The Simple AP® Biology Unit 2 Cheat Sheet

2.1 Subcellular Components

Ribosomes: In Every Cell

Ribosome (rRNA + protein) builds proteins. No membrane → in prokaryotes AND eukaryotes.
Free ribosomes → proteins for the cytosol. **Bound** (on rough ER) → proteins to secrete, or to put in membranes & lysosomes later on.

Organelle Quick Map

Organelle	Function
Rough ER	Makes, folds proteins
Smooth ER	Lipids, detox, Ca^{2+}
Golgi	Modify, sort, ship
Mitochondria	Cell resp. → ATP
Chloroplast	Photosynthesis
Lysosome	Digest, recycle
Vacuole	Store H_2O, ions
Nucleus	Holds DNA

Key Details

Lysosome: digestive enzymes at pH ~5; breaks down food & worn-out organelles to recycle.
Central vacuole (plants): full of H_2O → turgor pressure → plant stands upright.
Plant only: chloroplasts, cell wall, central vacuole.
Golgi: receives ER vesicles → adds sugar tags → ships proteins to their destination.

⚠ Plants have mitochondria too. They photosynthesize AND do cellular respiration.

✓ Prokaryotes: ribosomes yes, membrane-bound organelles no. Know which is which.

2.2 Cell Structure & Function

Endomembrane System

Members: nuclear envelope, ER, Golgi, lysosomes, vacuoles, vesicles, plasma membrane. NOT mitochondria or chloroplasts (ex-bacteria).
Secretion path: rough ER makes protein → vesicle → Golgi modifies it → vesicle → plasma memb. → exocytosis (out of the cell, e.g., insulin).
Rough ER: folds new proteins & keeps them apart from the cytosol until they're shipped.

Folded Membranes = More Output

Mitochondria: folded inner memb. (**cristae**) → ↑ surface area → more ATP made. **Matrix** = Krebs cycle enzymes + its own circular DNA.
Chloroplasts: stacked **thylakoids** (grana) → ↑ SA for light rxns. **Stroma** = Calvin cycle.

Space	Mito	Chloro
Folds	Cristae	Thylakoids
Fluid	Matrix	Stroma

Cells With a Job

Secretes protein (pancreas) → lots of rough ER + Golgi. **Muscle** → lots of mitochondria.
Liver → lots of smooth ER (detox).
Nucleus: **nuclear pores** let mRNA out to ribosomes; **nucleolus** makes ribosome parts.

⚠ Proteins made on FREE ribosomes stay in the cytosol. Secreted proteins start on rough ER.

✓ FRQ: structure (folds, ↑ SA) → more enzymes or membrane → more function. Link all 3.

2.3 Cell Size: Surface Area to Volume

Why Cells Stay Small

Surface area (SA) sets how fast a cell trades O_2, food, waste. **Volume** (V) sets how much it needs.
As a cell grows: V grows faster than SA → **SA:V ↓** → exchange is too slow for its needs.
High SA:V (small cell) = fast, efficient exchange. This limits how big a single cell can get.

Apply the Formula Sheet

Cube: SA = $6s^2$, V = s^3. **Sphere**: SA = $4\pi r^2$, V = $4/3\pi r^3$ (both on the formula sheet).

Side	SA	V	SA:V
1 µm	6	1	6 : 1
2 µm	24	8	3 : 1
3 µm	54	27	2 : 1

Pattern: double the side → SA:V halves.
Cylinder: SA = $2\pi rh + 2\pi r^2$, V = $\pi r^2 h$.
Units: SA:V in $\mu m^2/\mu m^3 = \mu m^{-1}$.

How Life Beats the Limit

Folds: microvilli (gut), root hairs, alveoli (lungs) → ↑ SA w/o adding much volume to the cell.
Shape & division: flat or long cells, or cells that split in 2 before SA:V gets too low.
Small animals: high SA:V → lose heat fast → high metabolic rate per gram (mice vs elephants).
Agar-cube lab: smaller cubes → dye reaches the center faster (higher SA:V wins).

⚠ Bigger cell = MORE total SA but LOWER SA:V. Answer w/ the ratio, not the SA itself.

✓ Grid-in: find SA, then V, then divide.

2.4–2.5 Plasma Membranes & Permeability

Fluid Mosaic Model

Phospholipid bilayer: water-loving heads face out; water-fearing (hydrophobic) tails face in.
Fluid = lipids & proteins drift sideways. **Mosaic** = proteins scattered all through it.
Unsaturated tails (kinks) → more fluid membrane.

Part	Role
Integral protein	Spans memb.; channels
Cholesterol	Keeps fluidity steady
Glycoproteins	Cell ID tags

Selective Permeability

Crosses freely: small nonpolar (O_2, CO_2), lipids.
Needs a protein: ions (Na^+, K^+) b/c charged; big polar molecules (glucose); lots of H_2O.
Why: the hydrophobic core repels charged & polar particles, so they need a protein's help.
Amphipathic phospholipids form bilayers on their own in H_2O, w/ no energy needed.

Cell Walls

Cell wall (plants, fungi, bacteria): shape + stops bursting. Lets H_2O & small solutes through.
Membrane proteins: transport, enzymes, signal receptors, cell-cell joining, anchors.
Cholesterol: blocks tight packing in the cold; limits lipid movement in the heat. A buffer.

⚠ Ions are tiny but charged, so they still can't cross the bilayer w/o a channel or pump.

✓ Small + nonpolar = crosses on its own. Charged, or big + polar = needs a protein.

2.6–2.7 Membrane Transport

Passive vs Active

Passive: high → low conc. (down the gradient). No ATP needed; it just happens on its own.
Active: low → high conc. (against the gradient). Needs ATP + a pump protein to push it.
Equilibrium: no NET movement; molecules still move both ways at equal rates, nonstop.

Type	Gradient	ATP?
Simple diff.	Down	No
Facilitated	Down	No
Osmosis	Down	No
Active	Up	Yes
Bulk	Either	Yes

2.7 Facilitated Diffusion

Channel proteins: tunnels for ions; **aquaporins** = H_2O channels. No ATP used; fast & passive.
Carrier proteins: grab the solute, change shape, then release it on the other side.
Saturation: once all carriers are busy, the rate stops rising, even if [solute] keeps going ↑.

Pumps

Na^+/K^+ pump: 3 Na^+ out, 2 K^+ in per ATP → membrane potential (charge difference).
Cotransport: an ion flows back down its gradient → drags glucose uphill along with it.
Rate ↑ w/ steeper gradient, higher temp, more SA.

⚠ Facilitated diffusion uses a protein but NO ATP.

✓ Rate levels off as solute ↑ → the carriers are full (saturated), not simple diffusion.

2.8 Tonicity & Osmoregulation

Osmosis & Tonicity

Osmosis: H_2O moves across a membrane from low solute → high solute (passive, no ATP).
Tonicity: compares solute conc. of soln vs cell.

Soln	H_2O	Animal	Plant
Hyper	Out	Shrivels	Plasmol.
Hypo	In	Bursts	Turgid
Iso	No net	Normal	Flaccid

Water Potential (Ψ)

$\Psi = \Psi p + \Psi s$ (pressure + solute). H_2O flows high Ψ → low Ψ. Pure H_2O in an open beaker: Ψ = 0.
$\Psi s = -iCRT$. More solute → Ψs more negative → H_2O moves in toward it from higher Ψ.
Terms: i = # of ions (sucrose 1, NaCl 2); C = molarity; R = 0.0831; T = °C + 273 (kelvin).
Pressure (turgor) → Ψp ↑ (positive).
Example: 0.1 M NaCl (i = 2) at 27 °C → Ψs = −(2)(0.1)(0.0831)(300) ≈ −4.99 bar (open beaker).

Osmoregulation

Contractile vacuole: freshwater protists pump out extra H_2O, using ATP to do it nonstop.
Plant cell wall resists bursting → turgor pressure keeps the plant firm & upright, not wilted.
Plasmolysis: the membrane pulls off the wall in a hypertonic soln → wilting, often cell death.

⚠ "Hyper/hypo" describe the SOLUTION. Water moves TOWARD the hypertonic side.

✓ Graph % mass change vs molarity: the 0% change point = the isotonic molarity.

2.9–2.10 Bulk Transport & Compartments

2.9 Endocytosis & Exocytosis

Exocytosis: vesicle fuses w/ membrane → contents out (hormones, enzymes).
Endocytosis: membrane folds in → vesicle brings big stuff in. Both directions use ATP.
Exocytosis adds membrane to the surface; **endocytosis** removes membrane from it.

Type	Takes in
Phagocytosis	Large particles
Pinocytosis	Fluid + solutes
Receptor-mediated	Specific molecules

Receptor-mediated: molecule binds receptor → coated pit → vesicle (e.g., LDL cholesterol).
Then: the food vacuole fuses w/ a lysosome → its enzymes digest the contents for reuse.

2.10 Why Compartments?

Separate spaces → own pH & enzymes → opposite rxns can run at the same time.
Builds gradients (H^+ in mito, chloro) → makes ATP.
Internal membranes → ↑ SA for rxns.
Example: lysosome pH ~5 vs cytosol ~7 → its enzymes work only inside it, safely.
Prokaryotes: no organelles, but infoldings of the plasma membrane host the ETC.

⚠ Bulk transport moves big molecules in vesicles, not through channels.

✓ FRQ: name the compartment + the condition it keeps (pH, H^+) + why it helps the cell.

2.11 Origins & Unit 2 Exam Strategy

Endosymbiont Theory

Claim: a host cell engulfed bacteria → became **mitochondria**, later **chloroplasts**.
Evidence: double membrane; own circular DNA; own ribosomes; divide like bacteria.
Order: mitochondria first (nearly all eukaryotes), chloroplasts later (plants, algae).

Prokaryote vs Eukaryote

Feature	Prok.	Euk.
Nucleus	No	Yes
Organelles	No	Yes
Ribosomes	Yes	Yes
DNA	Circular	Linear

Shared by all cells: membrane, cytoplasm, ribosomes, DNA → common ancestry.

Exam Moves

Predict: "If organelle X fails..." → name its lost function → the effect on the whole cell.
Calculate: SA:V and Ψ show up as grid-ins. Show your setup & keep the units (bar, μm^{-1}).
Links: Unit 1 lipids → Unit 3 ETC in mito/chloro → Unit 4 membrane receptors & signals.
Endosymbiosis FRQ: give 2 pieces of evidence, each tied to a trait of bacteria (circular DNA).

⚠ Mito and chloro are NOT part of the endomembrane system; they came from bacteria.

✓ The formula sheet gives SA, V & Ψ equations. Know when to use each one & its units.