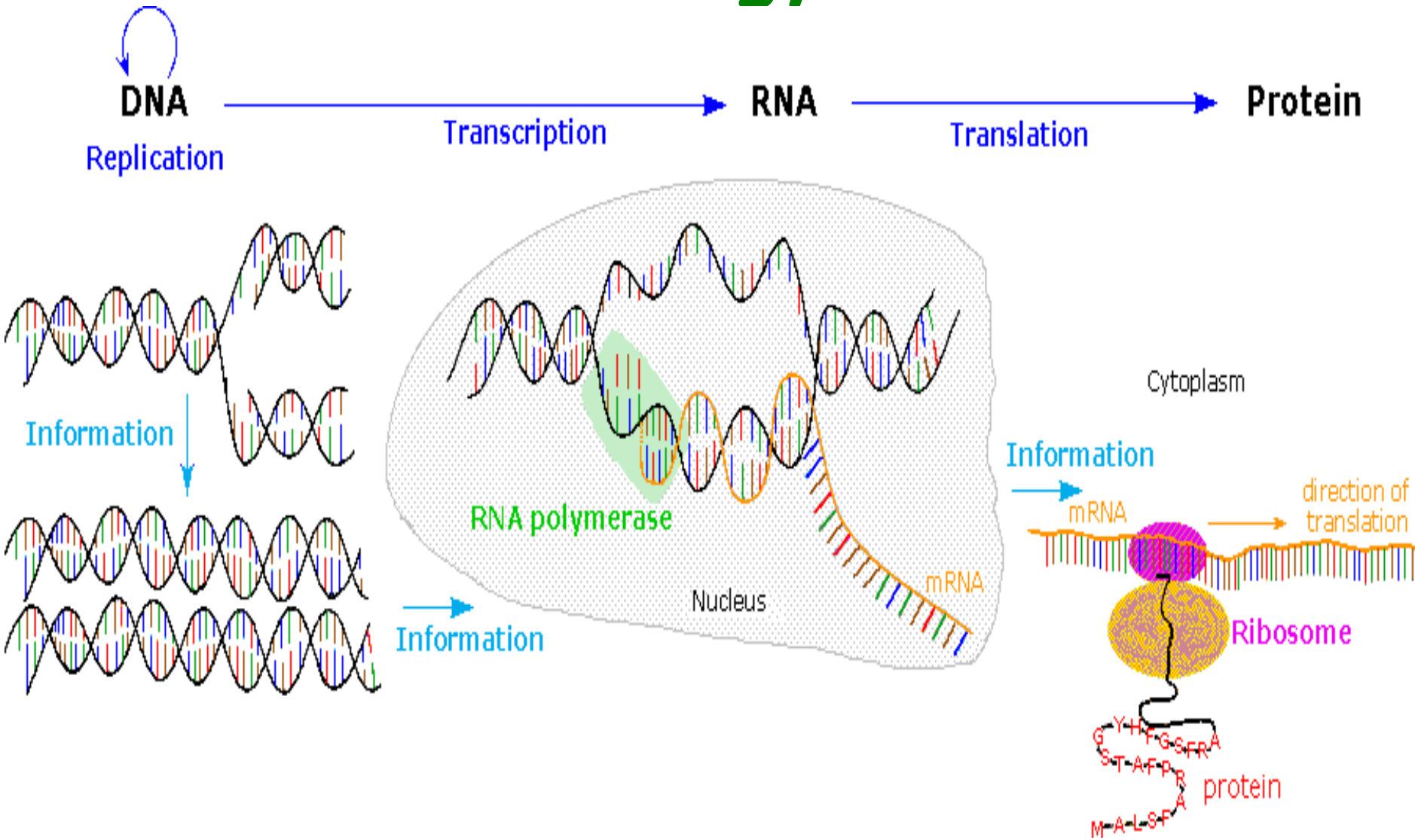
- Replication errors can occur. Cell has repair enzymes that usually fix problem. An error that persists is a **mutation.**
- **This is permanent, and alters the phenotype.**

Protein synthesis in Plants

Central Dogma of Molecular Biology

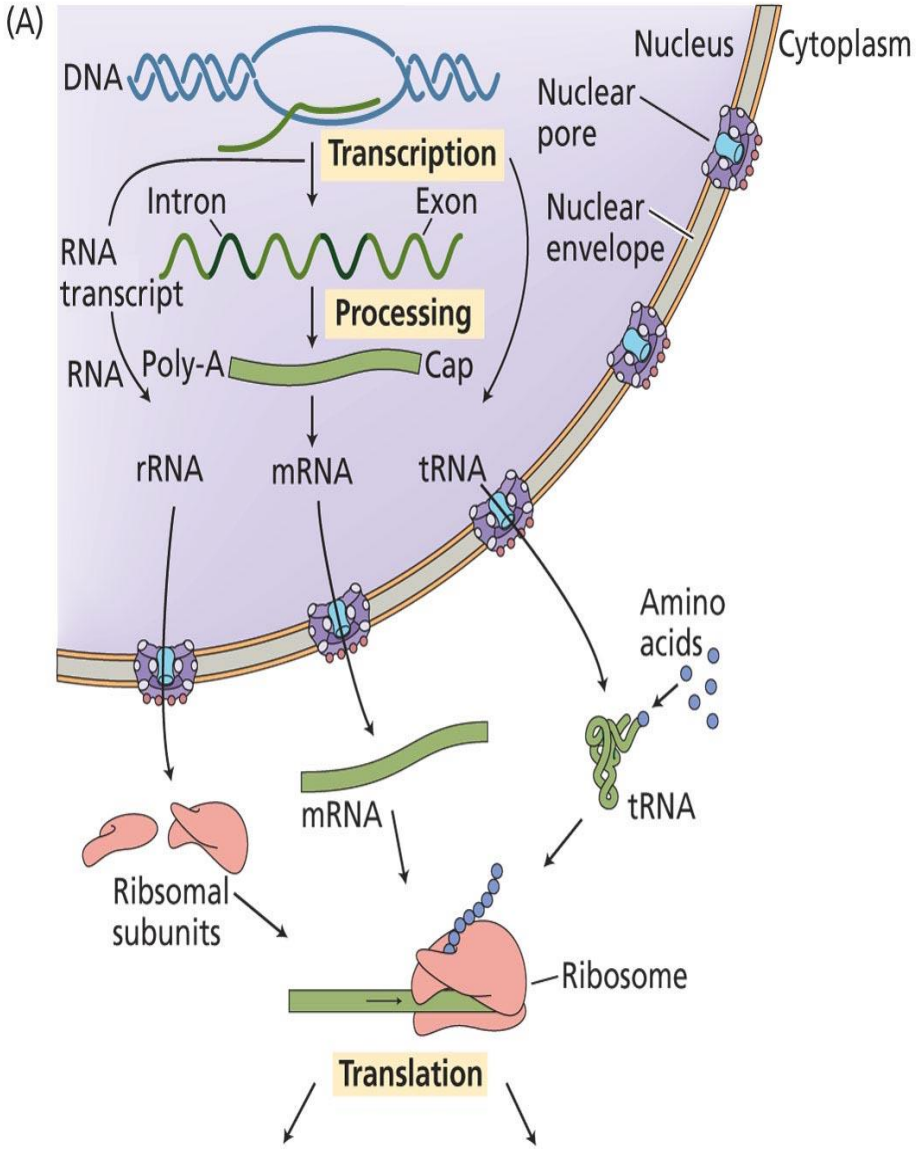
- DNA holds the code
- DNA makes RNA
- RNA makes Protein
- DNA to DNA is called ***REPLICATION***
- DNA to RNA is called ***TRANSCRIPTION***
- RNA to Protein is called ***TRANSLATION***

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.



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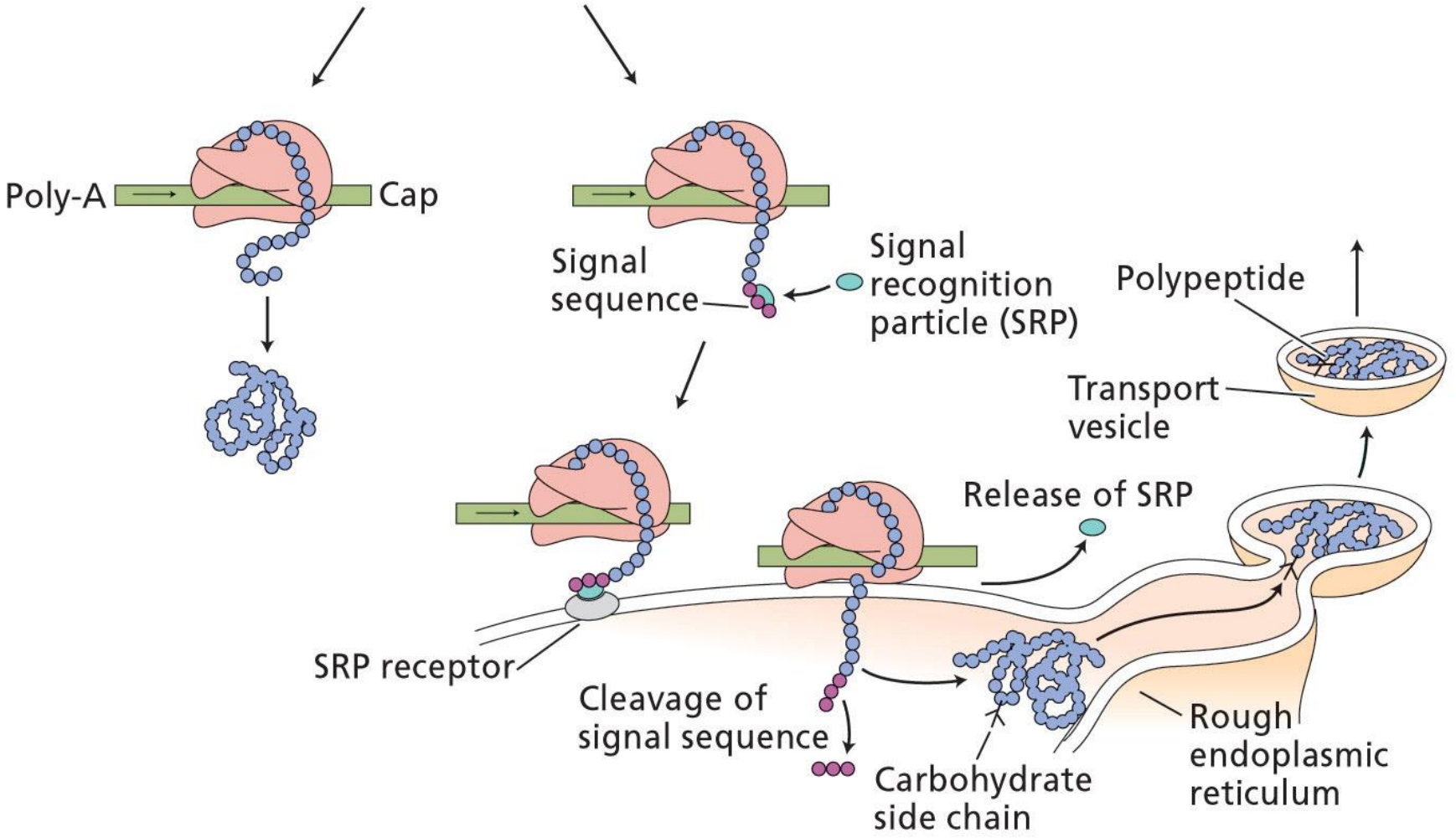
Occurs in the cytoplasm or on Rough ER



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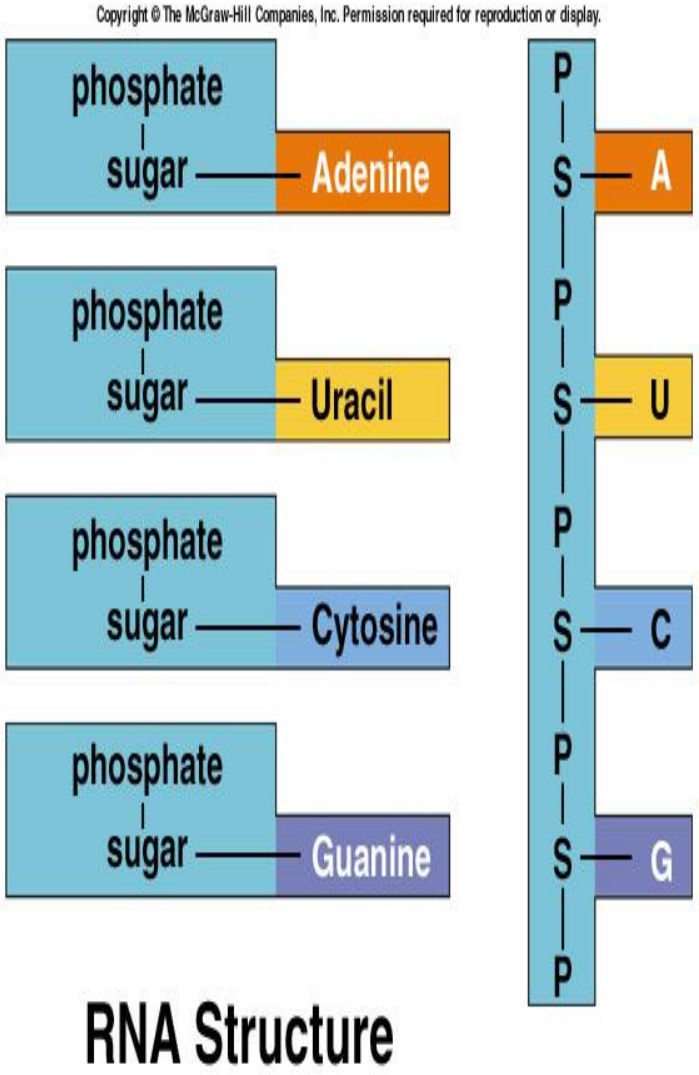
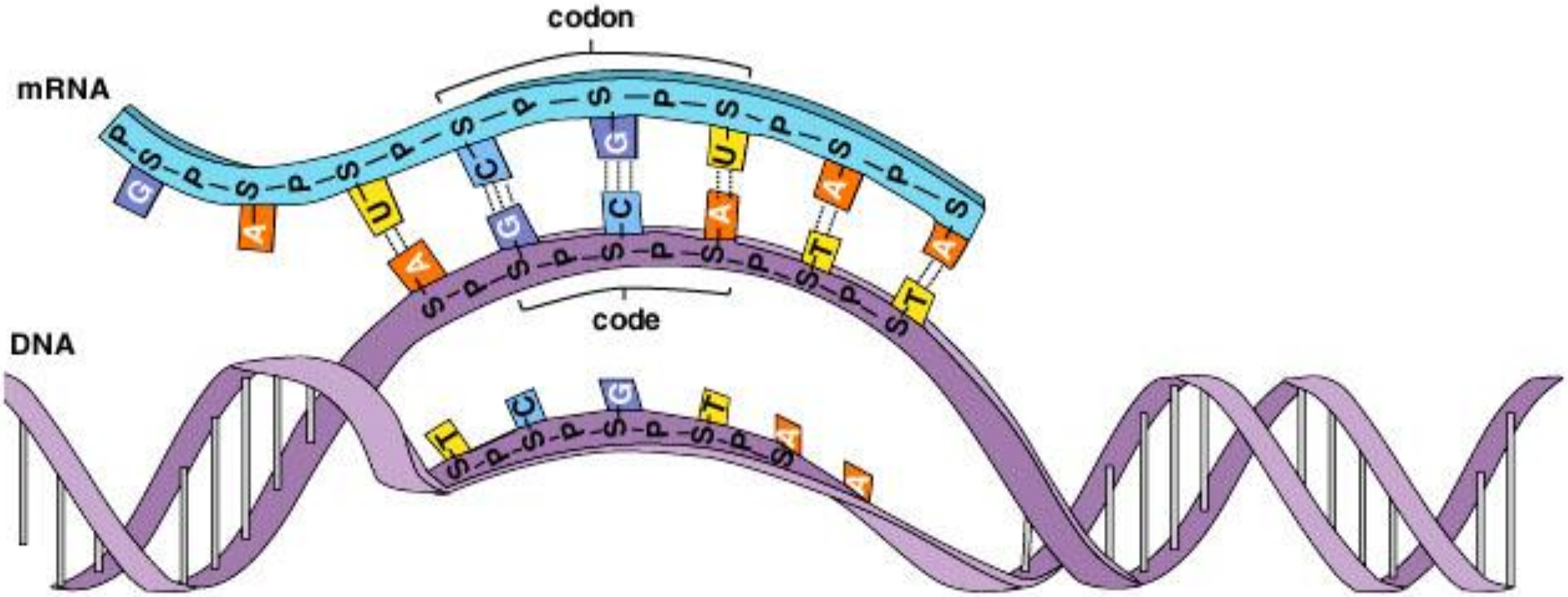
RNA

- 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

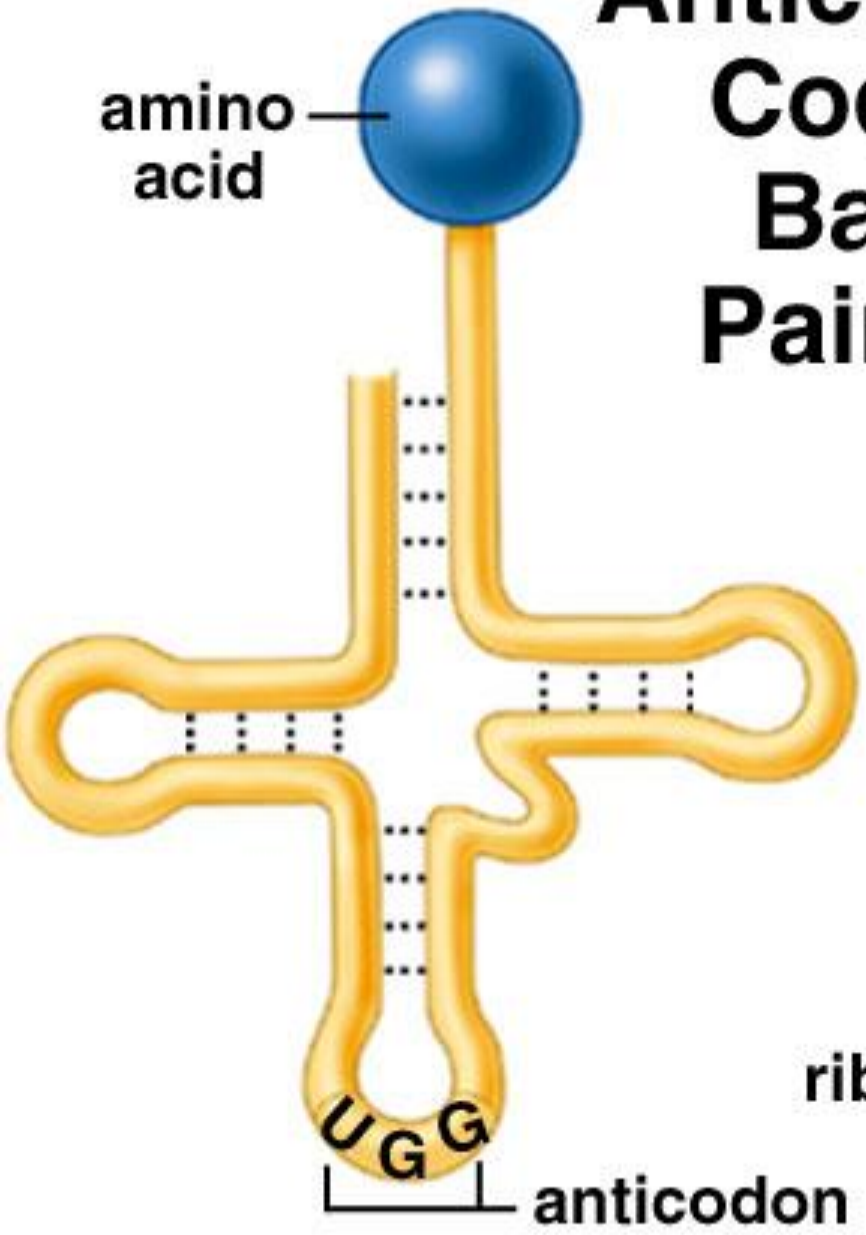
Transcription



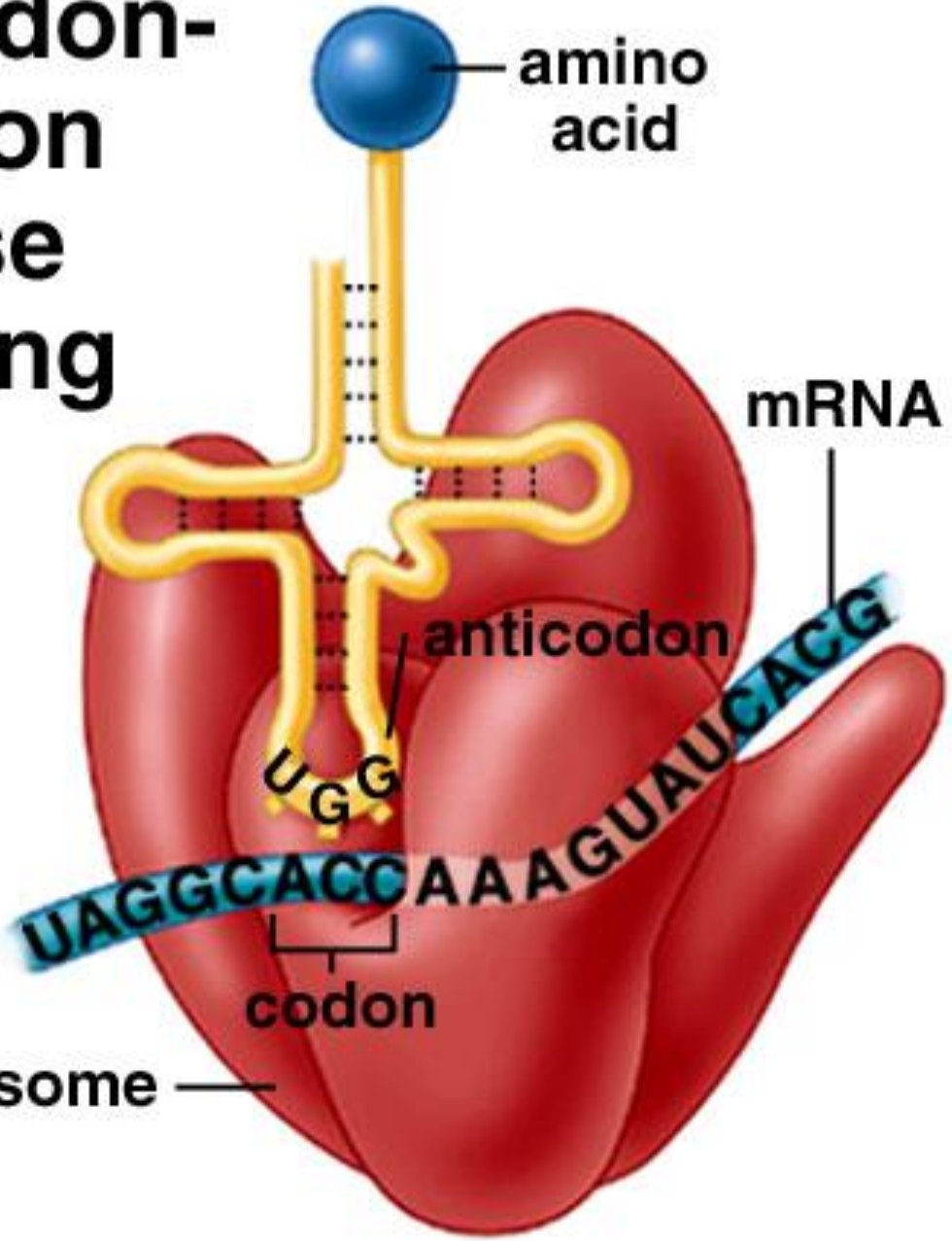
Translation

- 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



tRNA–amino acid



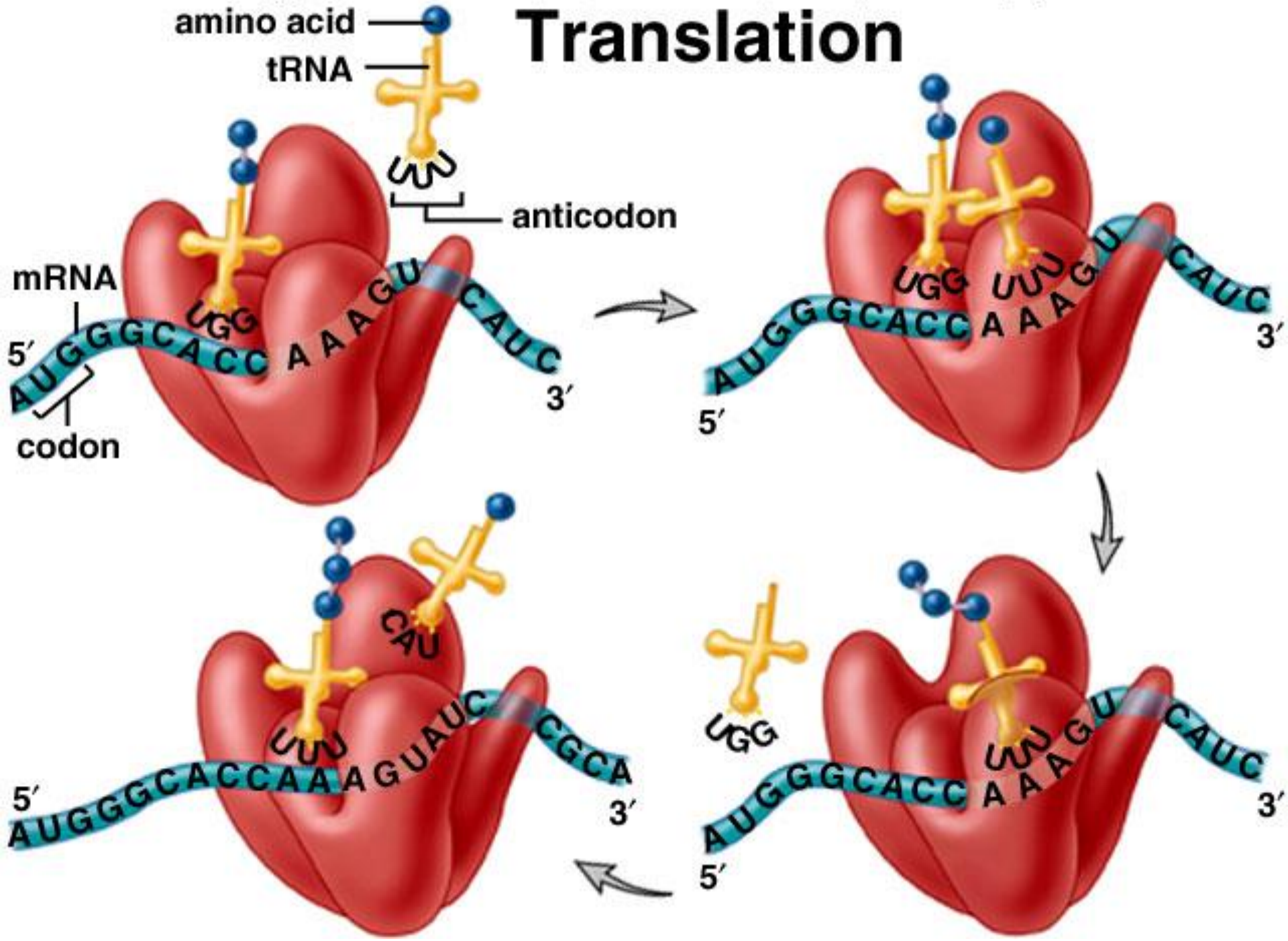
tRNA–amino acid at ribosome

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
- ***Termintion***—

  Stop codon--complex falls apart

Translation



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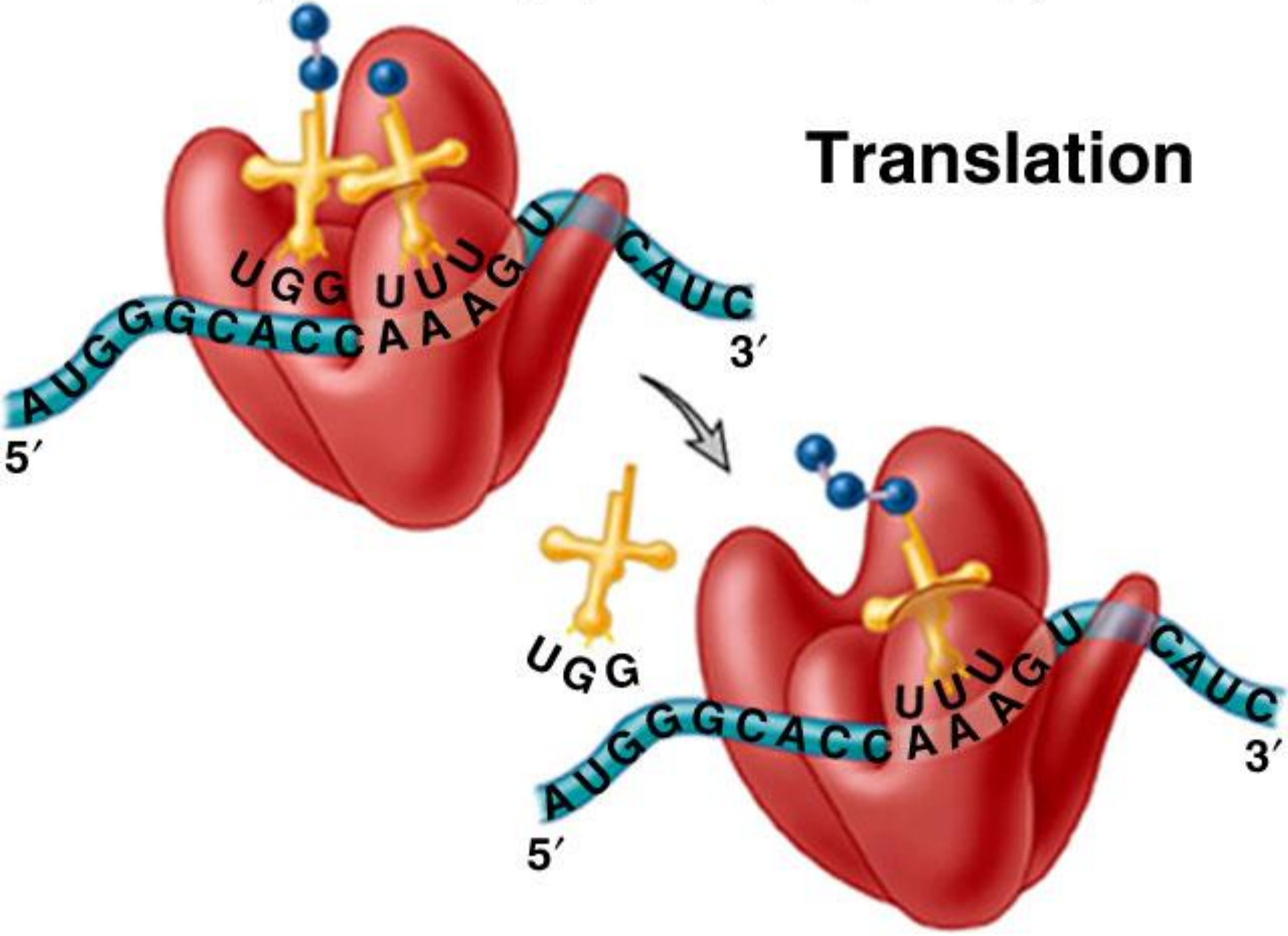

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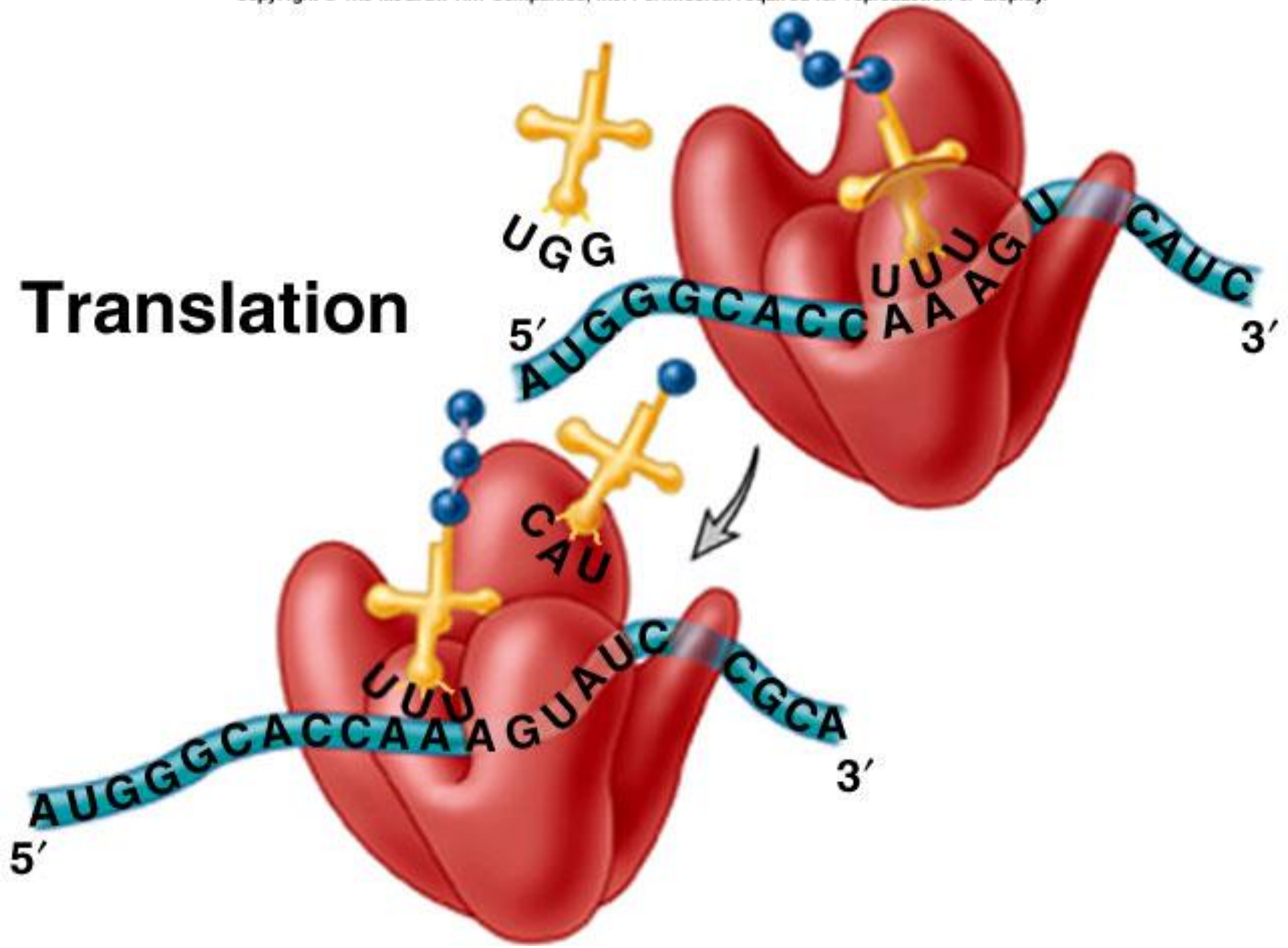
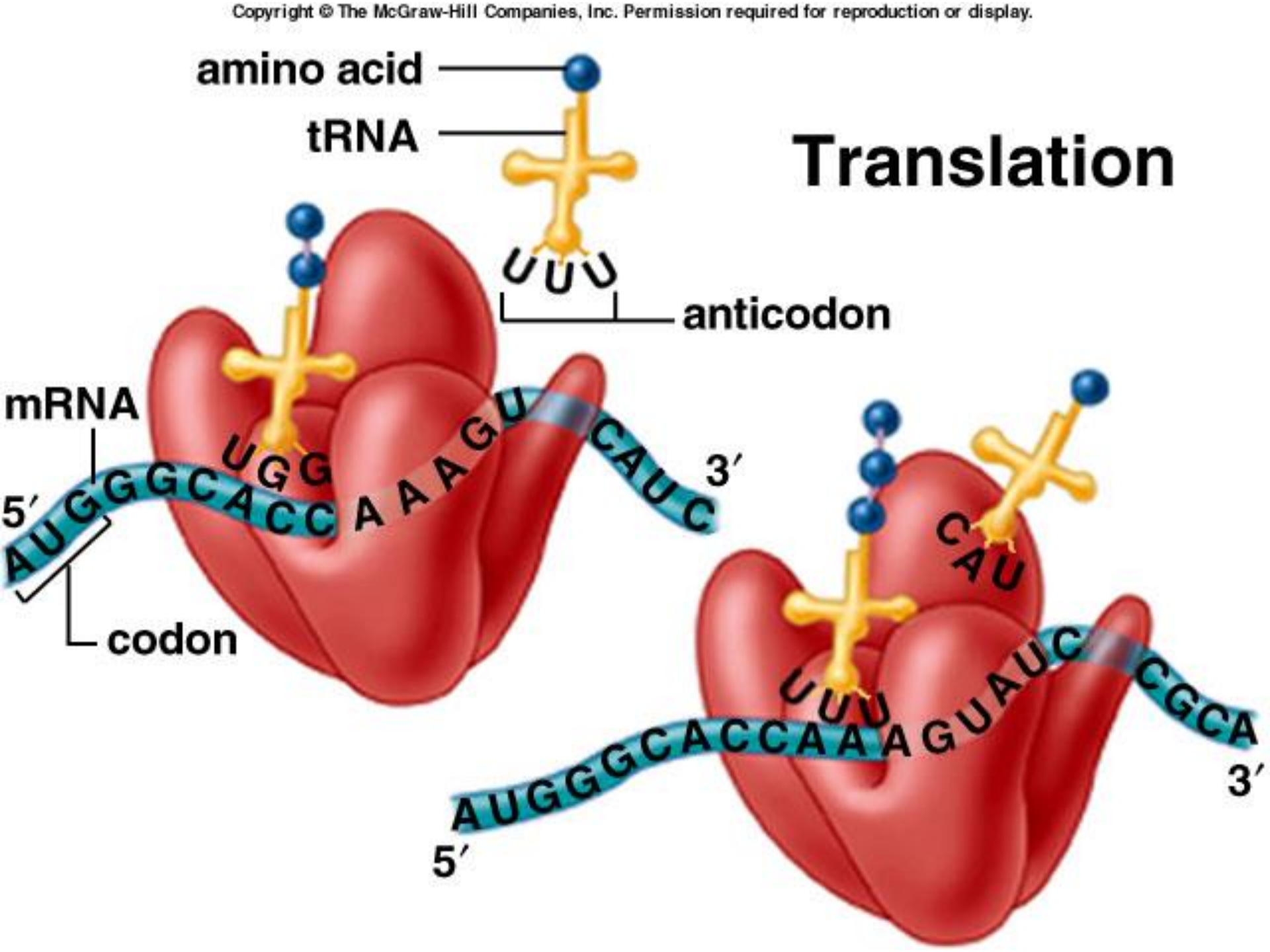
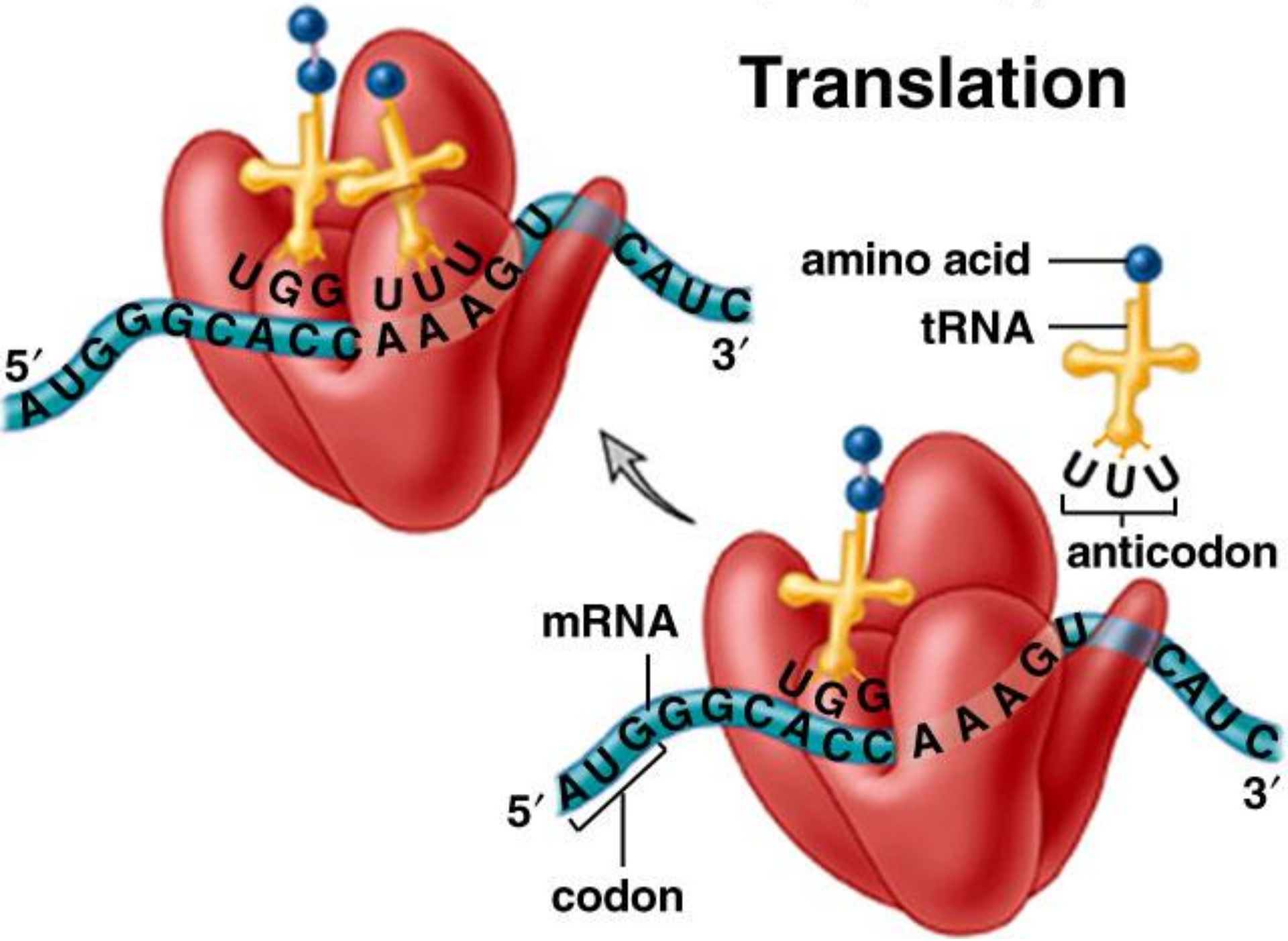
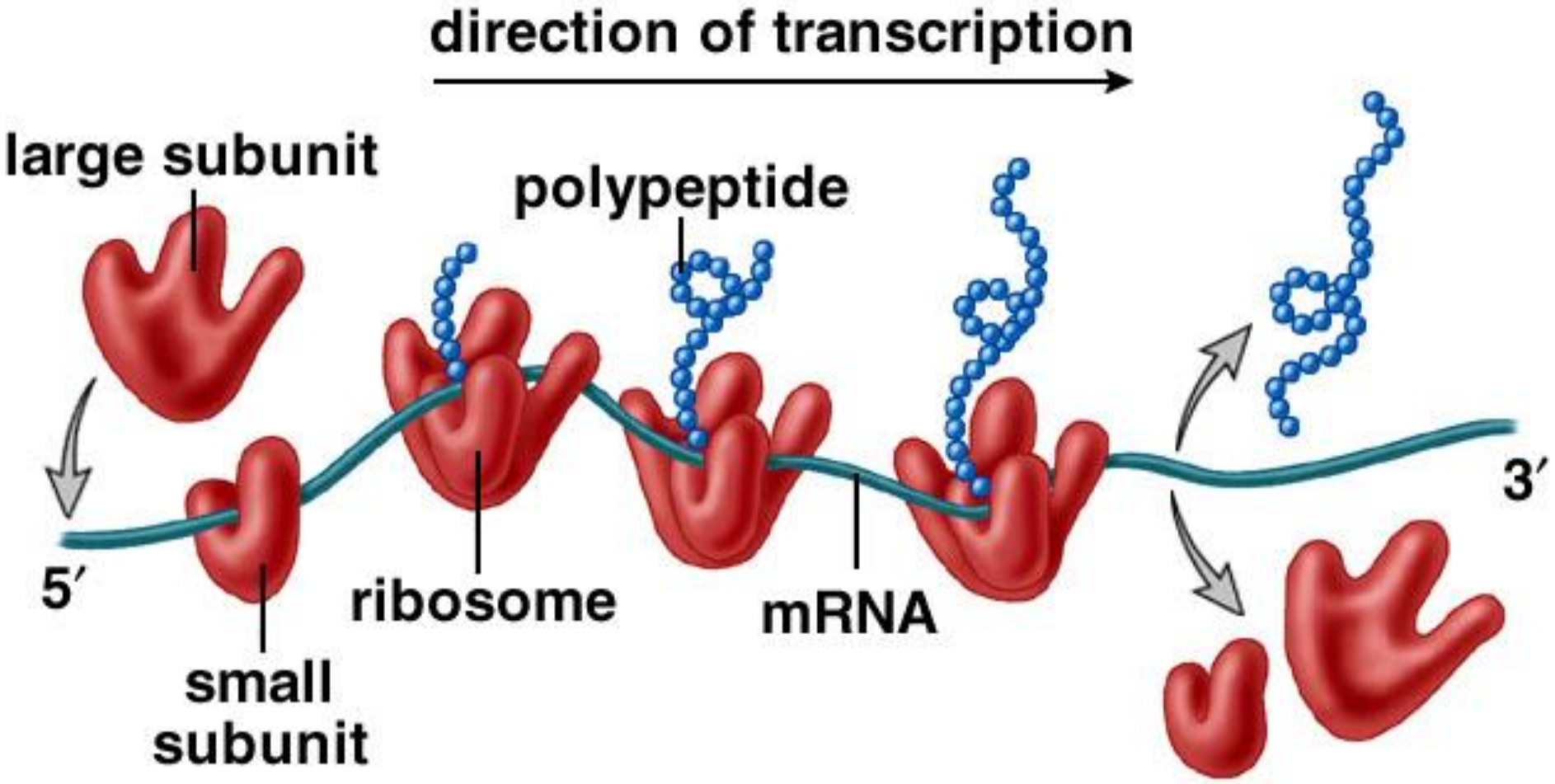




Translation



Polyribosome Structure



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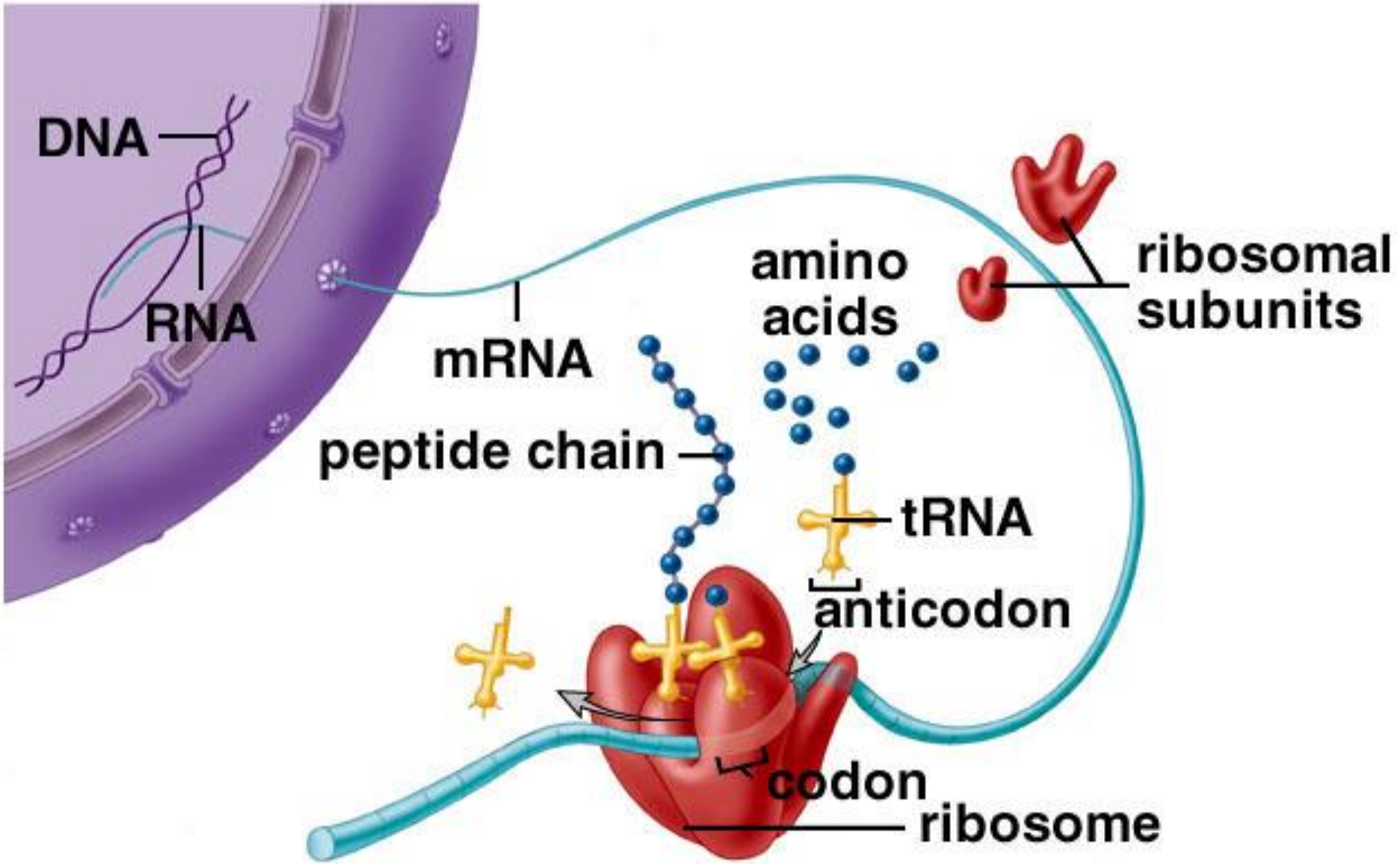
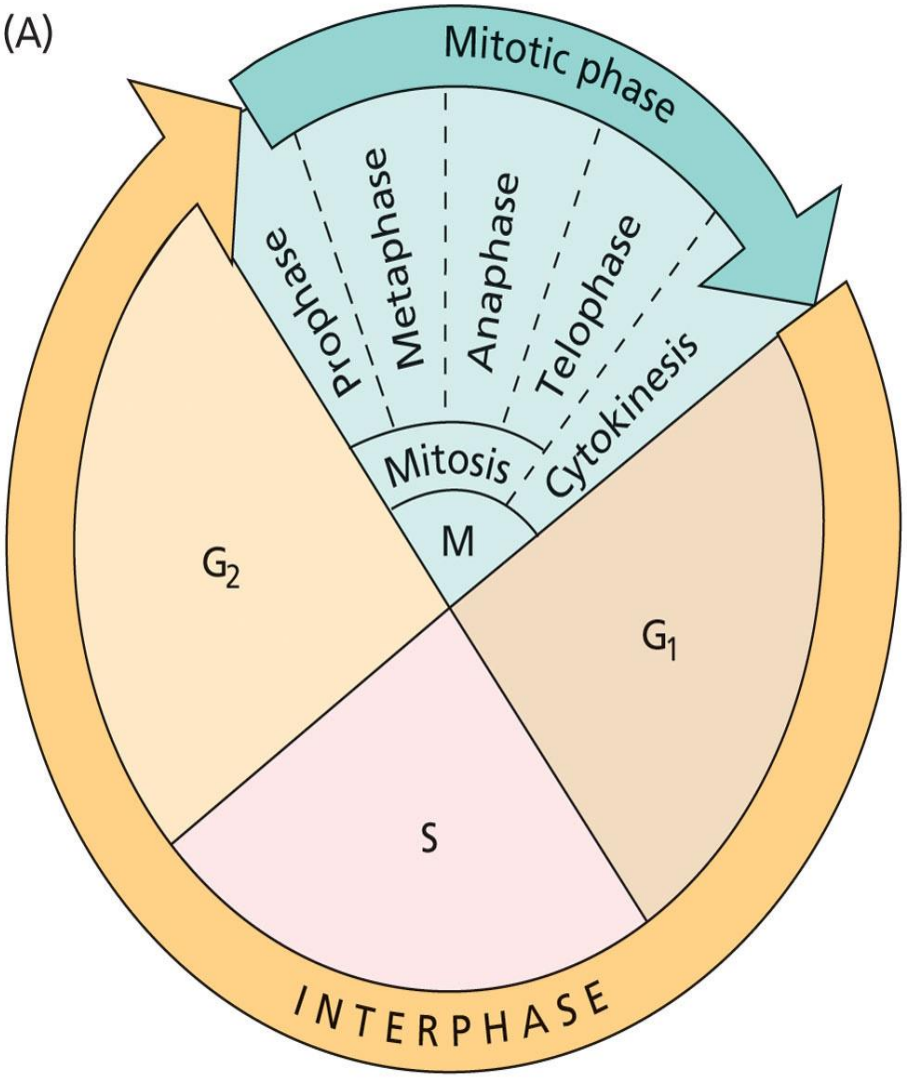
Summary of Gene Expression



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.



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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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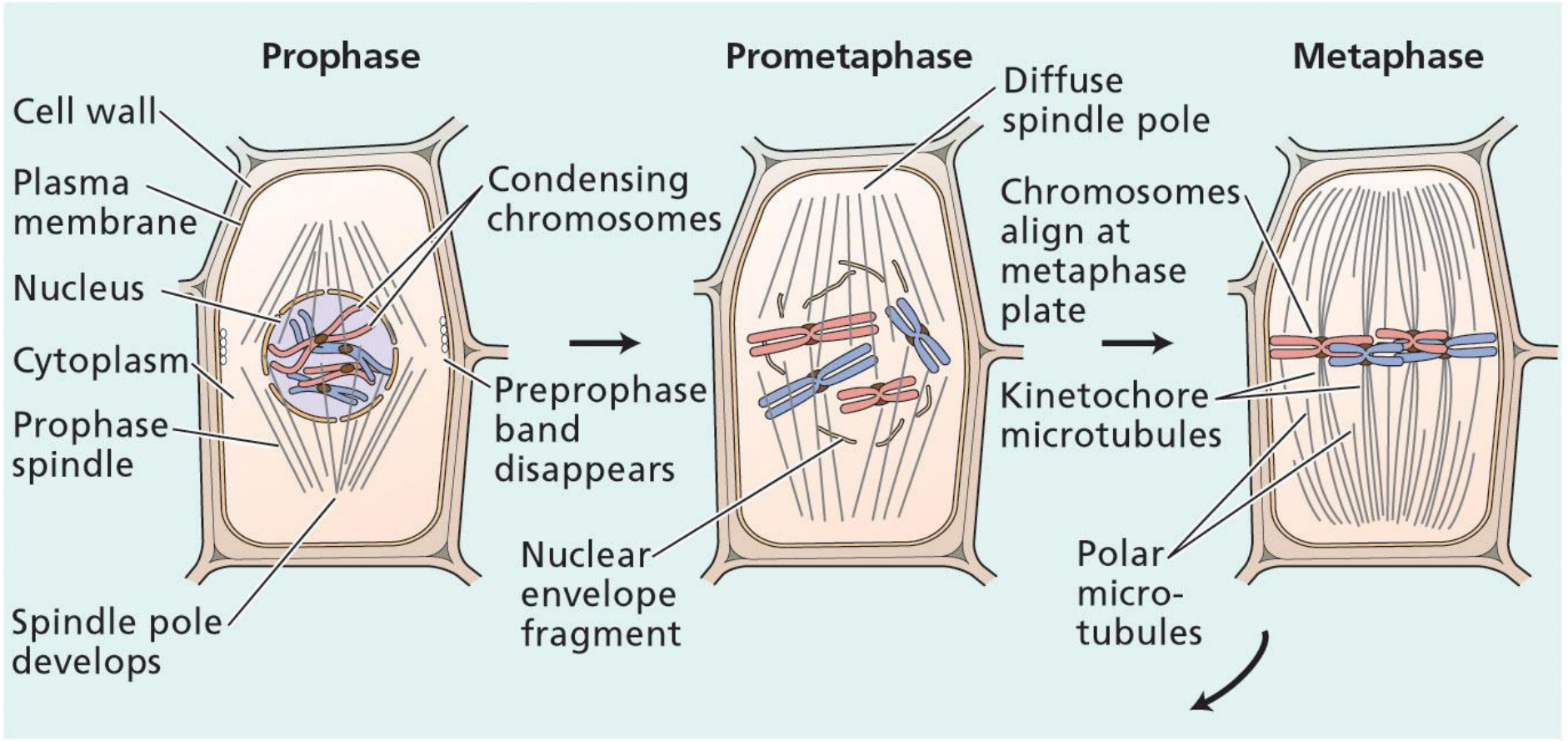

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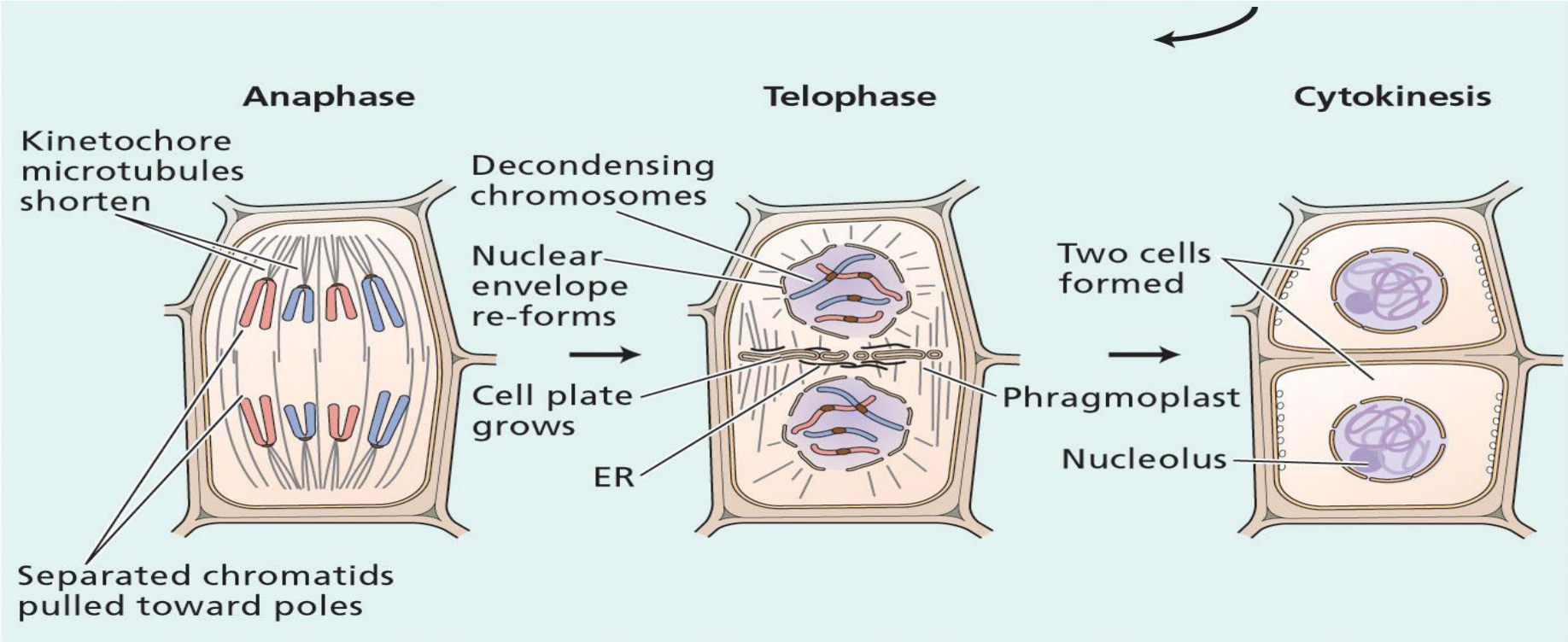
- ***Anaphase***--spindle pulls sister chromatids apart.
- ***Telophase***--chromatids begin to decondense and become chromatin. Spindle disappears.
  - **NEW CELL WALL IS FORMED**
- ***Cytokinesis***--divide cell and organelles. Actin ring, or cleavage furrow splits cell.



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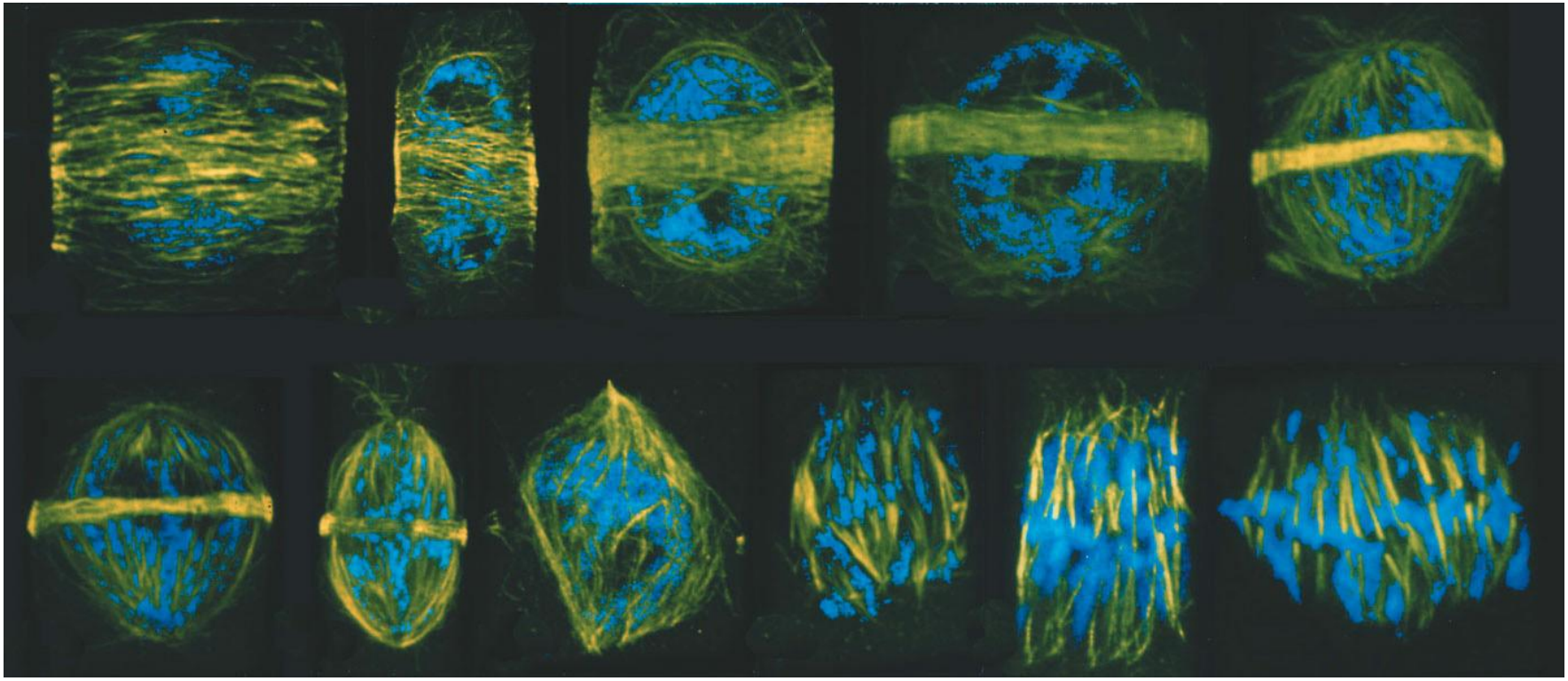
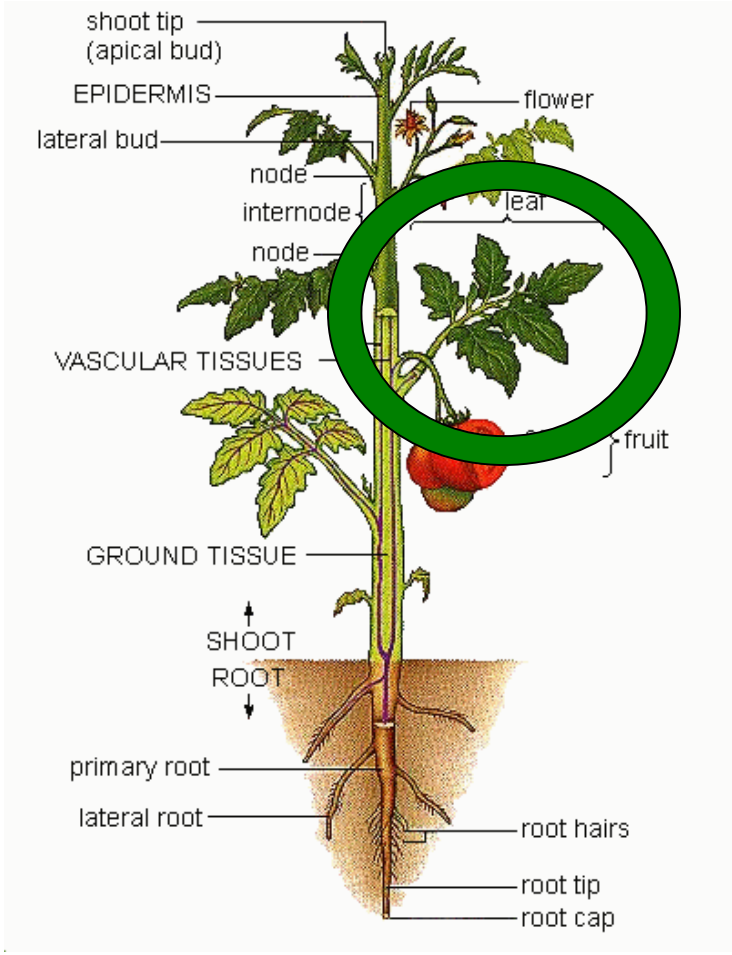
Remember the cytoskeleton?

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



The Plant Body: Leaves

- FUNCTION OF LEAVES
  - Leaves convert light energy to chemical energy



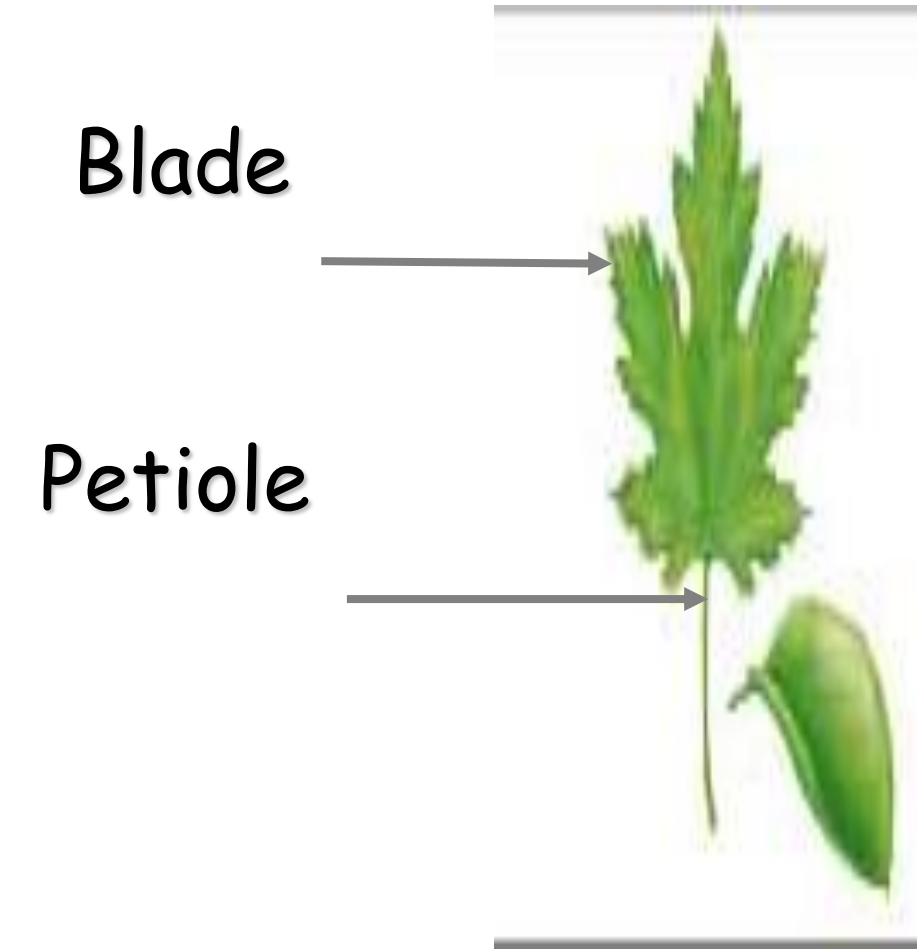
And so, on to leaves

- Leaves are the principle structure, produced on stems, where photosynthesis takes place.

- ***Cacti*** are an exception. The leaves are reduced to spines, and the thick green, fleshy stems are where photosynthesis takes place.

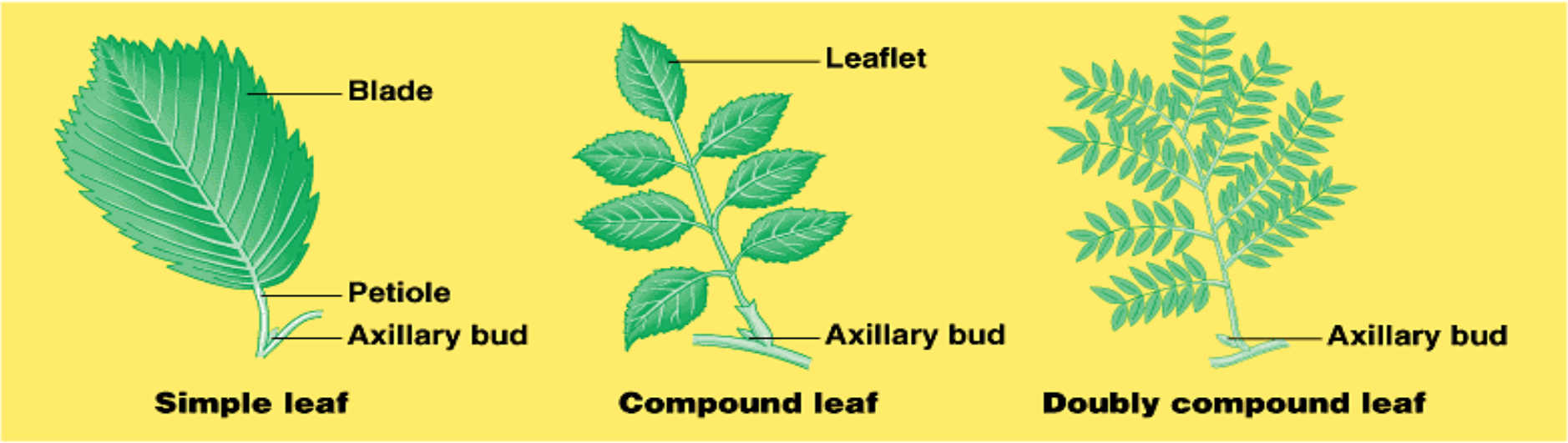
General leaf form

- Leaves are the main photosynthetic organs of most plants
  - but green stems are also photosynthetic.
  - While leaves vary extensively in form, they generally consist of a flattened **blade** and a stalk, the **petiole**, which joins the leaf to a stem node.
- Most monocots have parallel major veins that run the length of the blade, while dicot leaves have a multi branched network of major veins.



Leaf Arrangement on the Stem

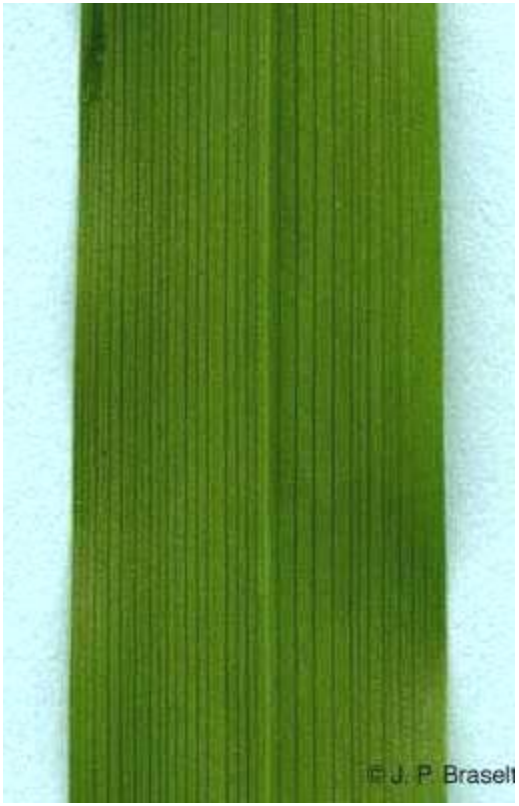
- Plant taxonomists use leaf shape, spatial arrangement of leaves, and the pattern of veins to help identify and classify plants.
  - A Simple leaves have a single, undivided blade, while compound leaves have several leaflets attached to the petiole.
  - A Compound leaf has a bud where its petiole attaches to the stem, not at the base of the leaflets.



Leaves - Comparisons

Monocots and dicots differ in the arrangement of **veins**, the vascular tissue of leaves

Most dicots have branch-like veins and palmate leaf shape



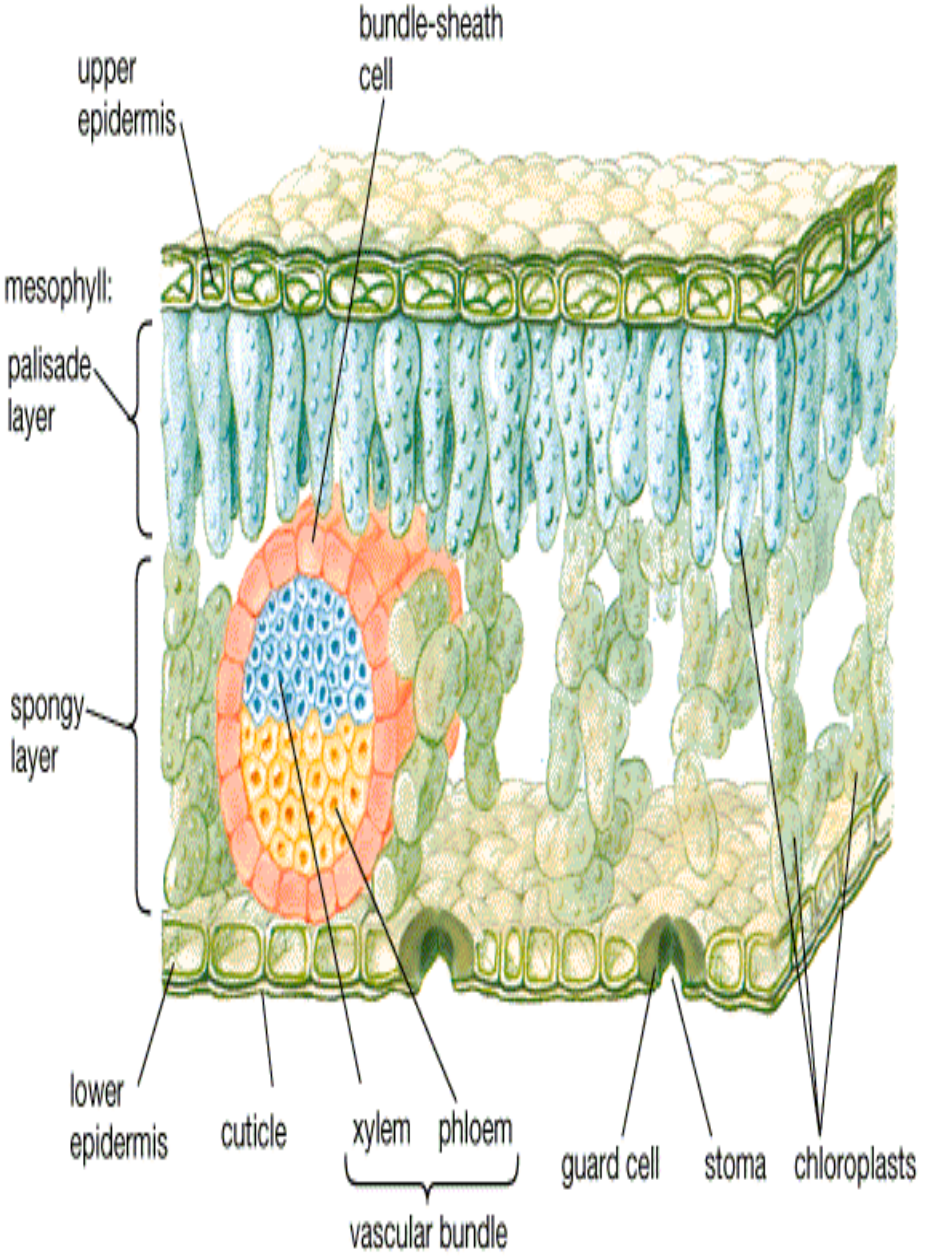
Monocots have parallel leaf veins and longer, slender blades

Structures of the Leaf

Cuticle – the outermost layer of both the upper and lower surfaces of the leaf. It is clear and waxy to prevent against water loss.

Epidermis – a layer of cells one cell thick that provides protection for the inner tissues. These cells are clear to allow light to reach the photosynthetic tissues.

Mesophyll – between the epidermal layers. It contains **palisade cells** that are tall, ***tightly packed, and filled with chloroplasts for photosynthesis***.



Structures of the Leaf

Stomates – openings in the surface of the leaf and stems for gas exchange. The lower surface of a leaf usually has more. Water vapor also passes out through these holes.

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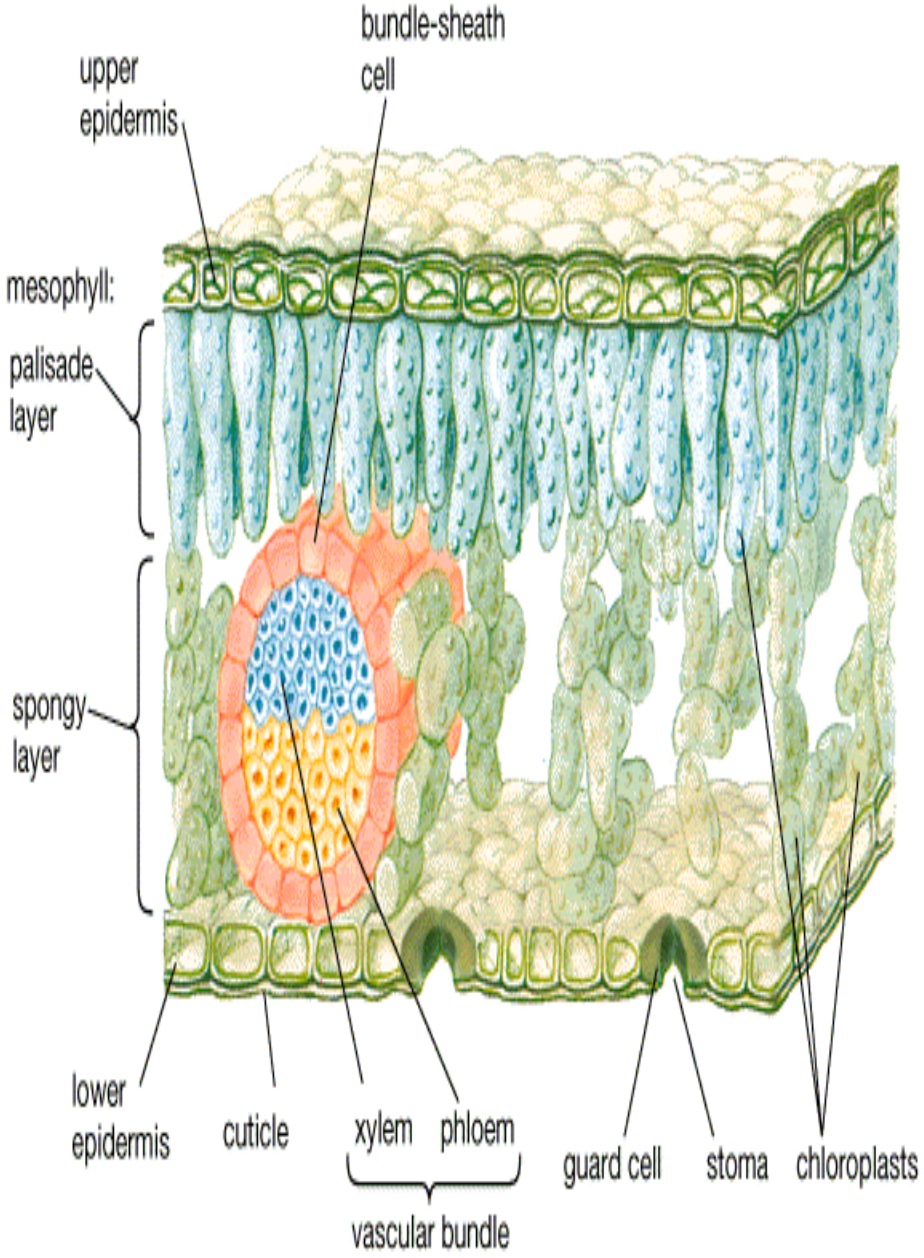
Veins – contain the vascular tissue that is continuous with that in the stem. **Xylem** carries water and minerals upward. **Phloem** carries dissolved food throughout the plant.



Stomatal control

- ***When water is abundant:***
- Temporal regulation of stomata is used:
  - ***OPEN*** during the day
  - ***CLOSED*** at night
- At night there is no photosynthesis, so no demand for CO_2 inside the leaf
- Stomata closed to prevent water loss
- Sunny day - demand for CO_2 in leaf is high – stomata wide open
- As there is plenty of water, plant trades water loss for photosynthesis products

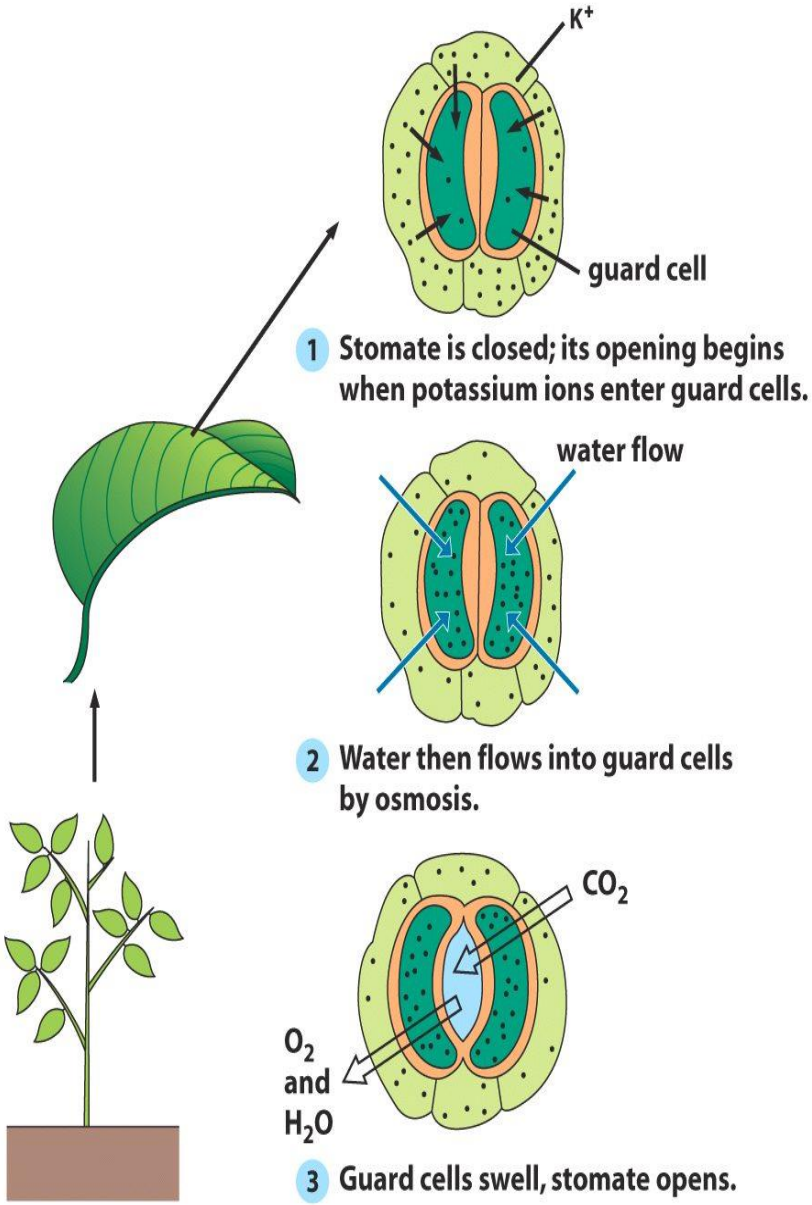


Figure 11-11 Biology Today, 3/e (© 2004 Garland Science)

Specialized Leaves

- The Venus fly trap has an "***active trap***"
- Good control over turgor pressure in each plant cell.
- When the trap is sprung, ion channels open and water moves rapidly out of the cells.
- Turgor drops and the leaves slam shut
- Digestive enzymes take over

When an insect touches the sensitive hairs of this Venus fly trap, the leaf halves snap together in less than half a second, trapping the insect.

Figure 11-12 (2) Biology Today, 3/e (© 2004 Garland Science)

ANY QUESTIONS?

THANK YOU FOR YOUR ATTENTION