Life's Common Challenges

Water and Wastes

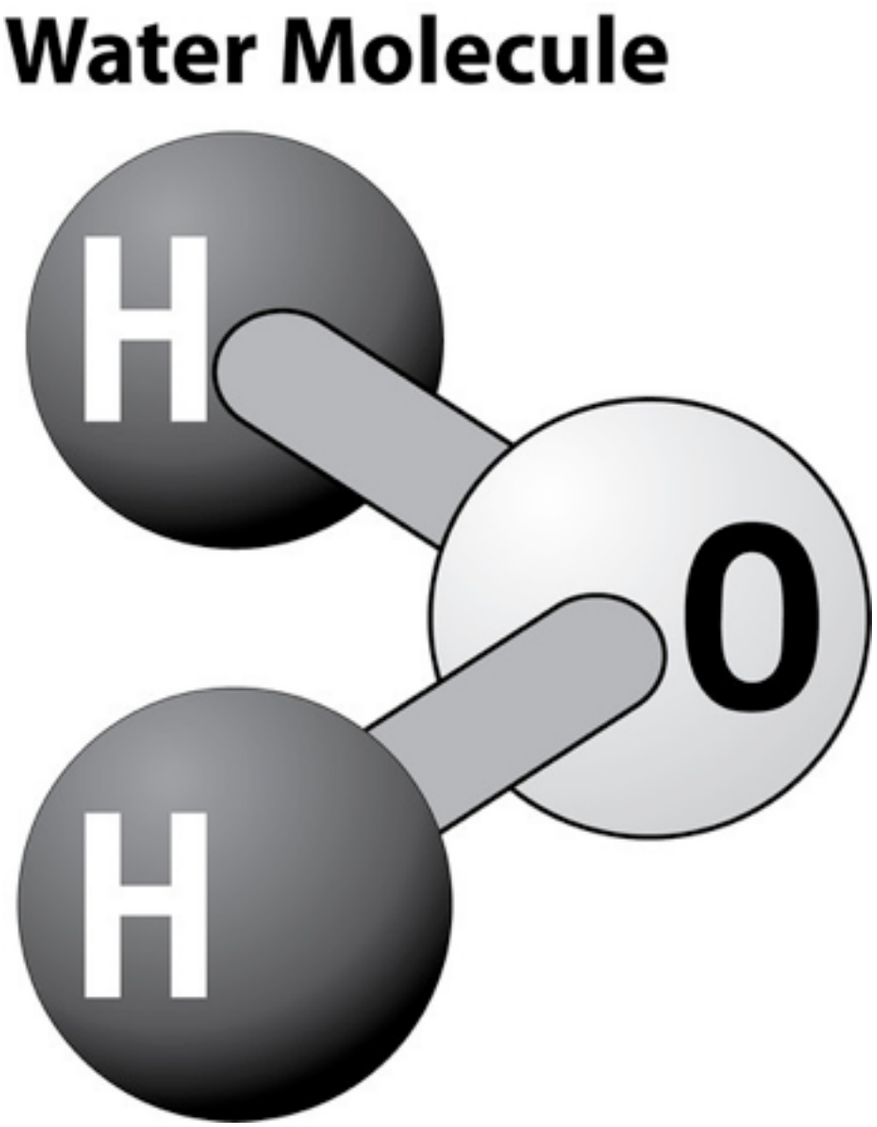
Life's Common Challenges

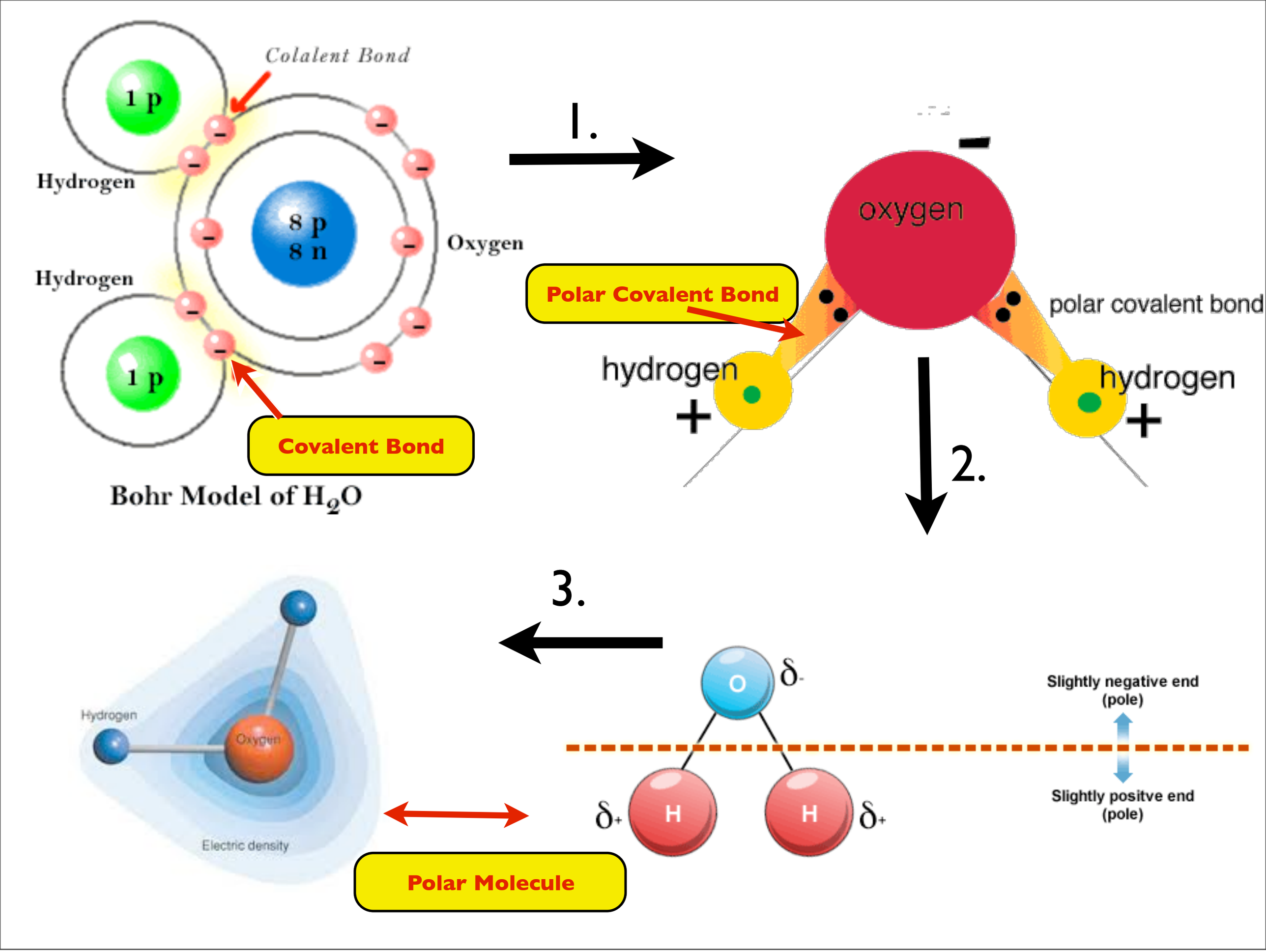
Water

- Water is the substance that makes life possible (as we know it)
- Almost every organism is made of mostly water
- Almost every organism lives in an environment dominated by water.
- Life began in water.
- Most life remains tied to water.
- Living organisms need water more any other substance.
- Water participates in most life sustaining chemical reactions.
- Most cells are bathed in water.
- Most cells are themselves mostly water.
- Water is the substance that makes life possible (as we know it)

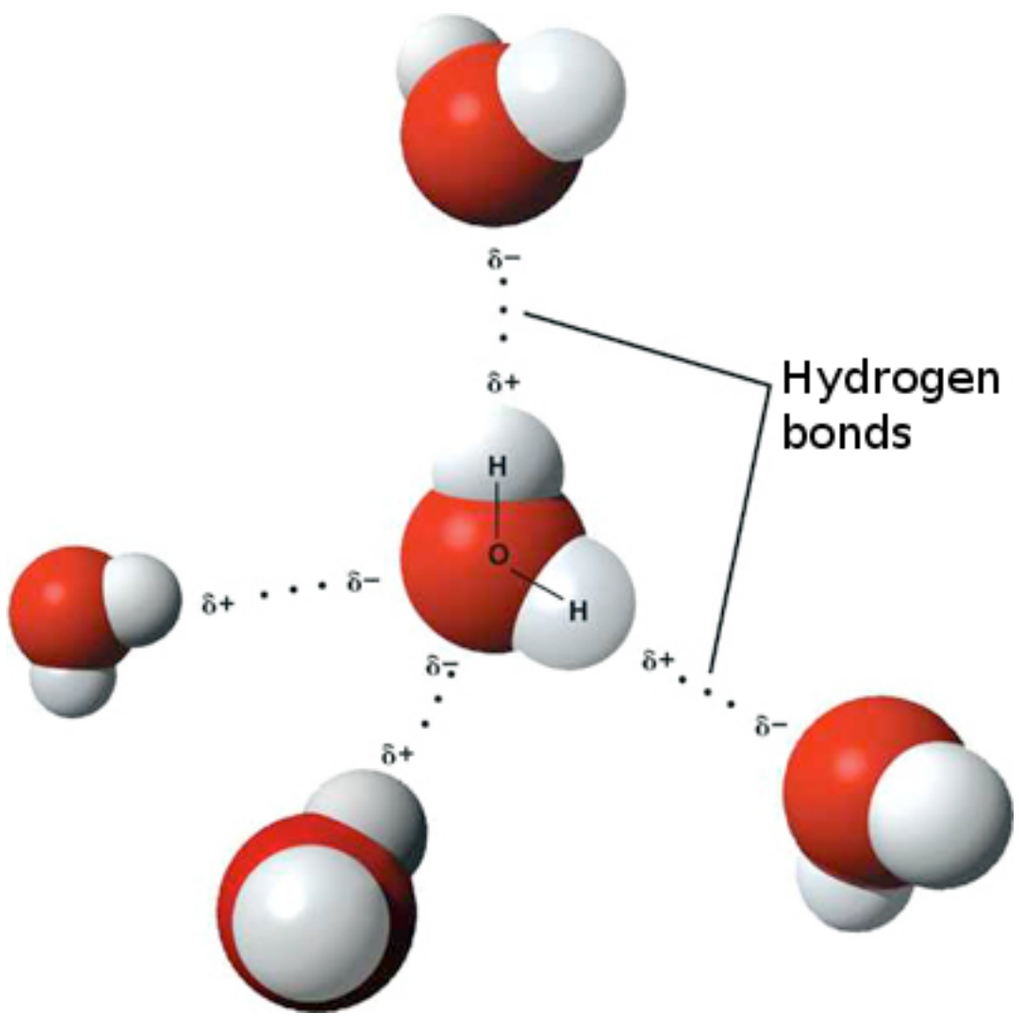
POLAR COVALENT BONDS IN WATER MOLECULES RESULT IN HYDROGEN BONDING

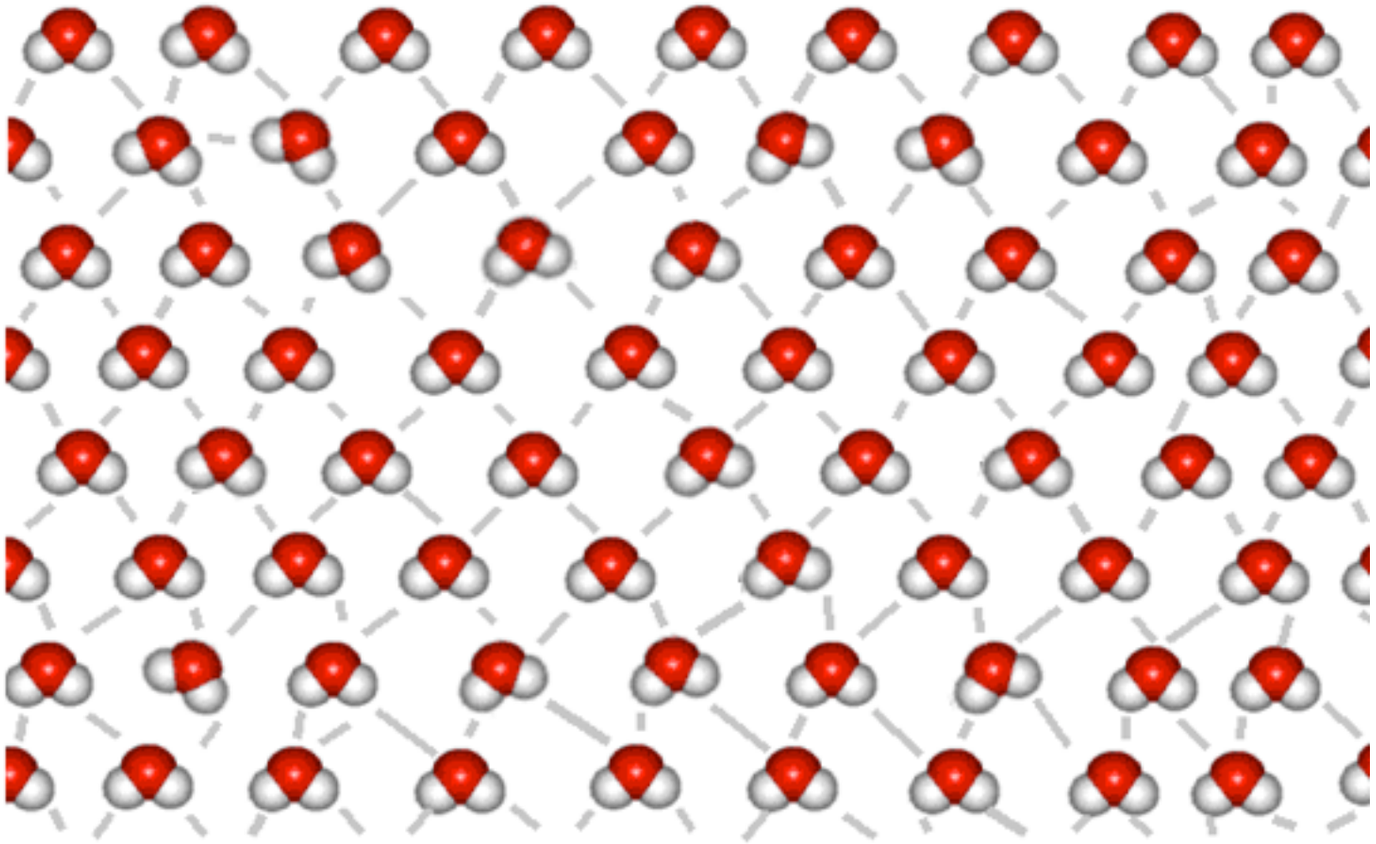
- Water is a small, simple "V" shaped molecule.




Colalent Bond
1 p
Hydrogen
8 p
8 n
Oxygen
Hydrogen
1 p
Covalent Bond
Bohr Model of H_2O
1.
oxygen
Polar Covalent Bond
polar covalent bond
hydrogen
hydrogen
2.
3.
Hydrogen
Oxygen
Electric density
O
δ-
δ+
H
H
δ+
Slightly negative end (pole)
Slightly positve end (pole)
Polar Molecule

- The properties of water arise from attractions between oppositely charged atoms of different water molecules.
- Two molecules are held together by hydrogen bonds.
  - H bonds are fragile,
  - They form, break and re-form with great frequency





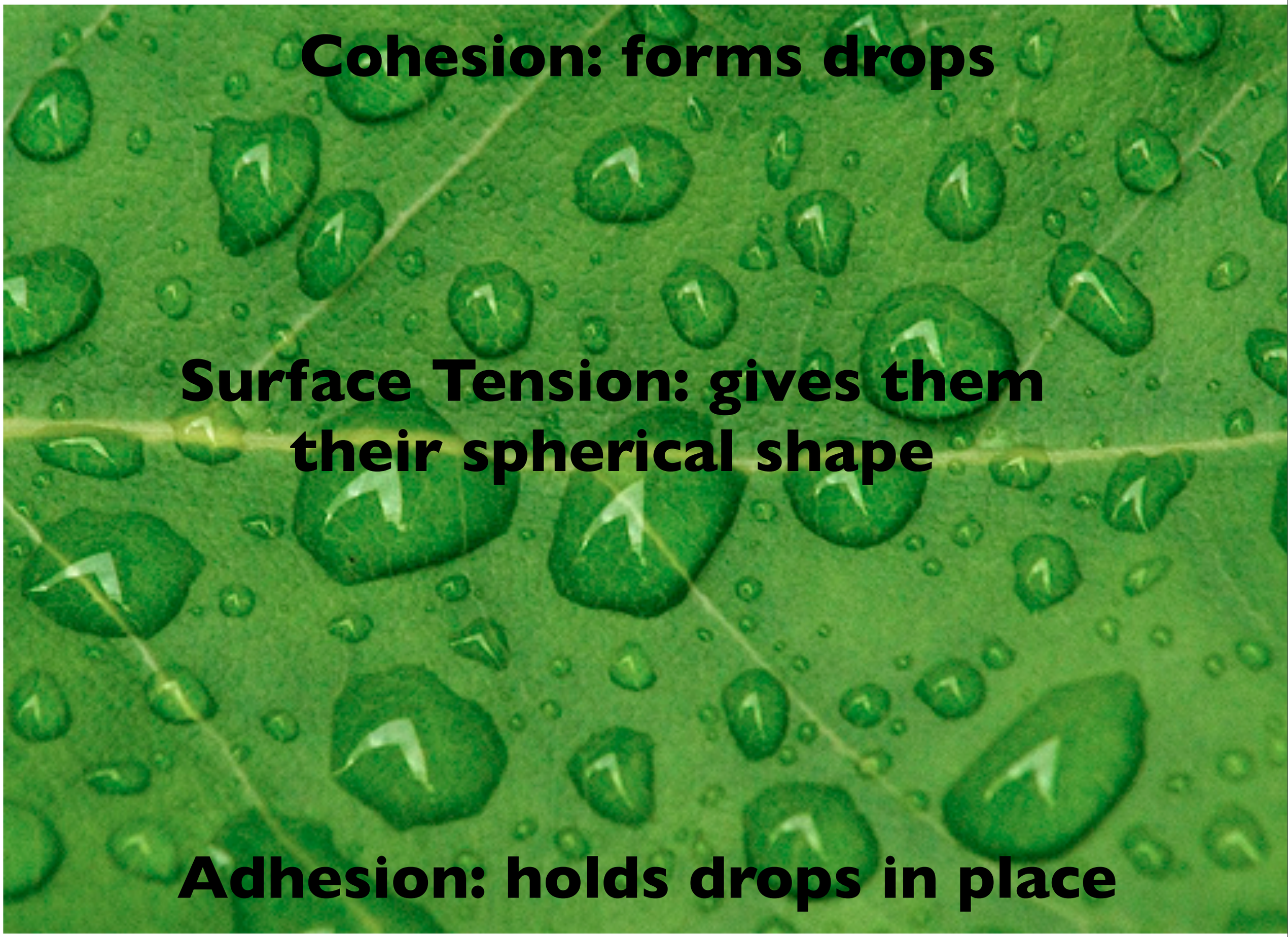
An idealized 2-dimensional view

FOUR EMERGENT PROPERTIES OF WATER CONTRIBUTE TO EARTH'S SUITABILITY FOR LIFE

- Cohesive Behavior
- Ability to moderate temperature
- Expansion upon freezing
- Versatility as a solvent (can dissolve a lot

A. Cohesion of Water Molecules

- Hydrogen bonds give water more structure than most other liquids
- Cohesion is the bonding of water molecules to each other through hydrogen bonds
  - Surface tension is (related to cohesion) a measure of how difficult it is to stretch or break the surface of a liquid
    - Water has one of the highest surface tensions!
- Adhesion is the bonding of water molecules to other substances through hydrogen bonds
- Water would not move through plants if not for cohesion and adhesion


Cohesion: forms drops
Surface Tension: gives them their spherical shape
Adhesion: holds drops in place

B. Moderation of Temperature

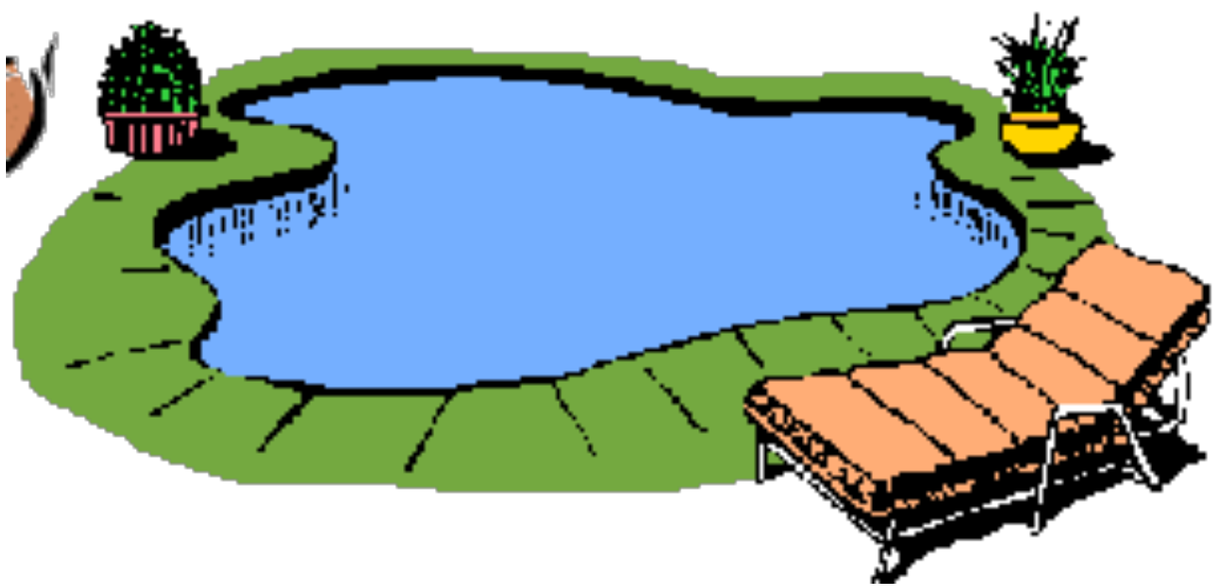
- Water can absorb heat from warmer air OR release heat to cooler air
- Water can absorb or release a relatively large amount of heat with only a slight change to its own temperature

1. Heat and Temperature

- *Kinetic Energy* is the energy of motion, anything moving has kinetic energy
  - atoms & molecules are constant random motion

1. Heat and Temperature (cont.)

- *Heat* is a form of energy
  - amount of heat is a measure of the matter's kinetic energy
    - heat depends somewhat on its volume of the matter
- *Temperature* is a measure of heat intensity, it represents the average kinetic energy, regardless of volume!



Which has higher temperature?
Which has more heat?

...the coffee
...the pool

1. Heat and Temperature (cont.)

- *Heat* moves from warmer object to a cooler one

How then does ice make water colder?

Ice does not add coldness, it absorbs heat from water, thus melts

- *Celcius scale* indicates temperature
  - Water freezes at 0°C, Boils at 100°C, Body temp 37°
- *Temperature* is a measure of heat intensity, it represents the average kinetic energy, regardless of volume!

2. Water's High Specific Heat

- *Specific Heat* is the amount of heat that must be absorbed or lost for 1g of a substance to change temp. by 1 °C
  - is a measure of well a substance resists changing its temp.
- Water has a unusually high specific heat
  - this property results from water's hydrogen bonding

Review...Relevance?

- ***Moderates both sea and land temperatures***
- ***Allows organisms to resist change in body temperatures***

3. Evaporative Cooling

- *Evaporation (vaporization)* is the transformation from a liquid to a gas
  - some evaporation occurs at any temperature.
- *Heat of Vaporization* is the amount of heat a liquid must absorb for 1g to be converted from liquid to gas
- *Evaporative cooling* occurs because "hottest" molecules (most energy) are most likely to leave and the liquid left behind becomes cooler.

Global Relevance

- ***Water evaporates at equator, water contains heat, moves towards poles, condenses and releases heat***

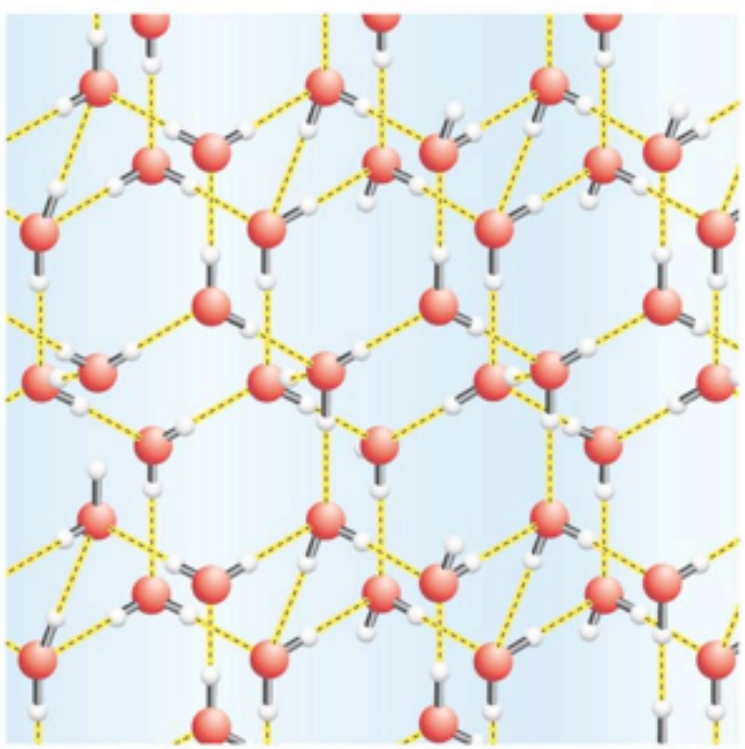
Organismal Relevance

- ***A mechanism that prevents terrestrial organisms from over heating***

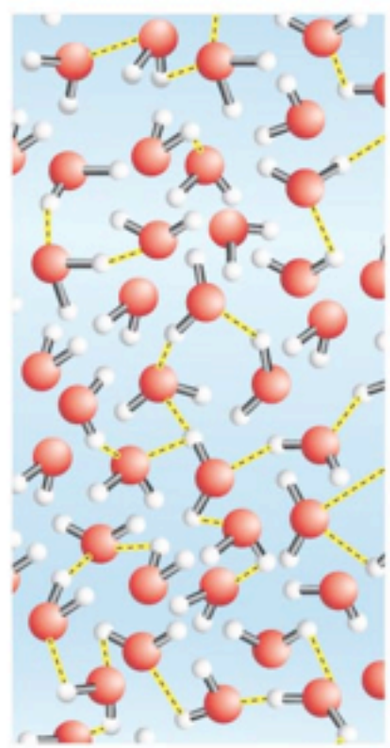
4. Ice Floats on Liquid Water

- *Water is one of the only substances that is less dense as a solid than as a liquid.*
  - most substances contract as they get colder, BUT water expands as it gets colder.
  - the cause is once again the unique hydrogen bonding

(a) In ice, water molecules form a crystal lattice.



(b) In liquid water, no crystal lattice forms.



(c) Liquid water is denser than ice. As a result, ice floats.

Relevance

-prevents bodies of water from freezing solid

-solid habitat

-insulation

5. Water the Solvent of Life

- *Solution*- a liquid homogenous mixture of two or more substances
  - *Solvent*- is the dissolving agent of the solution
  - *Solute*- the substance that is dissolved
  - *Aqueous Solution*- one where water is the solvent

***Water is a versatile solvent BUT it is NOT the universal solvent!**

Water dissolves Ionic compounds &
Nonionic Polar Compounds

Life's Common Challenges

Wastes

Excretion

- Cells produce metabolic waste as they carry out cellular activities.
- Some of these wastes can be toxic, particularly damaging to enzymes
- Excretion- is the process of removing these metabolic wastes
- NOT to be confused with elimination; the removal of undigested food or feces

Metabolic Wastes

Metabolic Activity	Wastes
cellular respiration	carbon dioxide + water
dehydration synthesis	water
certain metabolic processes	mineral salts
protein metabolism	nitrogenous

Many are soluble in water and move readily across plasma membranes

Animals

Water & Solute Regulation

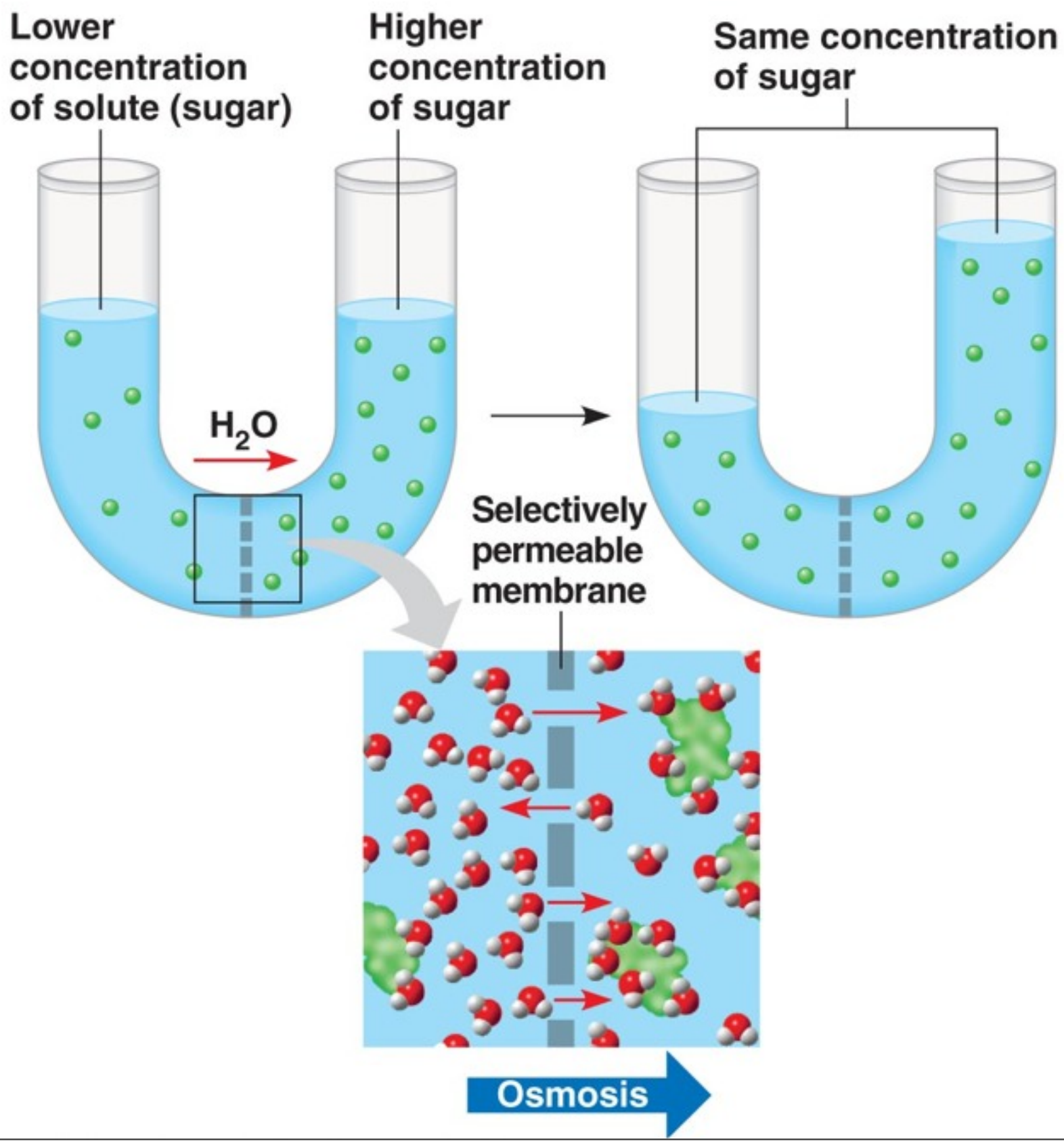
Water and Solutes

- All organisms need to balance to uptake and loss of water
- Water and solutes move together across membranes
- Thus the net effect is to balance both solutes and water at the same time
- Maintaining a fluid environment of cells and tissues requires keeping the relative concentrations of water and solutes within narrow limits

Osmoregulation

- The general term for the process by which organisms control solute concentrations and balance water loss and gain is called osmoregulation.
- A number of strategies have evolved, reflecting the varied and often severe osmoregulatory challenges presented by surroundings
- In addition, animals must also deal with hazardous ammonia produced from breakdown of proteins and nucleic acids

REVIEW: Osmosis



It has been said that water moves down its concentration gradient,

However it is more accurate and helpful if focus on solute concentration and remember that water moves from a less concentrated side to a more concentrated side. OR That water moves from a low solute concentration to a high solute concentration.

Review: Water Balance of Cells Without Walls

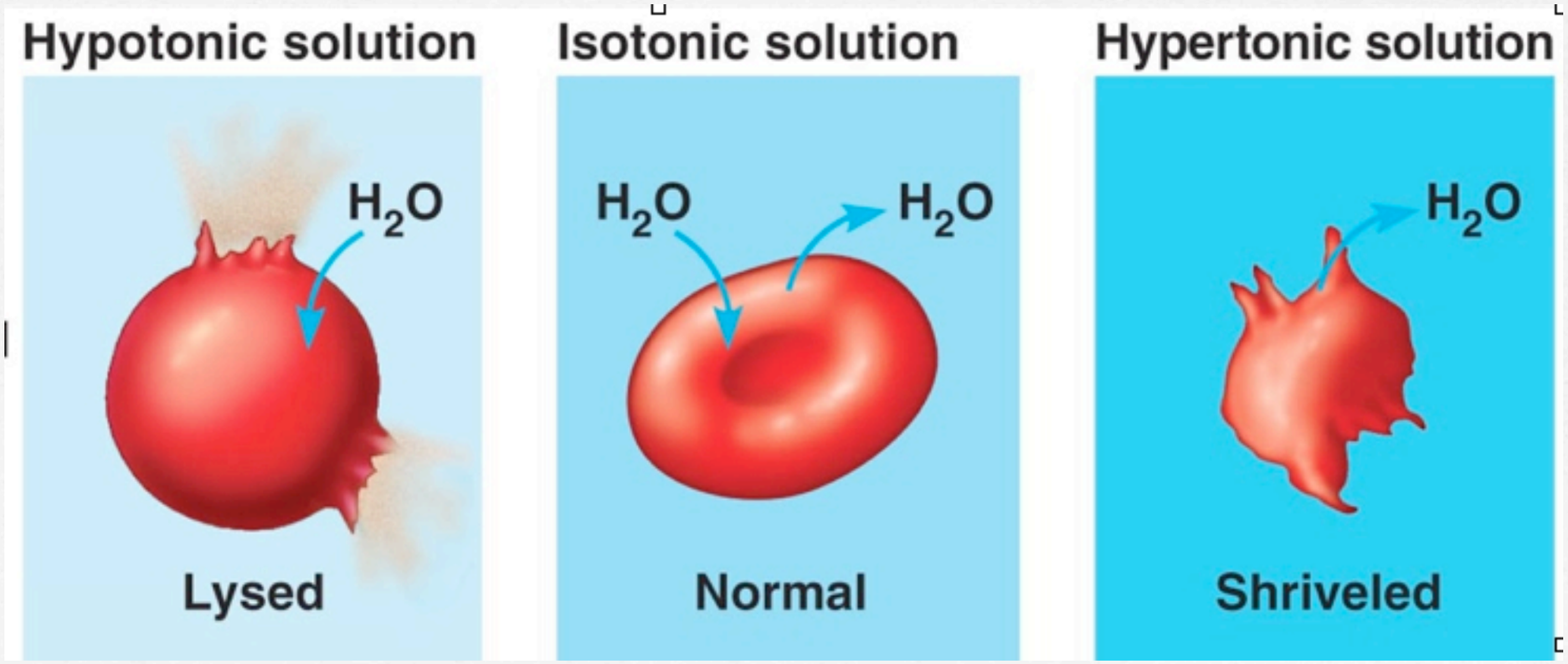
- **Tonicity** is the ability of a surrounding solution to cause a cell to gain or lose water.
  - The key is the "non-penetrating solutes" relative to cell's interior
  - **Isotonic** solutions are **same** as cell's solution thus no net movement of water.
  - **Hypertonic** solutions have **more** than a cell's solution thus a net movement of water out of the cell.
  - **Hypotonic** solutions have **less** than a cell's solution thus a net movement of water into the cell.

Review: Water Balance of Cells With Walls

- Because these cells have rigid walls they can not burst.
- As water moves in the cell wall pushes back (*turgor pressure*) which opposes further water uptake
  - **Isotonic** solutions cause these cells to be *flaccid* (limp).
  - **Hypertonic** solutions cause a net loss of water, which results in *plasmolysis* (membrane pulls away from cell wall)
    - This causes a plant to wilt and die
  - **Hypotonic** solutions cause these cells to be *turgid* (stiff).
    - This is a healthy state for plants.

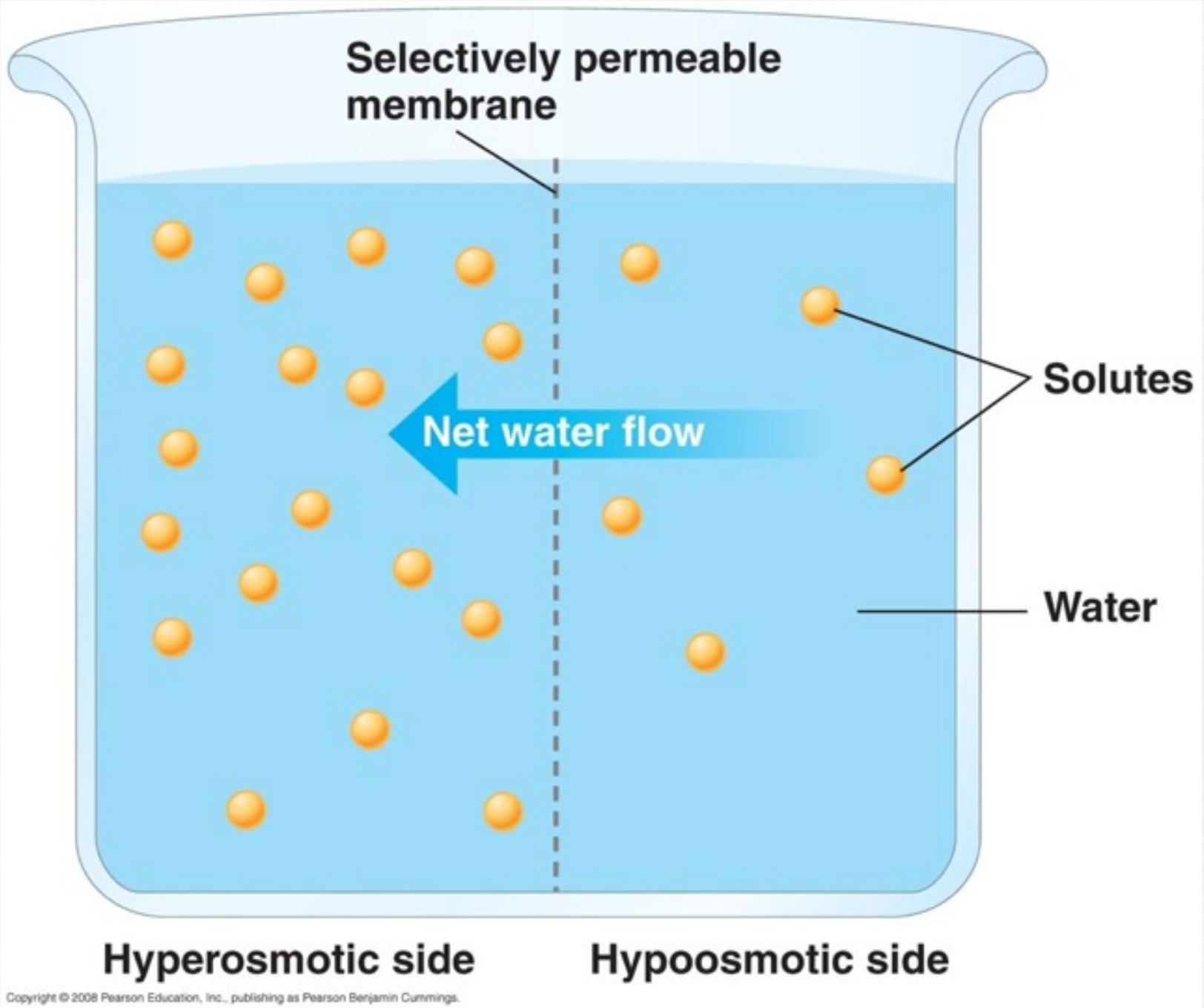
Osmoregulation

- If water uptake is excessive, animal cells swell and burst.
- If water loss is substantial animal cells will shrivel and die.



Osmolarity total solute concentration

Lower free water



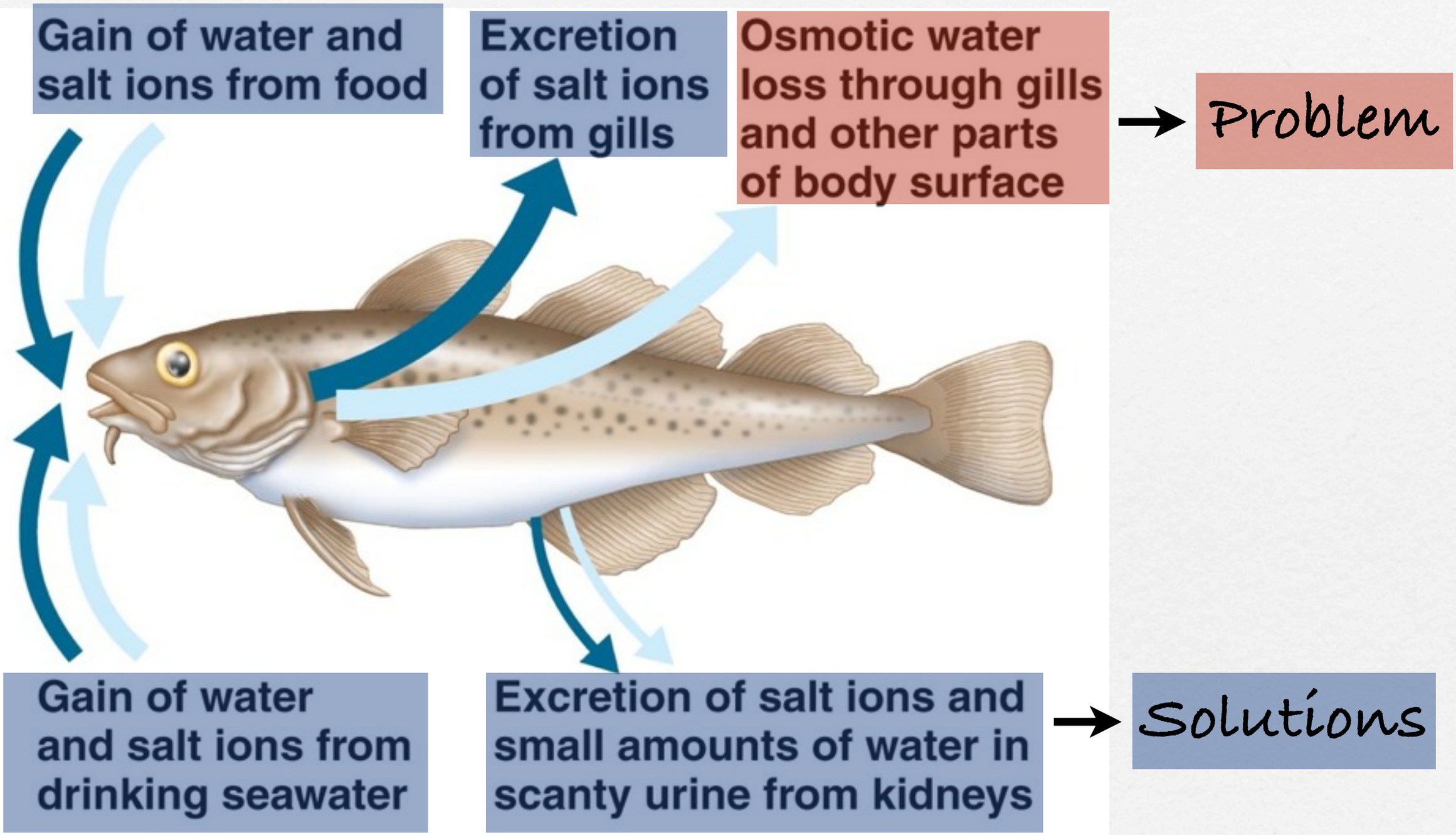
More free water

Osmotic Challenges

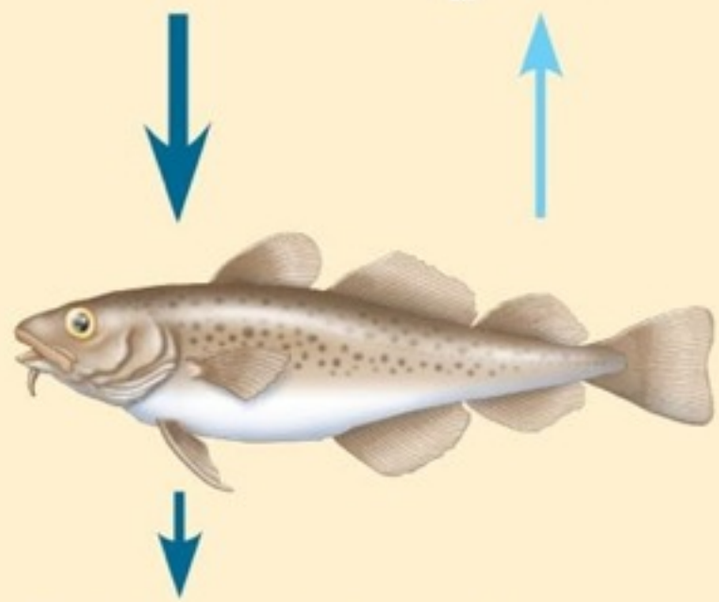
- Two strategies for maintaining a water balance
- Osmoconformers- are isoosmotic with their surroundings
  - marine animals
- Osmoregulators- control the internal osmolarity independent from the surroundings
  - fresh water organisms

Marine Animals

- Most marine invertebrates are osmoconformers
- Many marine vertebrates are osmoregulators

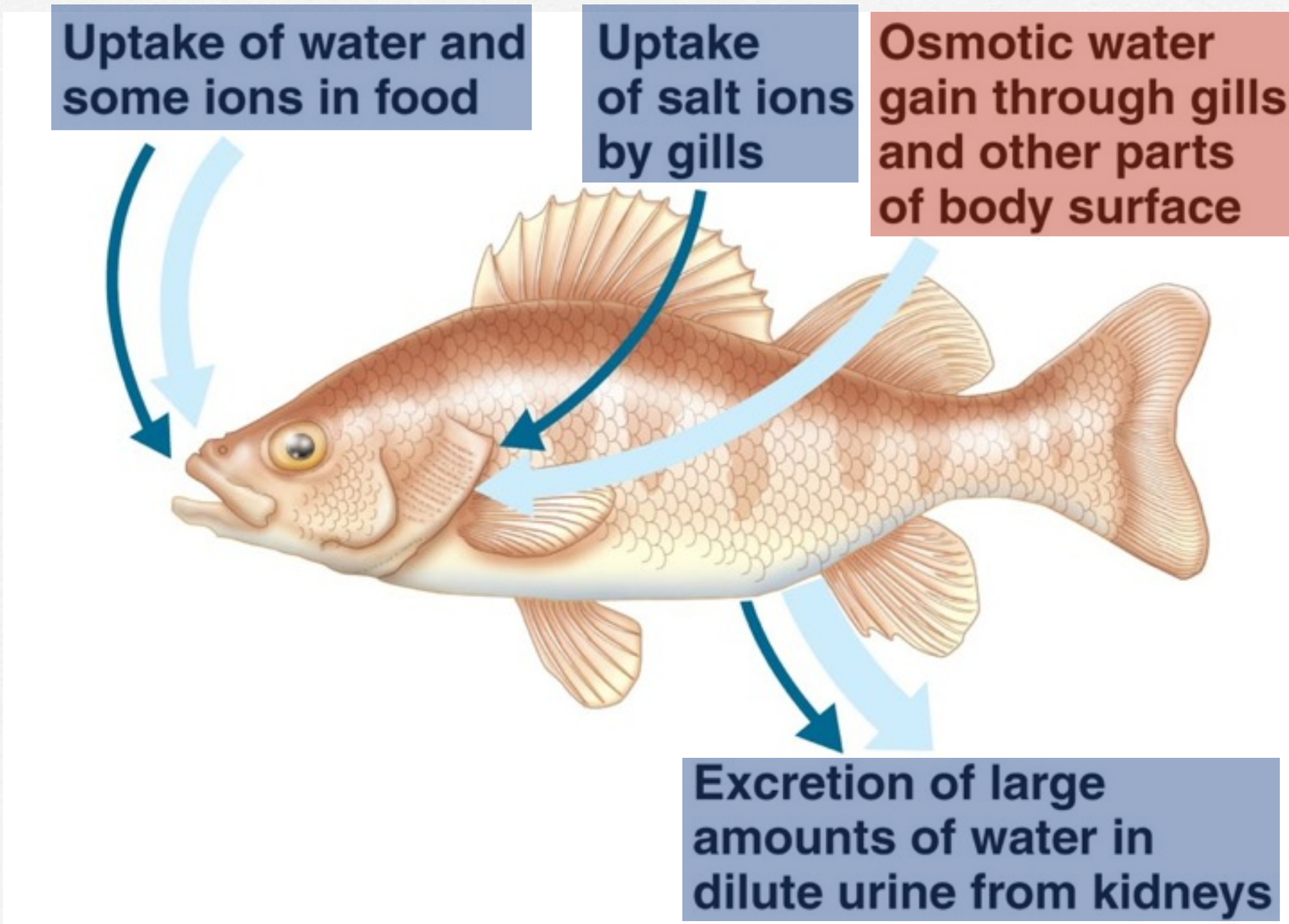


(a) Osmoregulation in a saltwater fish

Animal	Inflow/Outflow	Urine
Bony marine fish	Drinks water Salt in H_2O out  Salt out (active transport by gills)	 ▶ Small volume of urine ▶ Urine is slightly less concentrated than body fluids

Freshwater Animals

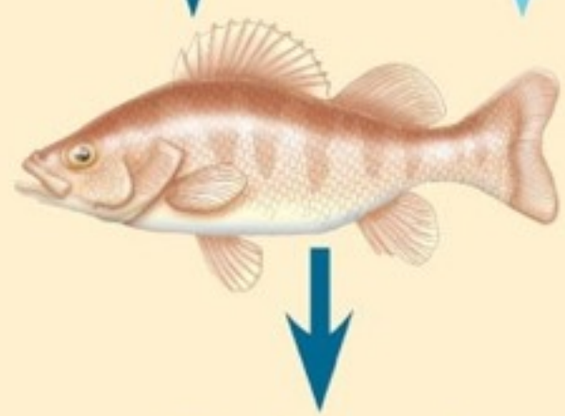
- Most freshwater animals are osmoregulators



→ Problem

→ Solutions

(b) Osmoregulation in a freshwater fish

Animal	Inflow/Outflow	Urine
Freshwater fish	Does not drink water Salt in (active transport by gills) H_2O in  Salt out	 ▶ Large volume of urine ▶ Urine is less concentrated than body fluids

Land Animals

- The threat of dehydration is a major regulatory problem for terrestrial organisms
  - Human can die if it loses only 12% of their body water
- Terrestrial organisms lose water through urine, feces, across their skin and during gas exchange.

Land Animals

- Adaptations that reduce water loss are key to survival on land.
  - Body coverings- exoskeletons, layers of dead skin cells
  - Behavior- nocturnal life styles
- Still land animals must drink, eat moist food, and produce water metabolically to offset water loss.

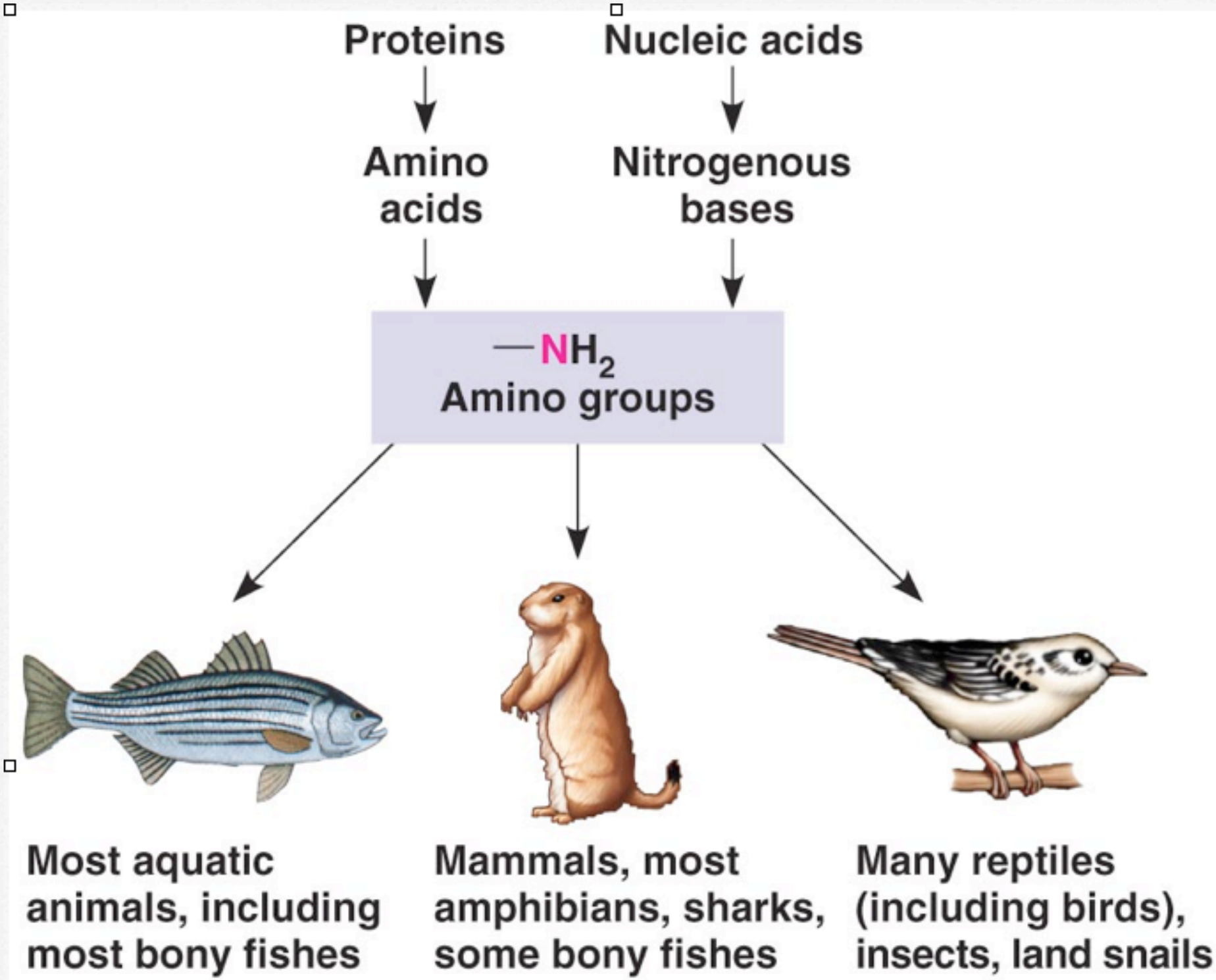
Animal	Inflow/Outflow	Urine
Terrestrial vertebrate	Drinks water Salt in (by mouth)  H_2O and salt out	 ▶ Moderate volume of urine ▶ Urine is more concentrated than body fluids

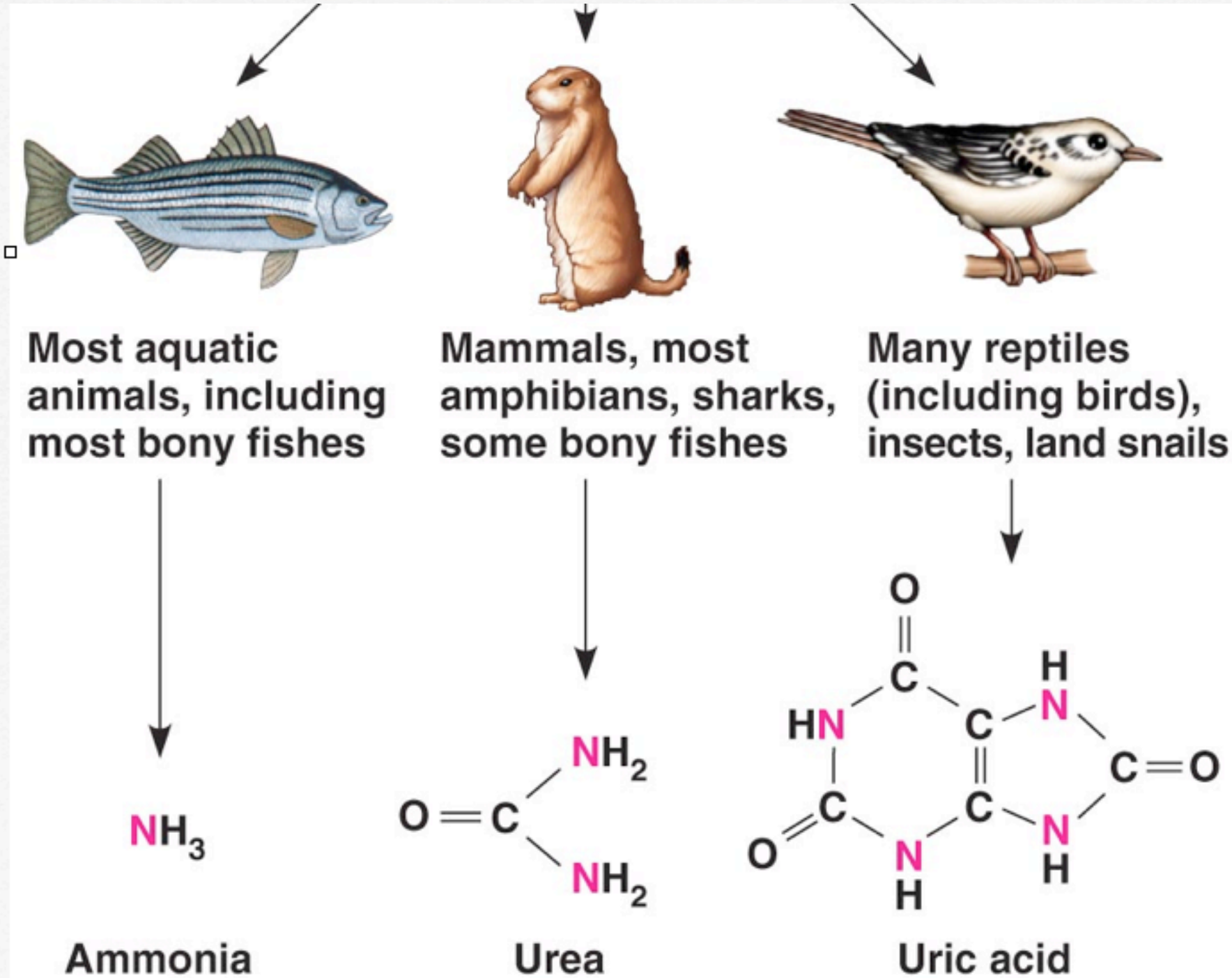
Animals

Water & Nitrogen Wastes

Removing Nitrogenous Waste

- Most metabolic waste must be dissolved in water in order to be eliminated
- The type and quantity of waste very much effects the water balance in an organism
- Forms of nitrogenous waste
  - Ammonia
  - Urea
  - Uric Acid


Proteins
Nucleic acids
Amino acids
Nitrogenous bases
—NH2
Amino groups
Most aquatic animals, including most bony fishes
Mammals, most amphibians, sharks, some bony fishes
Many reptiles (including birds), insects, land snails


Most aquatic animals, including most bony fishes
Mammals, most amphibians, sharks, some bony fishes
Many reptiles (including birds), insects, land snails
NH3
Ammonia
O=C
NH2
NH2
Urea
O
C
HN
C
H
N
C=O
C
C
O
N
H
N
H
Uric acid

Ammonia

- Highly Toxic
- Highly soluble
- Easily passes through membranes
- Requires ALOT of water to eliminate it
  - Thus most common in aquatic species

Urea

- Low Toxicity
- Highly soluble
- Requires energy to eliminate it
- Requires less of water to eliminate it
  - Most common in terrestrial species
    - The liver combines carbon dioxide and ammonia to produce urea

Uric Acid

- NOT Toxic
- NOT soluble
- Requires ALOT energy to eliminate it
- Requires NO water to eliminate it
  - Most common in insects, reptiles and birds

Animals

Excretory Systems

Excretion of Wastes: Animals

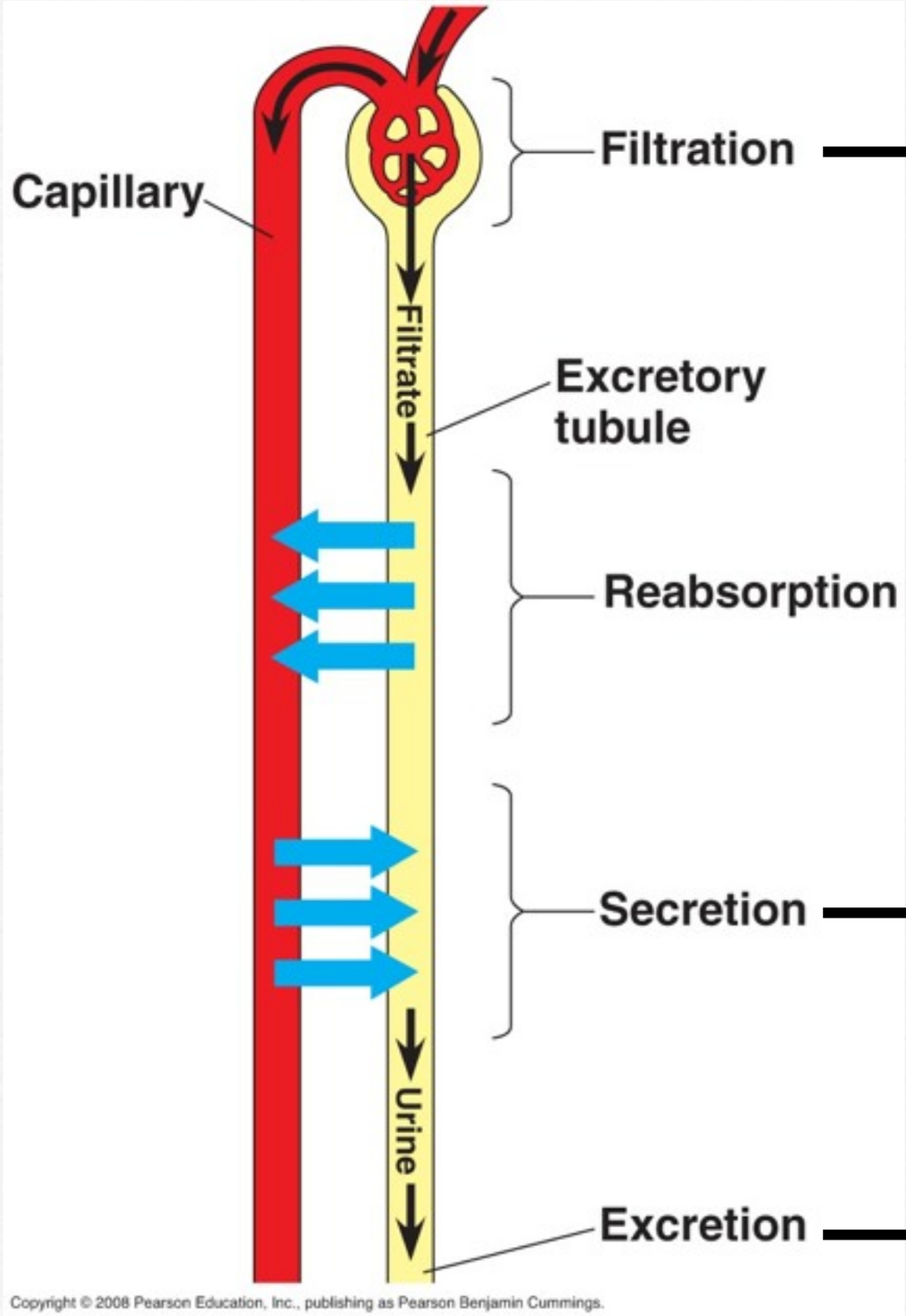
WASTE	HOW IT IS FORMED	MECHANISM OF EXCRETION
Carbon Dioxide	cell respiration	depends on the animal
Water	cell respiration, dehydration synthesis	depends on the animal
Nitrogenous (various forms)	removal of $-NH_2$ groups from amino acids leads to formation of NH_3	depends on the animal
Inorganic Salts	general metabolism	depends on the animal

Excretory Systems

- ALL water balance relies on the regulation of solute movement between internal fluids and external environments.
- Most of this movement in multicellular organisms is handled by excretory systems.
- These systems not balance water and solute concentrations but also excrete harmful wastes.

Excretion: The Process

- Animals produce a fluid waste called urine through 4 basic steps:
  - Filtration
  - Reabsorption
  - Secretion
  - Excretion

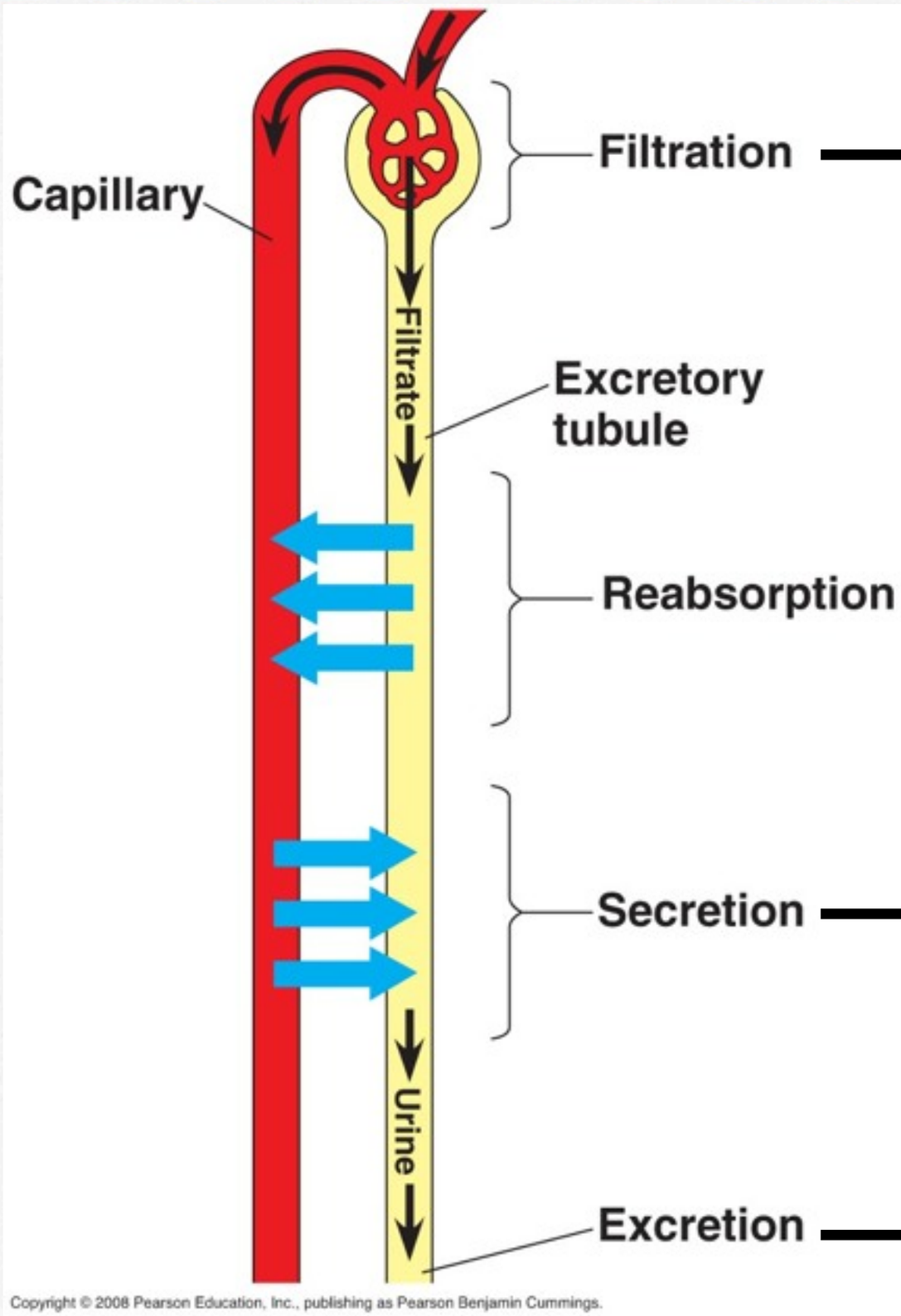


Water and solutes are forced out of the blood

Reclaims valuable substances from filtrate

Excessive solutes and toxins are removed from the blood

The altered filtrate leaves body as urine



water, salts, sugars, amino acids, nitrogenous waste, etc

water, certain salts, glucose, amino acids, vitamins, hormones

additional solutes and waste

water and nitrogenous waste, etc

Diverse Excretory Systems

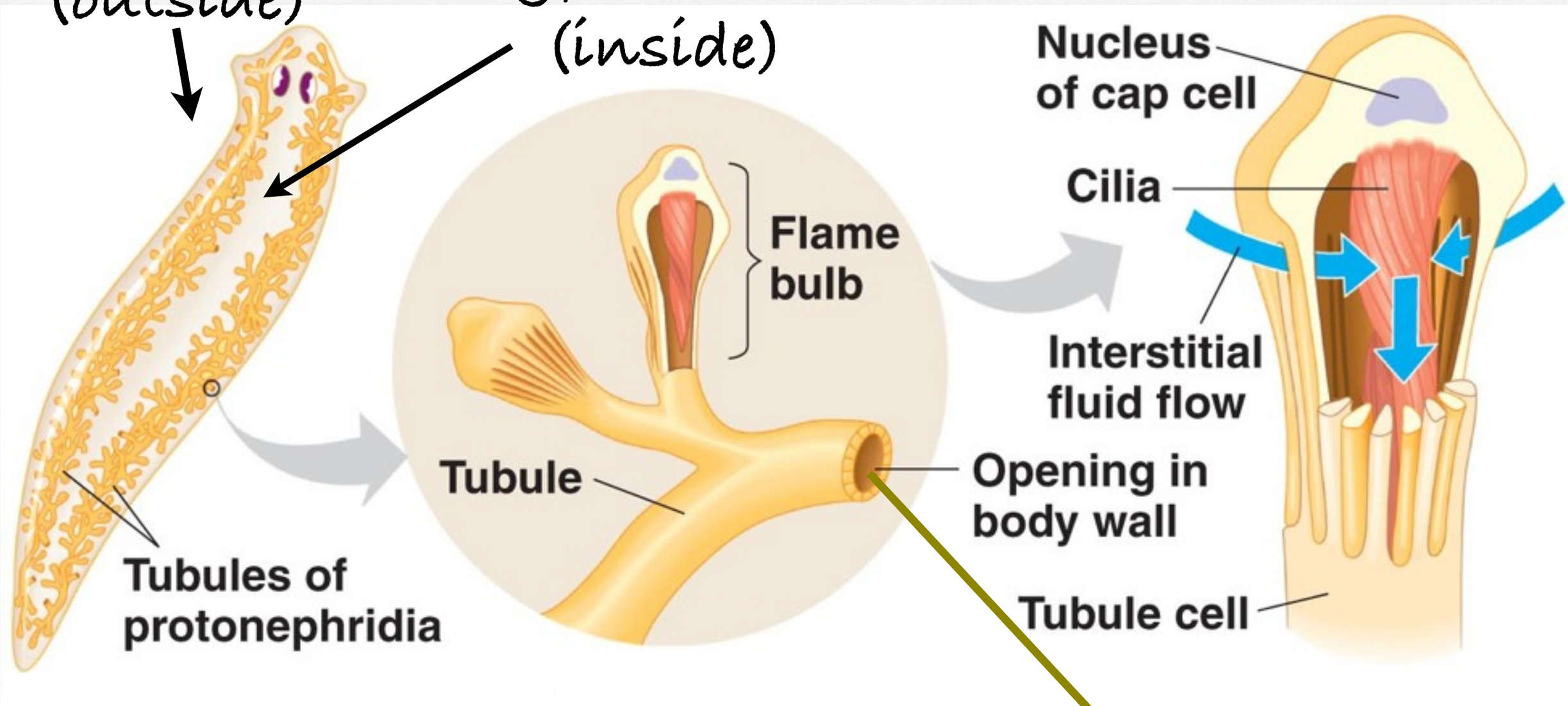
- Although structures vary among animals the functions remain the same-control solute concentration and balance water uptake and output.
  - Protonephridia-flatworms
  - Metanephridia-earthworms
  - Malphigian Tubules-insects (grasshoppers)
  - Kidneys-vertebrates (humans)

Protonephridia

- **Serve to regulate water!**
- Waste removal occurs across the body surface or waste is moved into the gastrovascular cavity where leaves through the mouth
- Freshwater flatworms produce dilute urine to counteract the constant influx of water

Hypoosmotic (outside)

Hyperosmotic (inside)

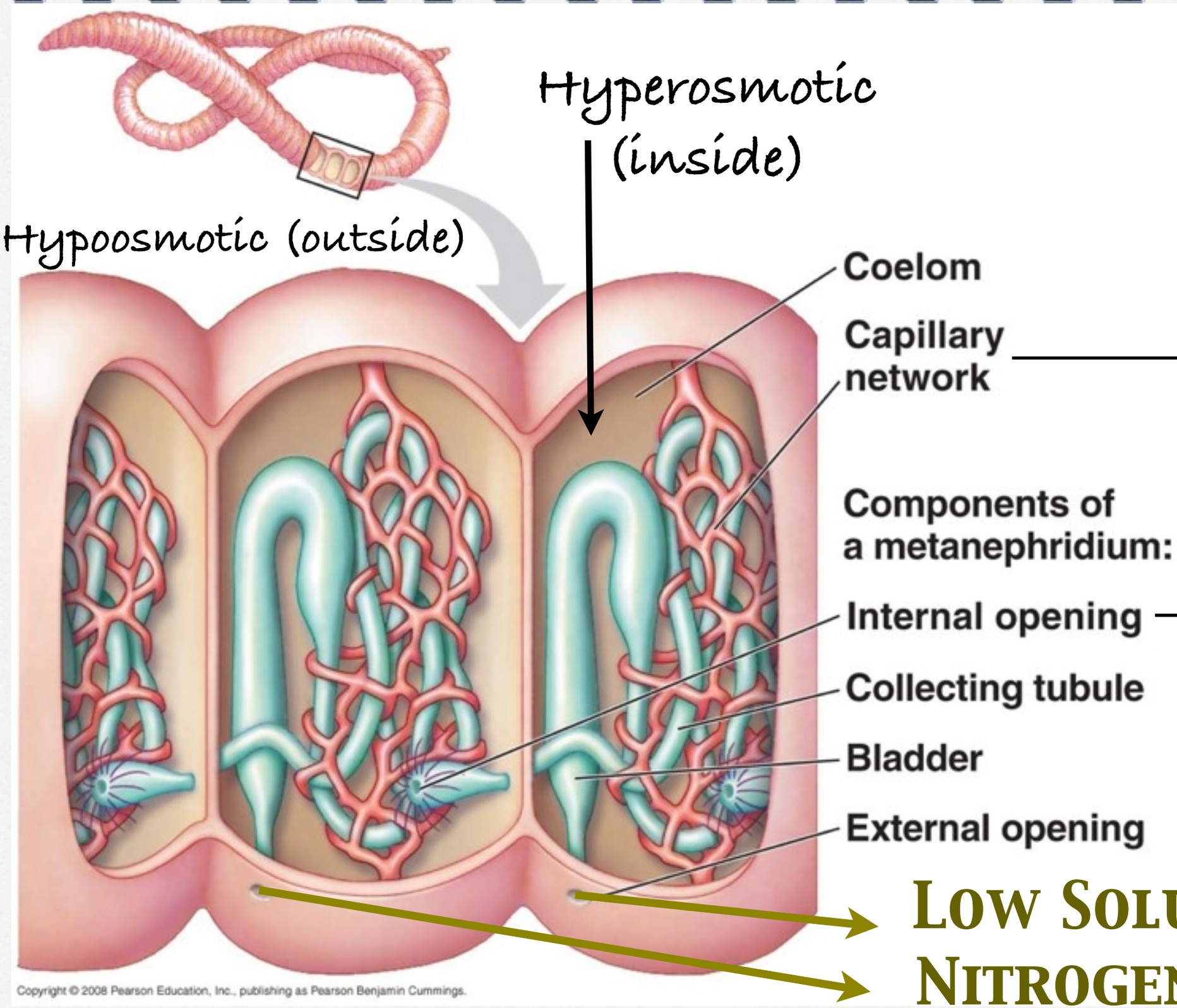


This system is used for osmoregulation, not waste removal

Low Solute Urine

Metanephridia

- **Serve to regulate water and eliminate waste!**
- Waste moves into and remains in the collecting tubule and is eventually excreted to the outside
- Earthworms inhabit moist soils and thus produce dilute urine to counteract the constant influx of water



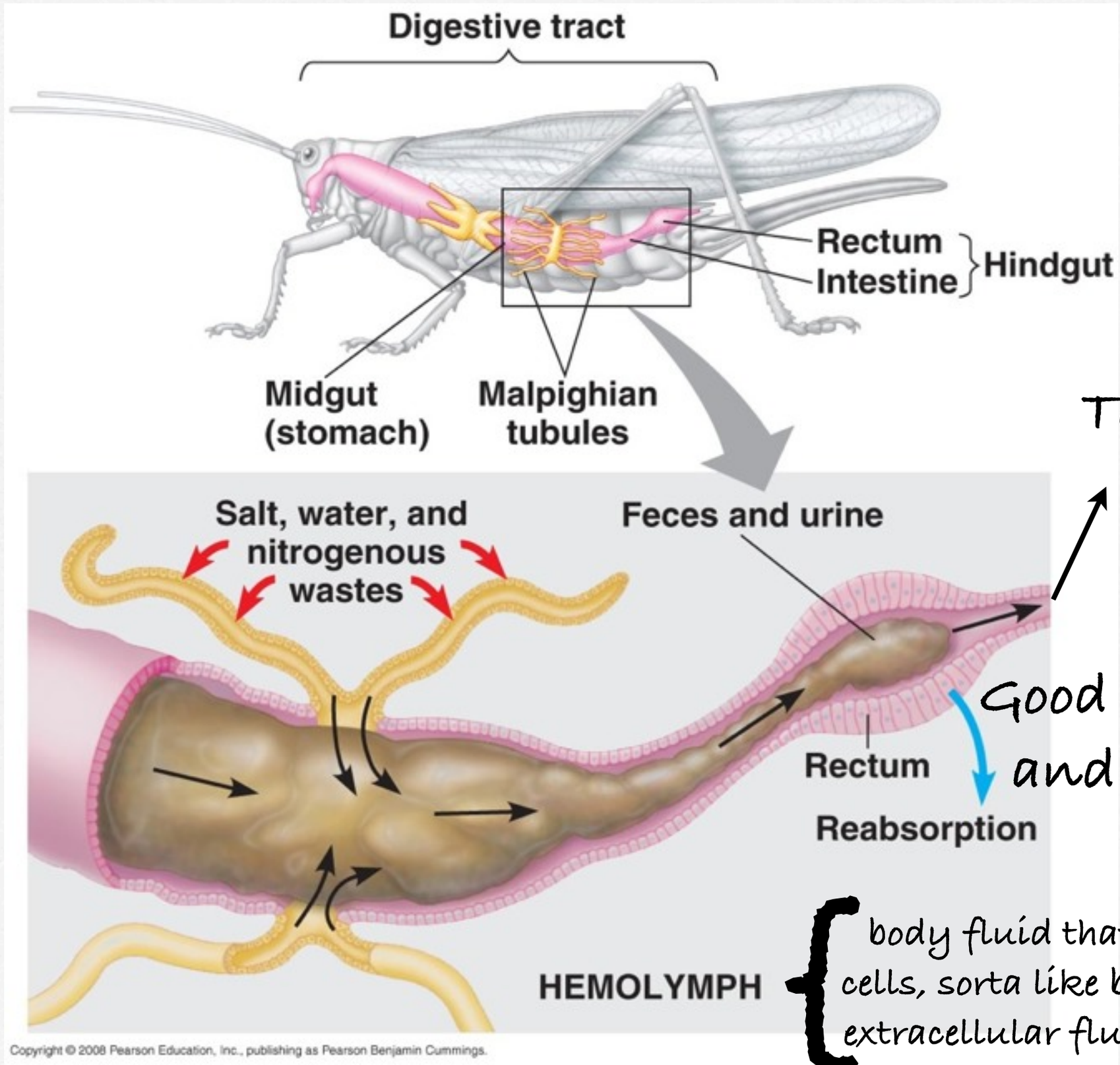
Reabsorbs most solutes ("good ones")

Collects fluid from coelom

Low Solute Urine & Nitrogenous waste

Malpighian Tubules

- **Serve to regulate water and eliminate waste!**
- Nitrogenous waste is actually moved into the (gastrovascular cavity) rectum where it is eliminated along with the feces
- Insects live in hyperosmotic environments and must therefore conserve water, producing non-soluble nitrogenous waste saves water



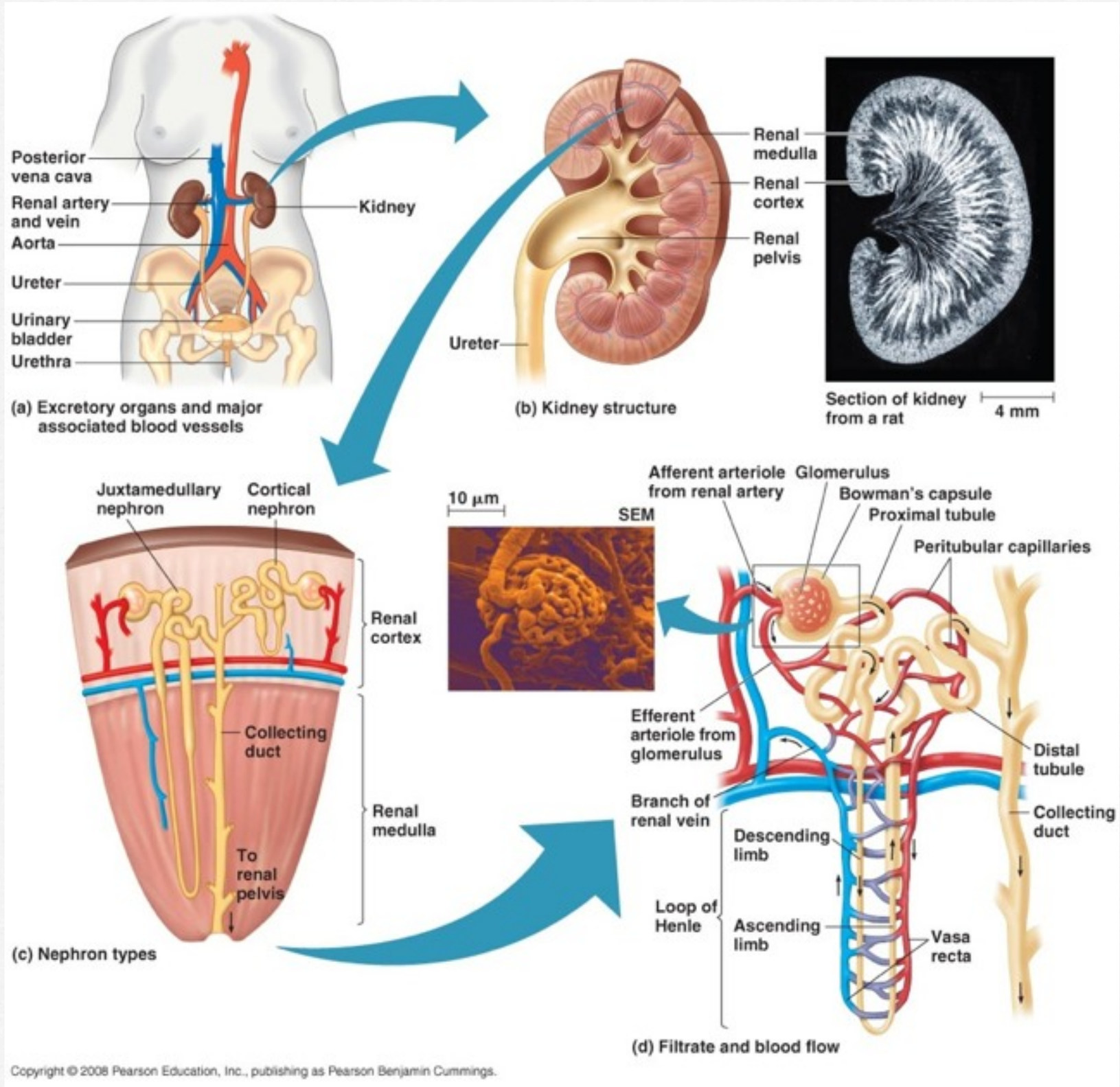
Text

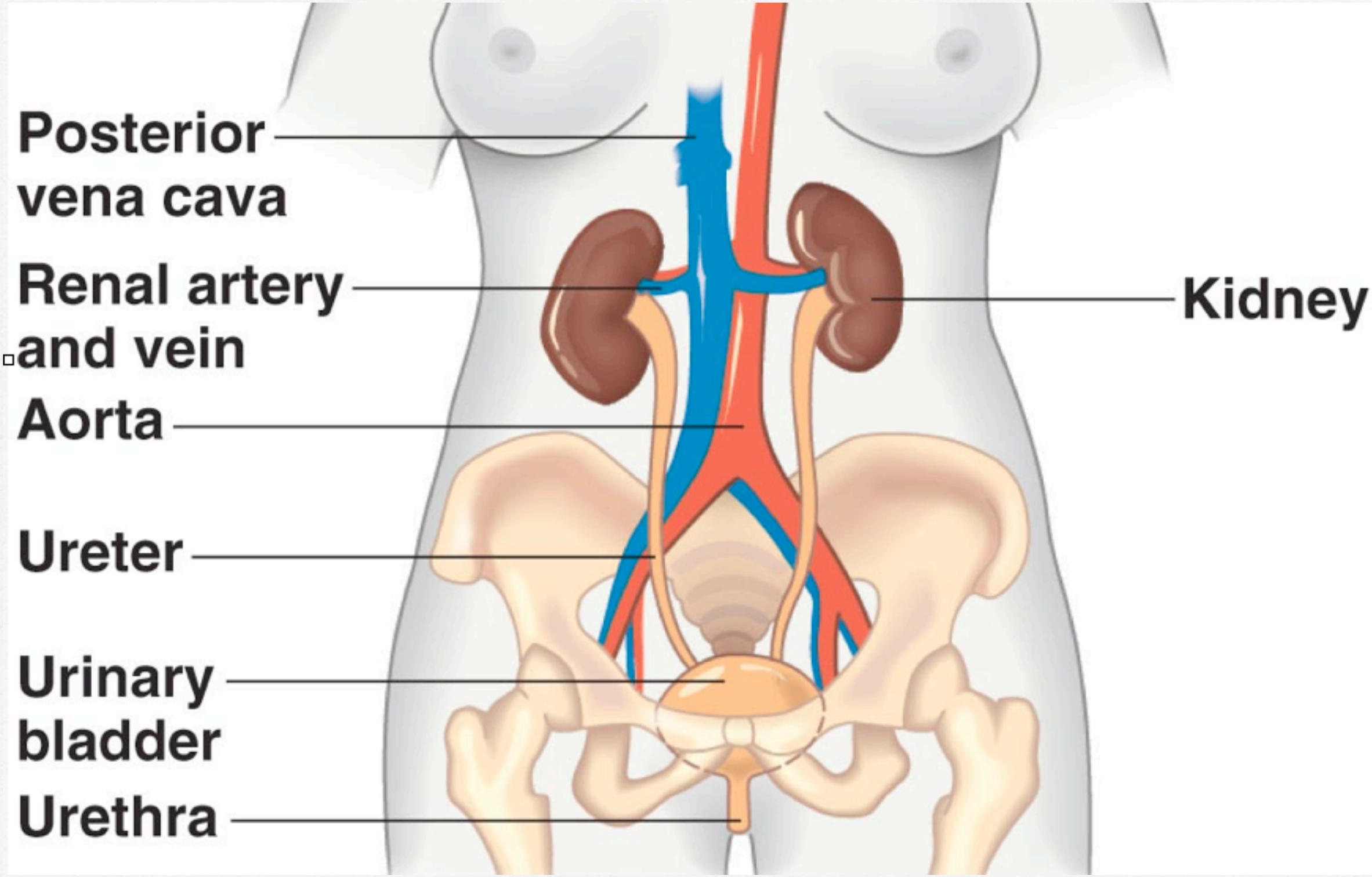
Good Solutes and Water

body fluid that bathes cells, sorta like blood and extracellular fluid combo

Mammalian Excretory System

- **Serve to regulate water and eliminate waste!**
- Nitrogenous waste is soluble and leaves in the urine
- Mammalian kidneys have the ability to produce dilute or concentrated urine depending the environmental circumstances




Posterior vena cava
Renal artery and vein
Aorta
Ureter
Urinary bladder
Urethra
Kidney

Mammalian kidneys filter blood

↓

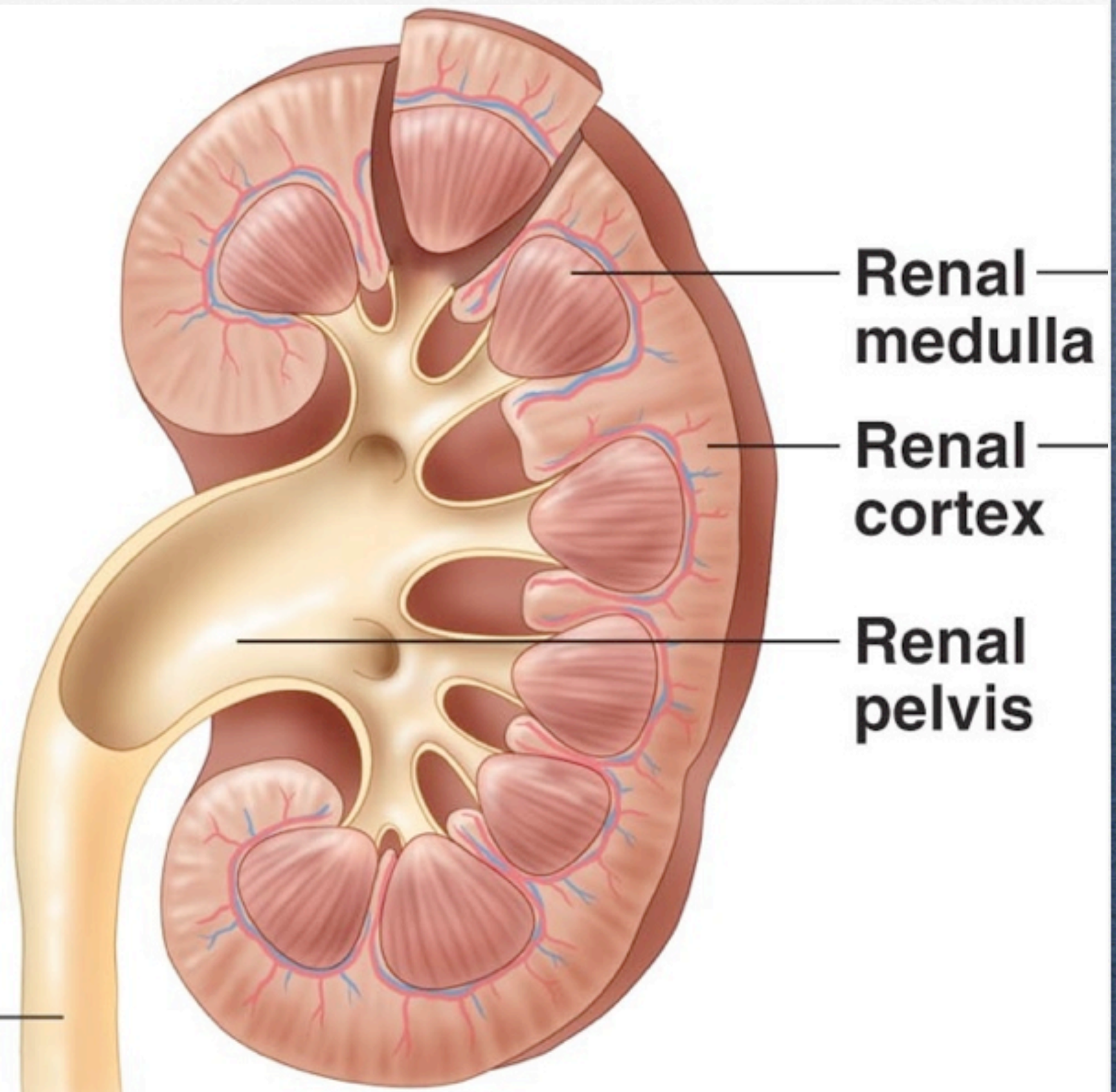
"Good stuff" is put back into blood

↓

"Bad stuff" stays and leaves in urine

↓

The concentration of urine will vary with the needs of the organism



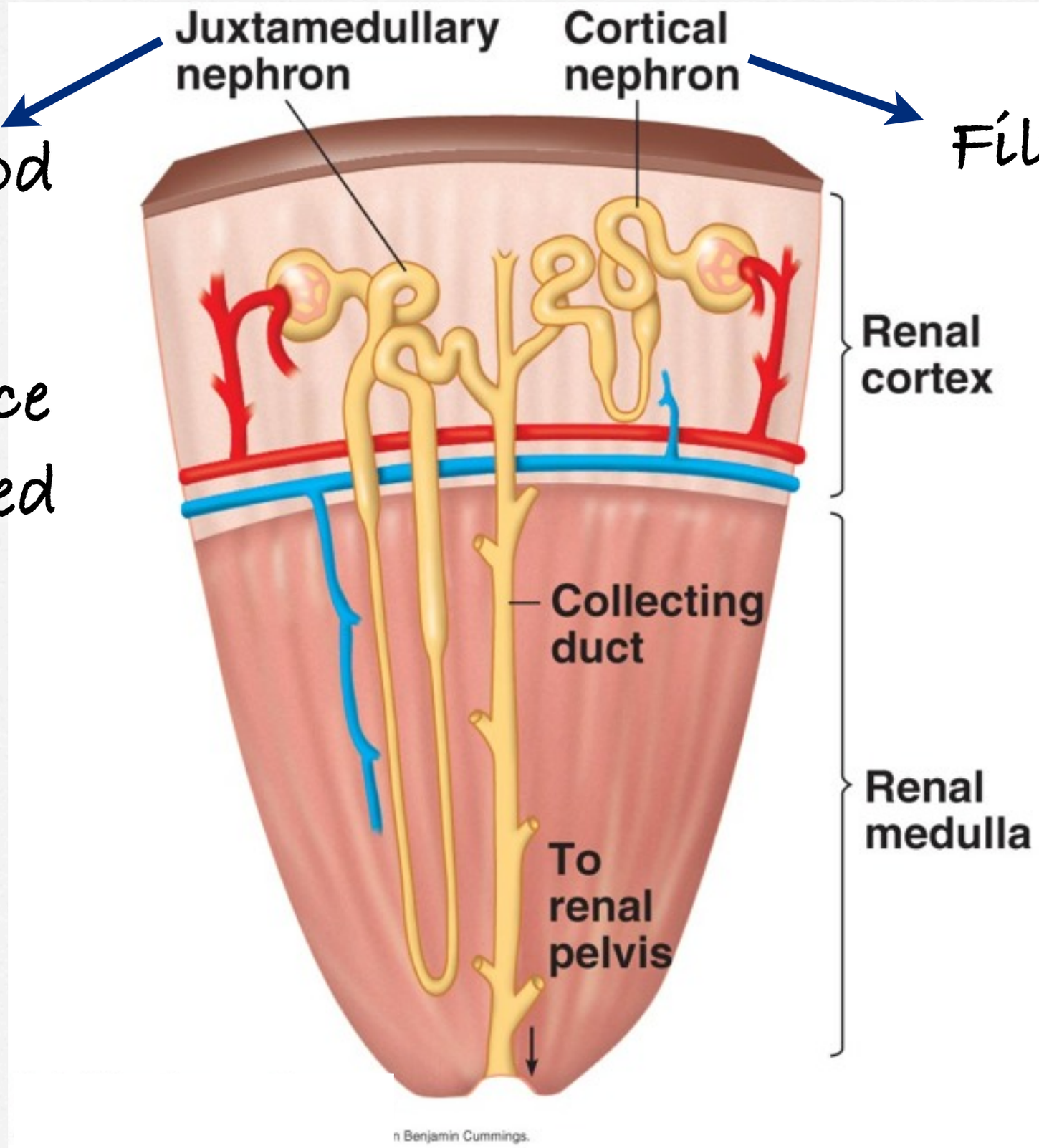
Filters Blood

and

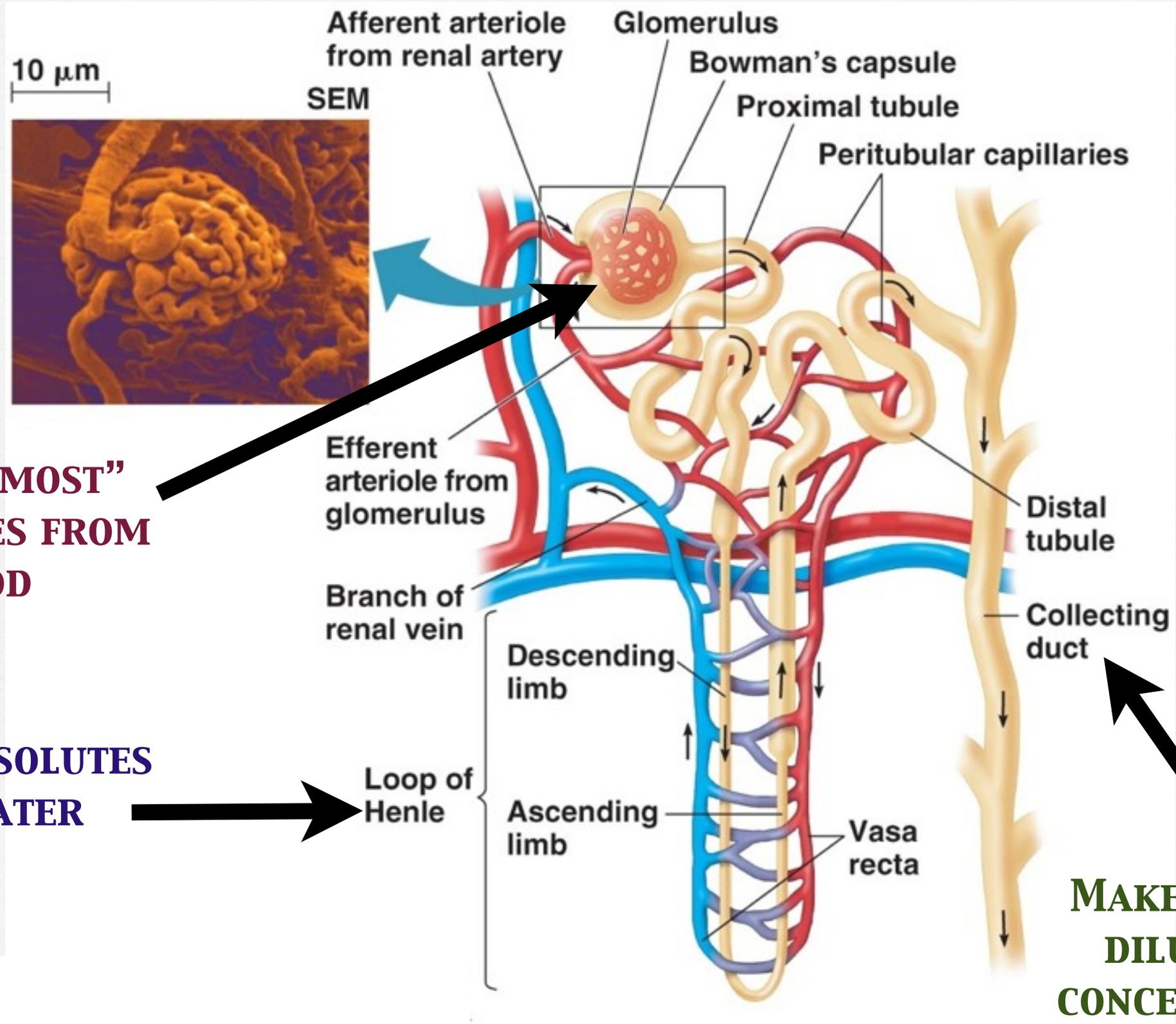
Can produce

concentrated

urine



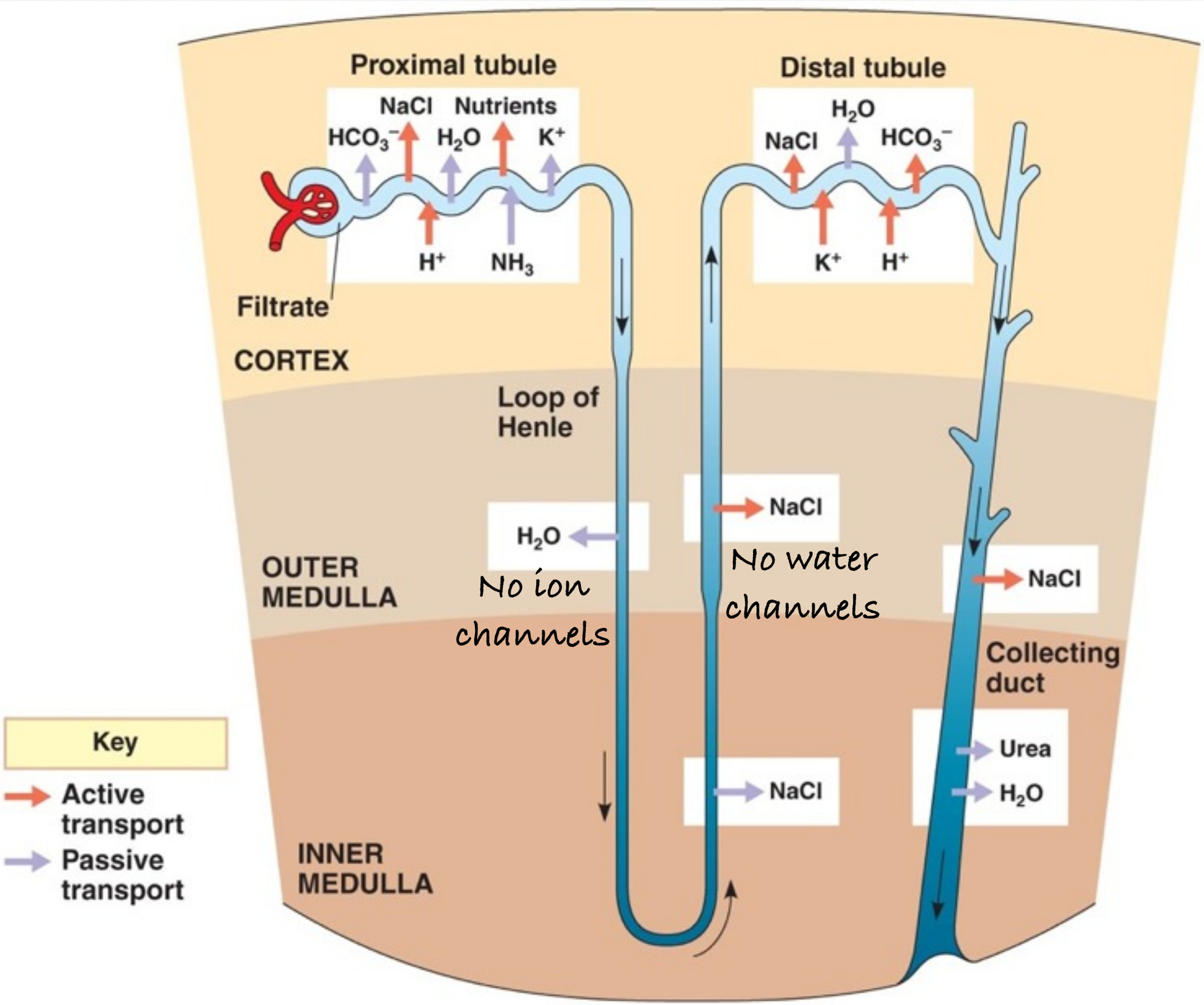
Filters Blood

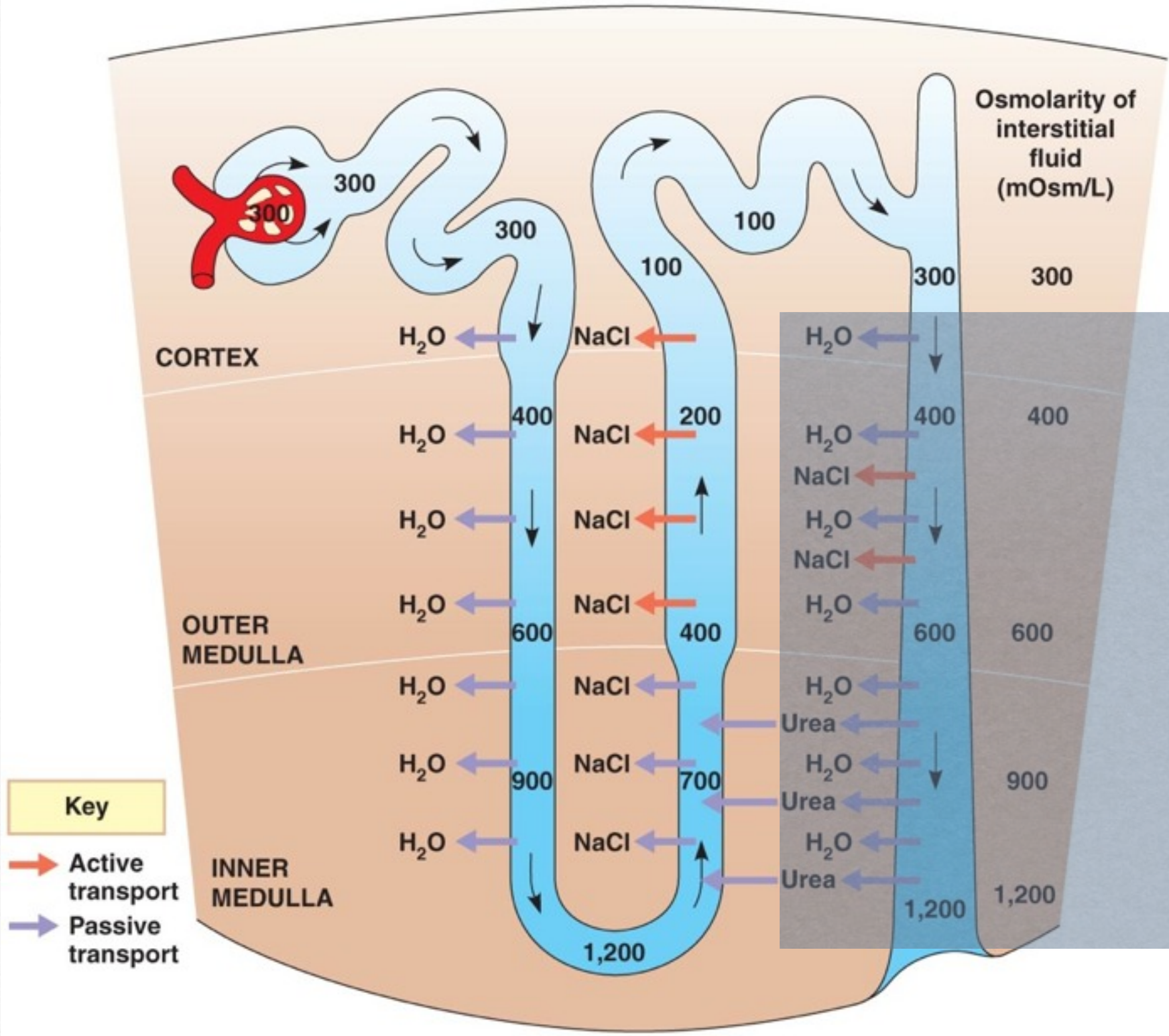


FILTERS "MOST" SUBSTANCES FROM BLOOD

RECLAIMS SOLUTES AND WATER

MAKES URINE DILUTE OR CONCENTRATED





THESE CHANNELS ARE UNDER HORMONAL CONTROL SO THAT THE BODY CAN REGULATE ITS WATER NEEDS

Adaptations of Kidneys

- Vertebrate animals occupy a wide range of habitats
  - Rain Forests to Deserts
  - Salty Lakes to Pure Mountain Streams
- Variation in kidney structure allows it to function according to the demands of the specific habitat

Mammals

- Long "loops of Henle" (juxtamedullary nephrons) allow terrestrial mammals to produce concentrated urine
- Hyperosmotic urine is key adaptation for land mammals, it conserves much water
- Aquatic mammals have much shorter nephrons, because the selective pressure for long nephrons was not as great

Birds & Reptiles

- These organisms live in very dehydrating environments
- They do not have long nephrons like mammals
- Instead they excrete their nitrogenous waste as uric acid which requires little to no water

Freshwater Fish & Amphibians

- These organisms live in a hypoosmotic environment
- They have many nephrons to produce large volumes of dilute urine
- They have to conserve salts!...by reabsorbing them in the distal tubules and leave water behind

Marine Bony Fish

- These organisms live in a hyperosmotic environment
- They gain salts and lose water to their surroundings
- They produce little urine, as a result that have few nephrons that are generally smaller

Plants

Waste Removal

Excretion of Wastes: Plants

WASTE	HOW IT IS FORMED	MECHANISM OF EXCRETION
Carbon Dioxide	cell respiration	diffusion out stomates, used in photosynthesis
Water	cell respiration, dehydration synthesis	diffusion out stomates, used in photosynthesis
Nitrogenous (none?)	removal of $-NH_2$ groups from amino acids leads to formation of NH_3	used in the metabolism of amino acids and other compounds
Inorganic Salts	general metabolism	stored in vacuoles

Waste Removal in Plants

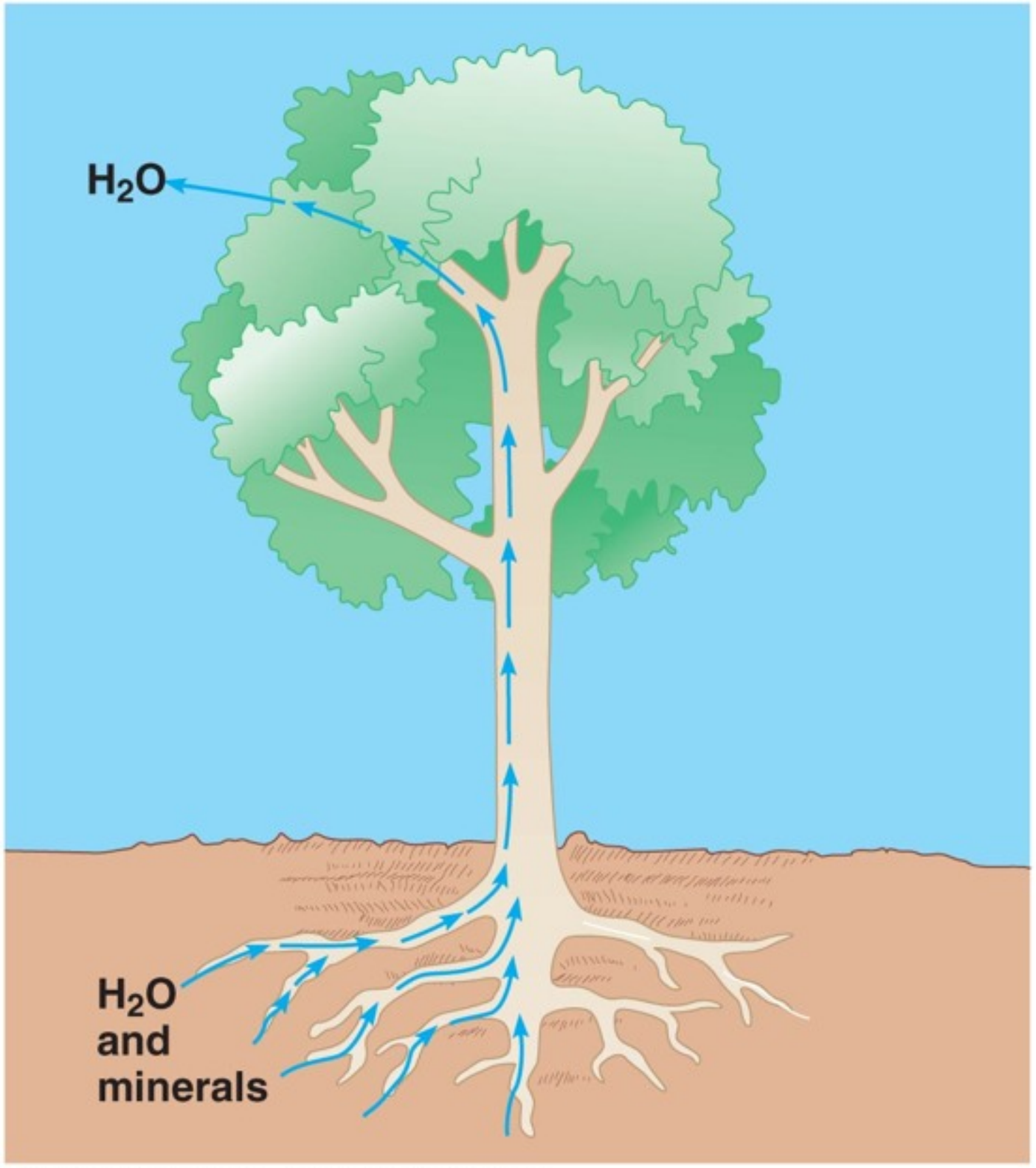
- Plants do not have excrete nitrogenous waste like other organisms because they can incorporate nitrogen compounds into amino acids
- There is some evidence to suggest that plants may move wastes into certain leaves only to be later dropped

Water Regulation

- With waste removal being less of an issue, plants focus on water regulation
- Water enters the plant from soil into the roots and most water is lost from the leaves

Plants can lose their weight in water each day!

Plants therefore have many important adaptations to obtain and conserve water.



Plants

Water & Solute Regulation

Water and Solutes

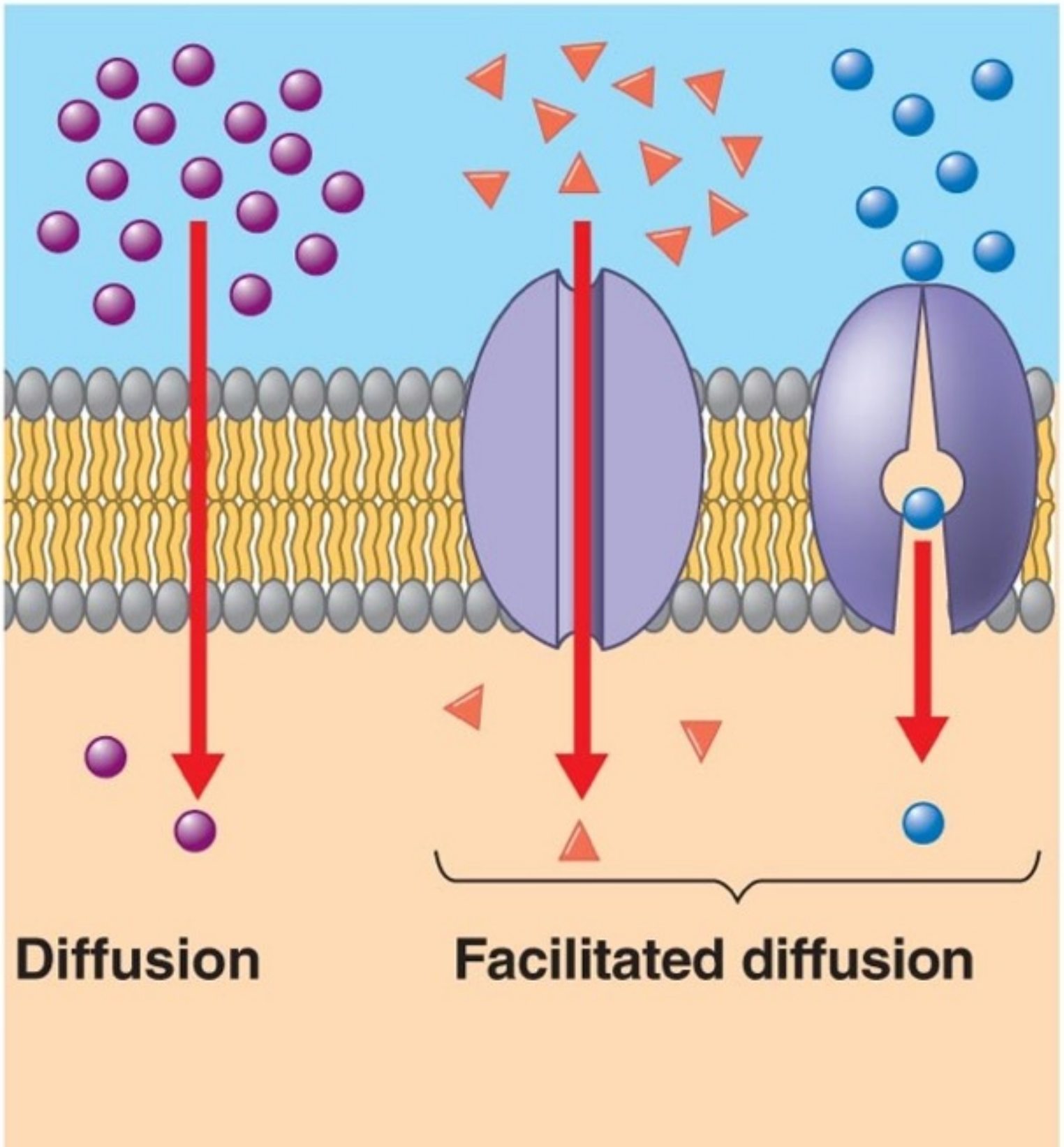
- All organisms need to balance to uptake and loss of water
- Water and solutes move together across membranes
- Thus the net effect is to balance both solutes and water at the same time
- Maintaining a fluid environment of cells and tissues requires keeping the relative concentrations of water and solutes within narrow limits

Osmoregulation

- The general term for the process by which organisms control solute concentrations and balance water loss and gain is called osmoregulation.
- A number of strategies have evolved, reflecting the varied and often severe osmoregulatory challenges presented by surroundings

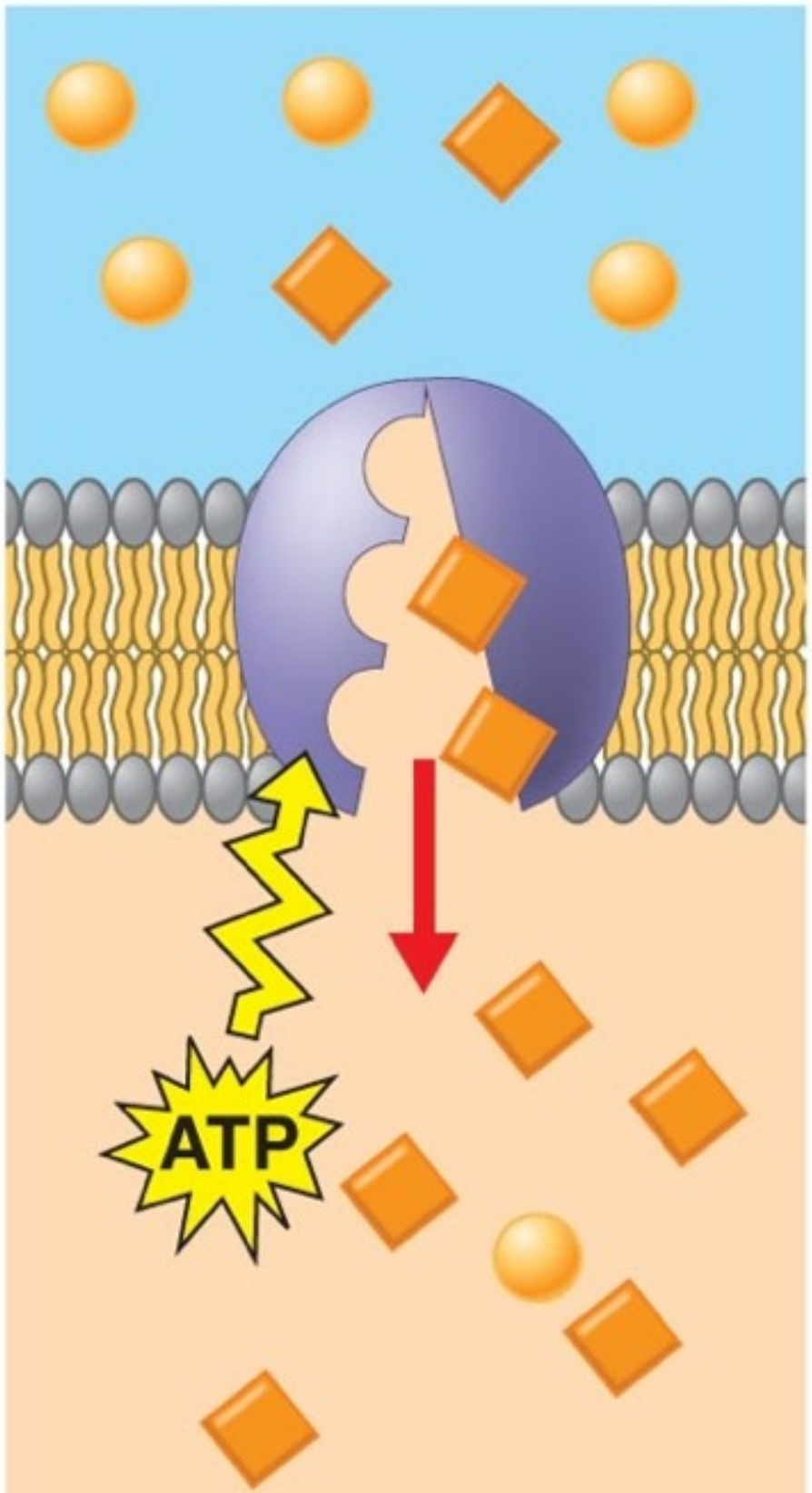
Passive transport

Review

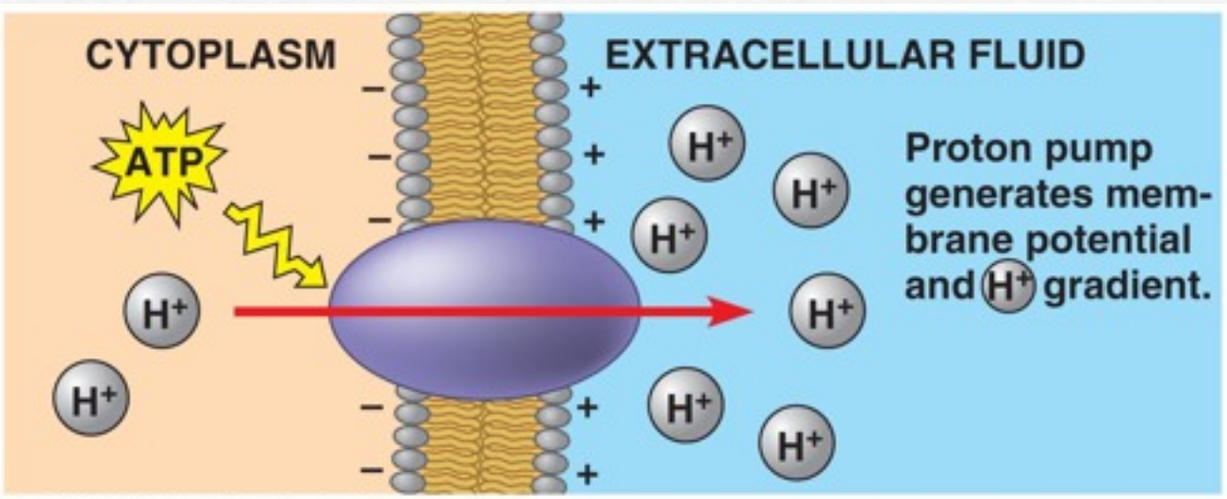


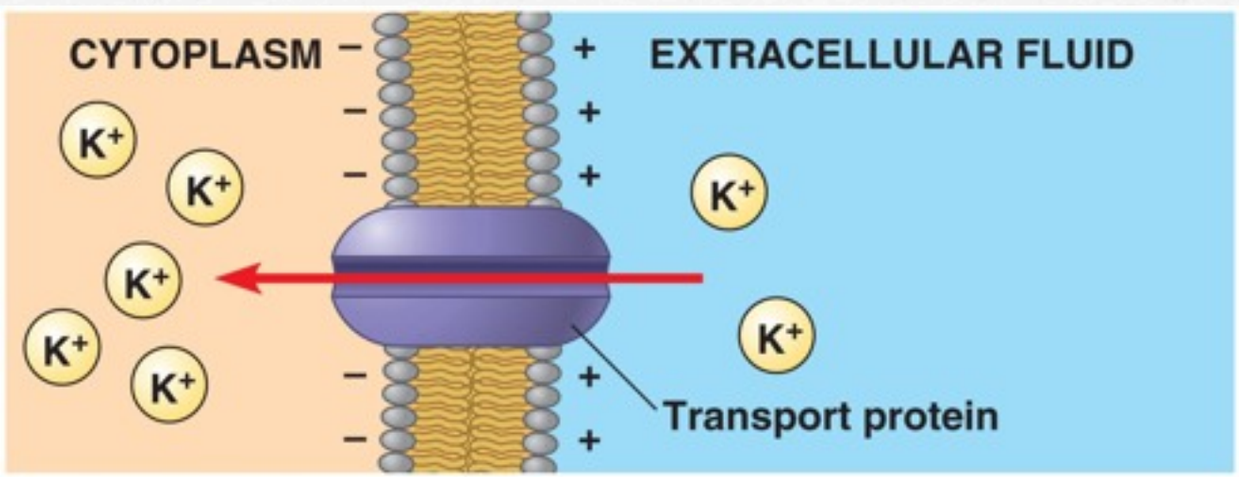
Active transport

Review

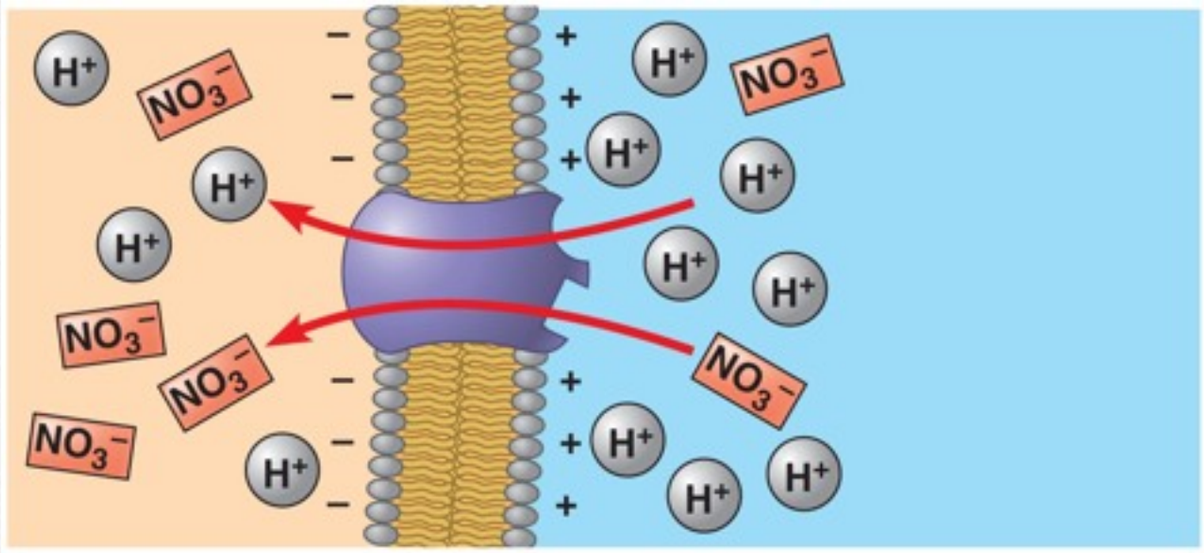


REVIEW

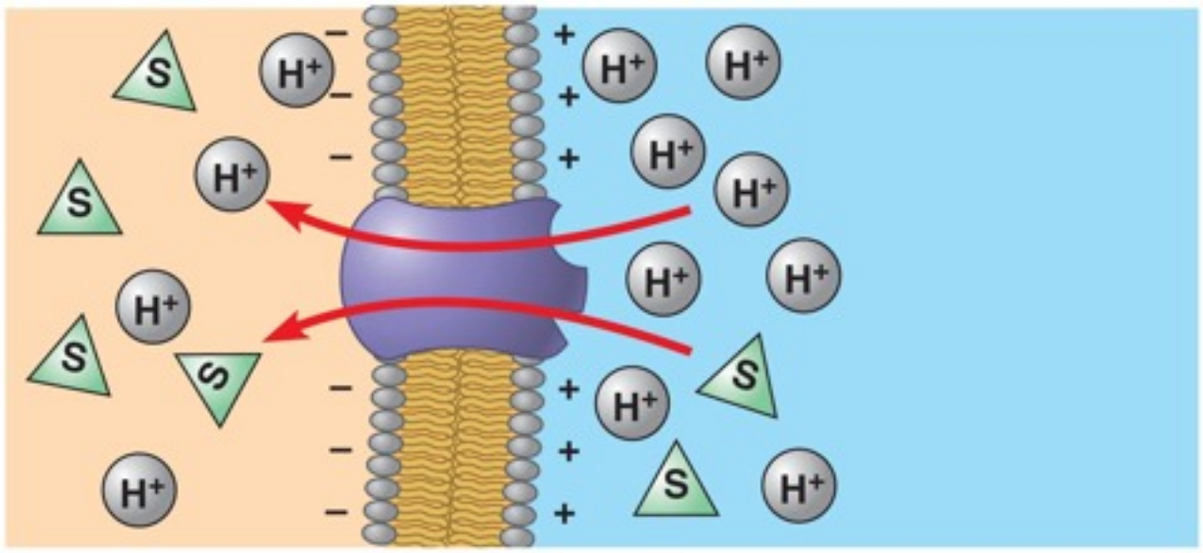




(a) Membrane potential and cation uptake



(b) Cotransport of an anion with H^+



(c) Cotransport of a neutral solute with H^+

Moving Water across Membranes

- The gain or loss of water by a cell occurs by osmosis
- The physical property that predicts the direction of water movement is called water potential
- Water potential considers both solute concentration and pressure as factors
- Water still moves from a high potential to a low potential

How Solutes and Pressure Effect Water Potential

$$\Psi = \Psi_p + \Psi_s$$

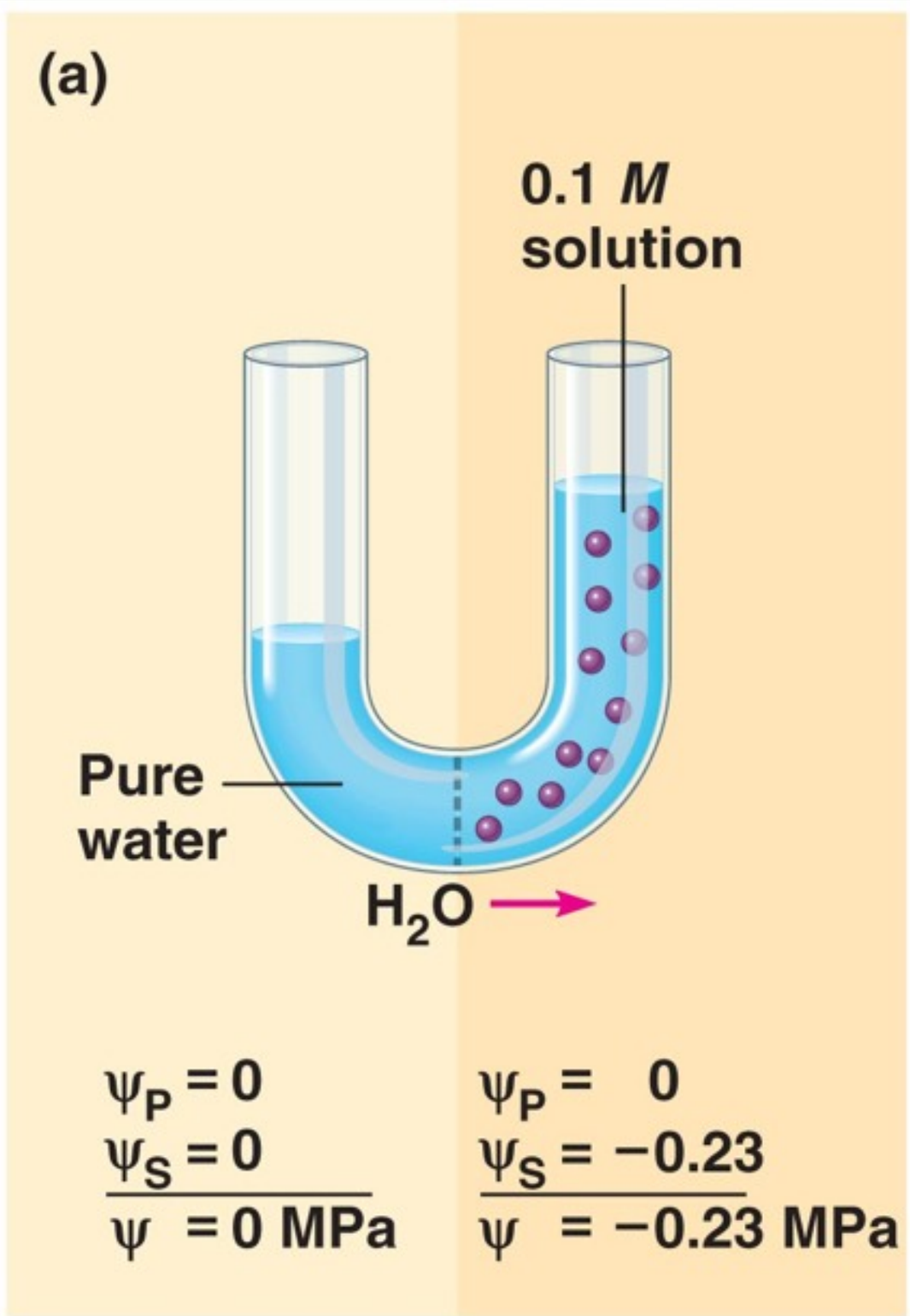
Water Potential — Pressure Potential — Solute Potential

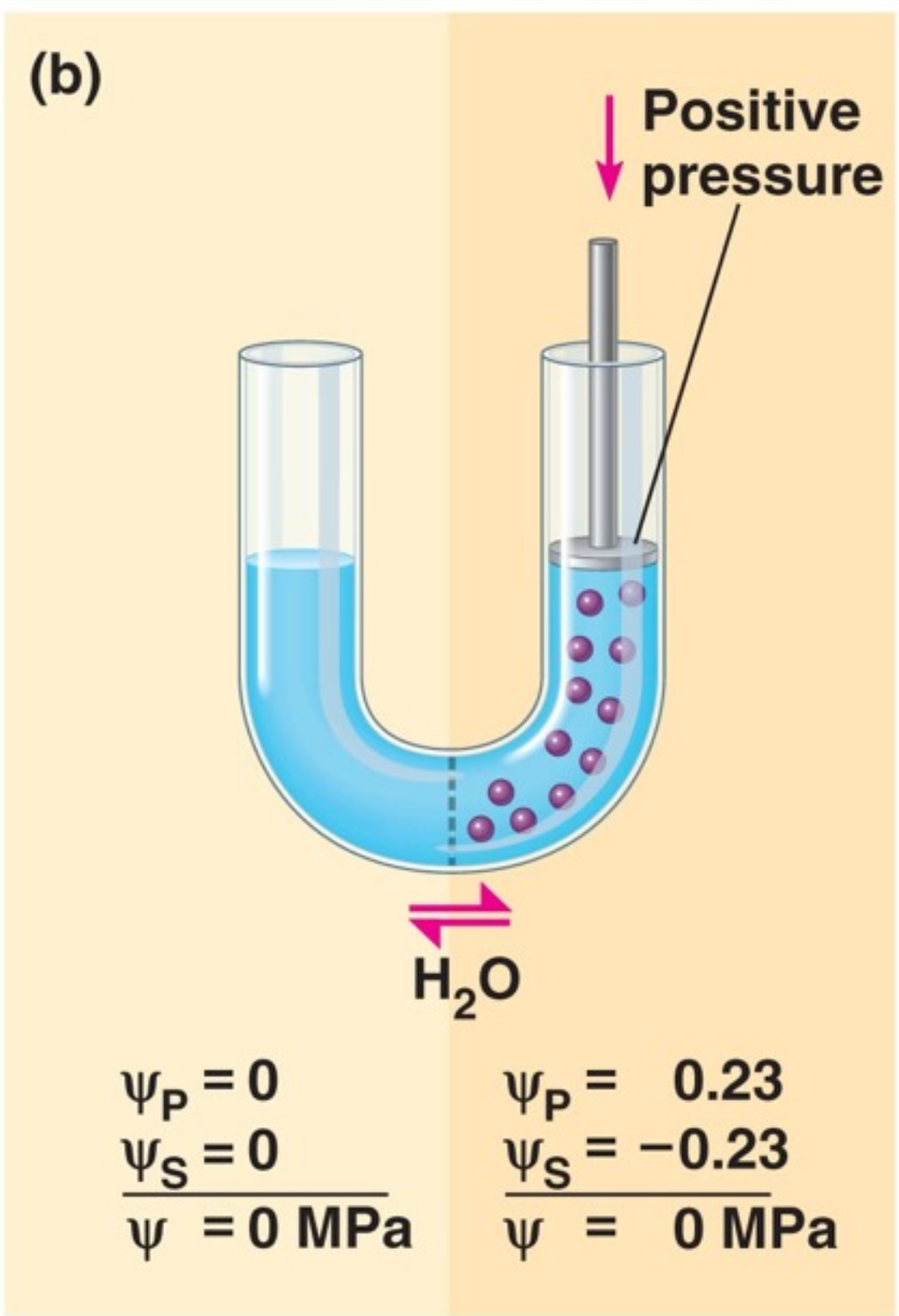
water in an open container at sea level under standard temp has by definition a pressure potential of ZERO

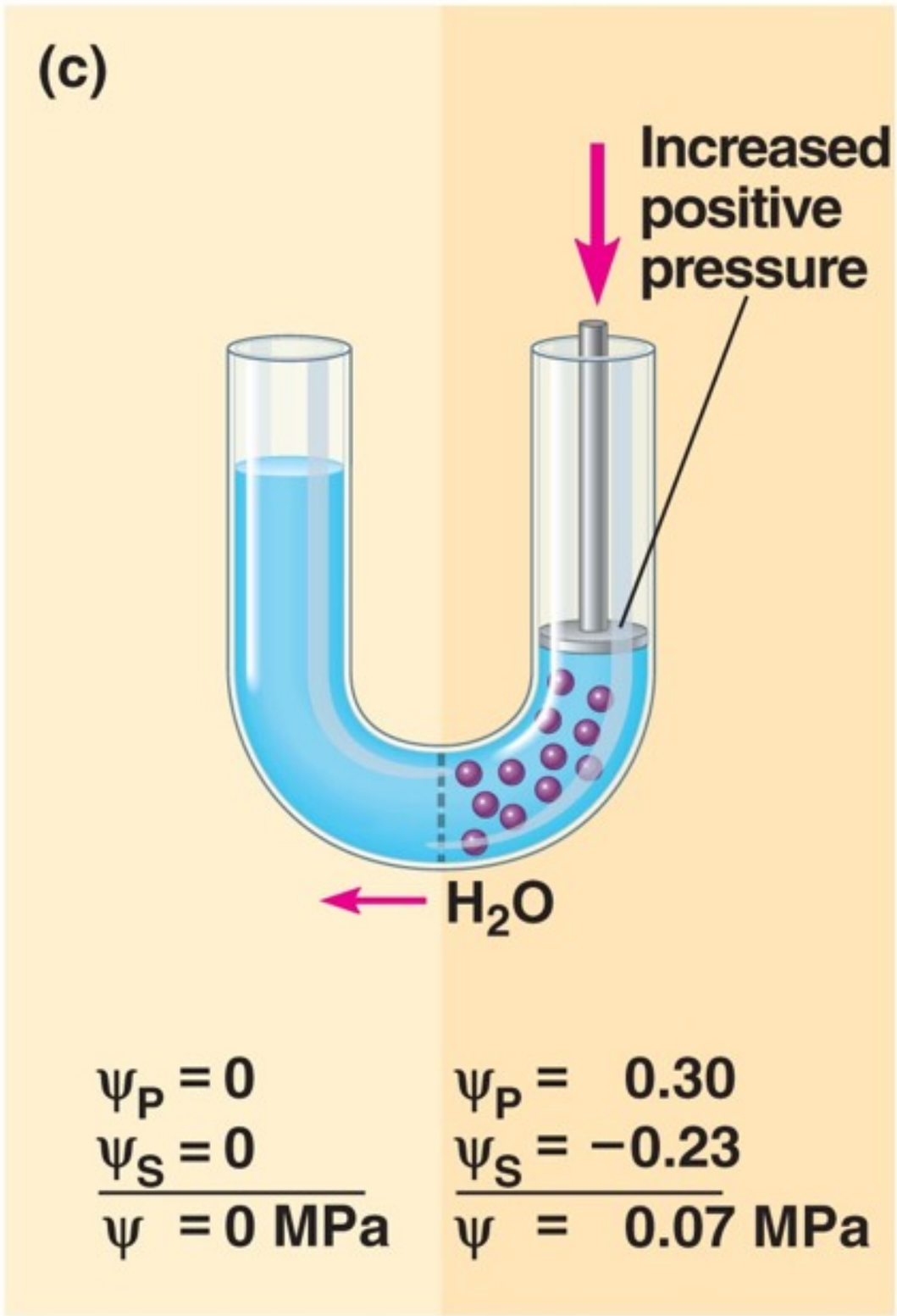
pure water has by definition a solute potential of ZERO

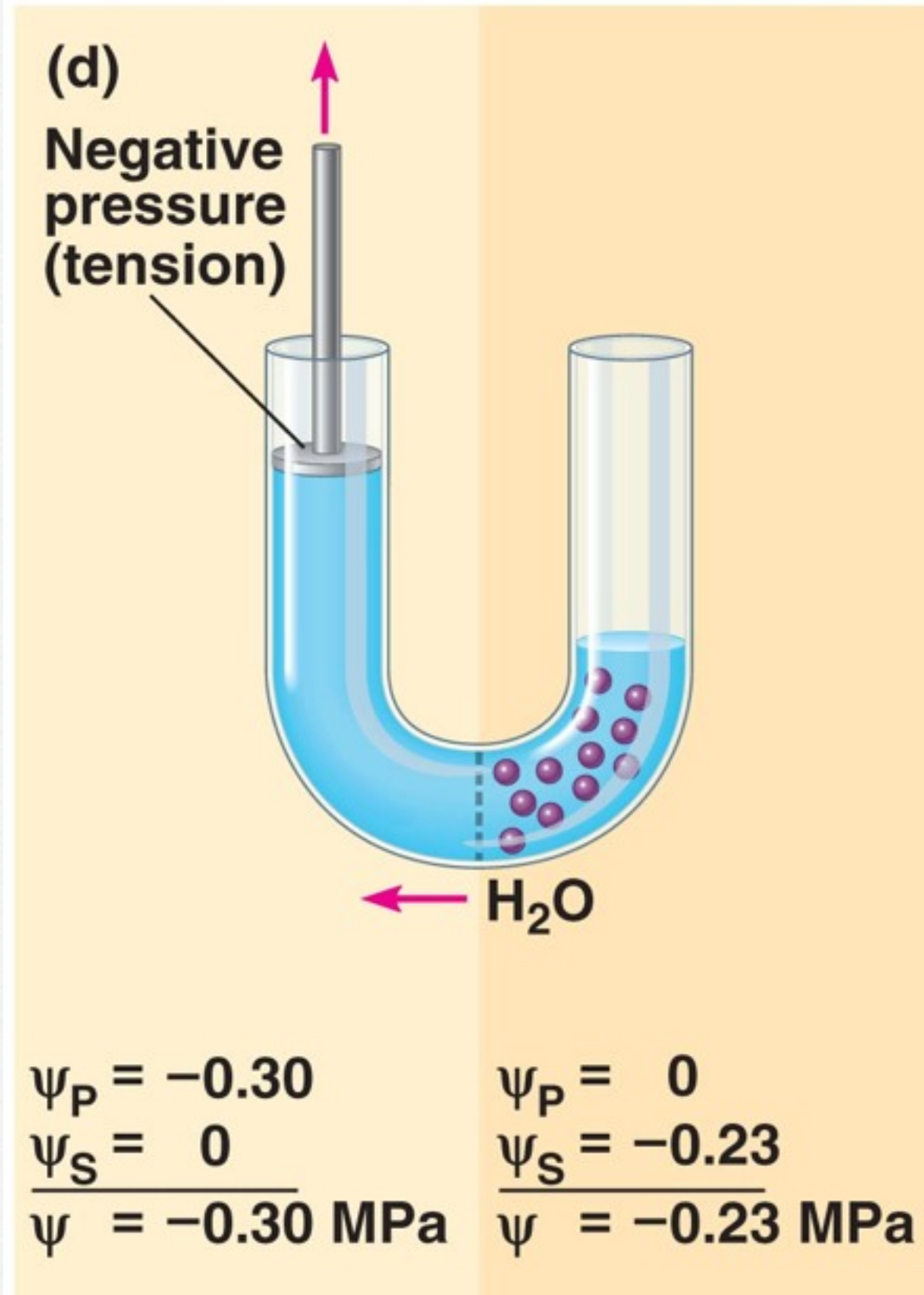
adding solutes makes the solute potential more negative

ADDING SOLUTES = LESS FREE WATER = LESS POTENTIAL TO DO WORK!

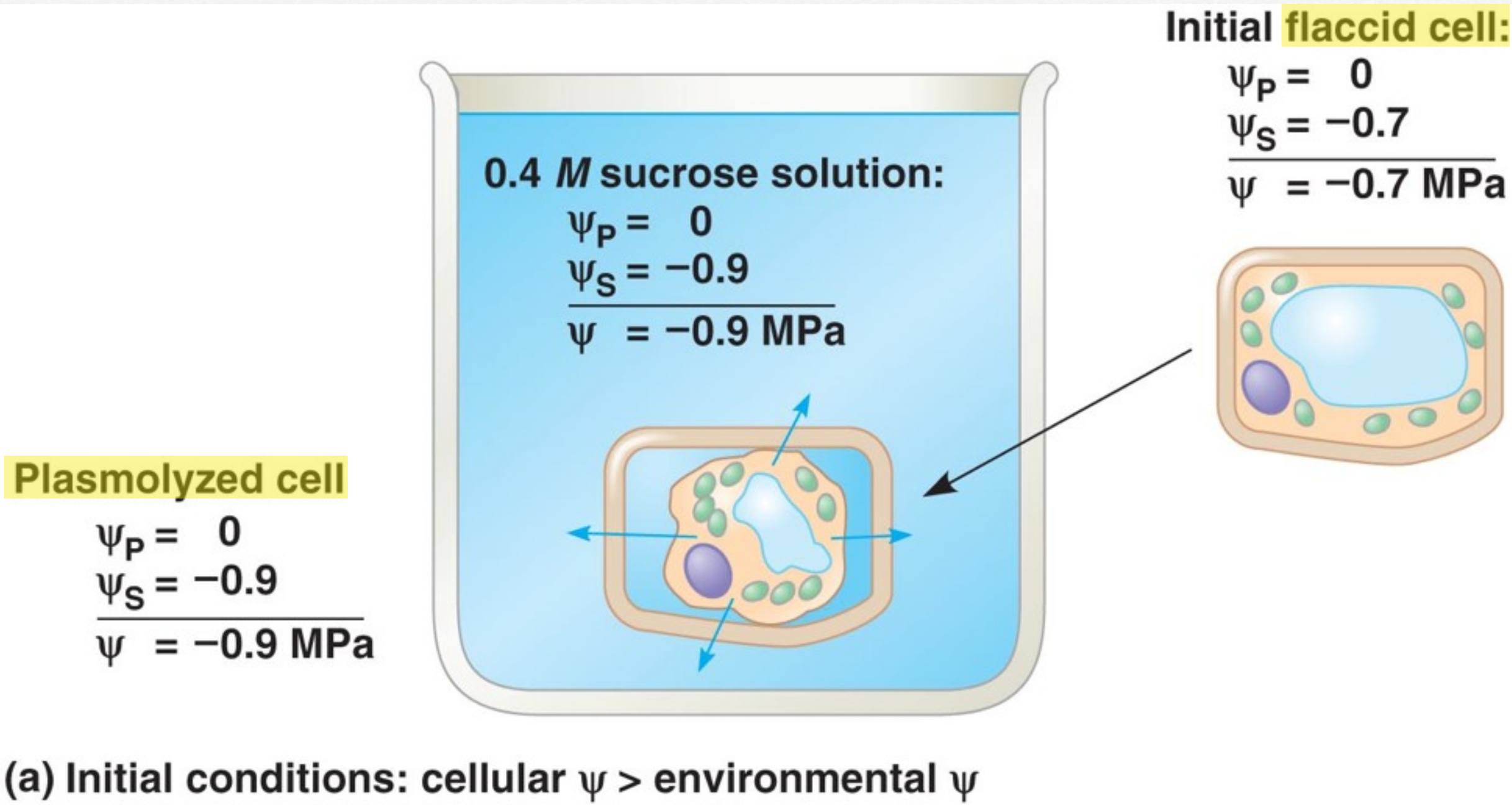






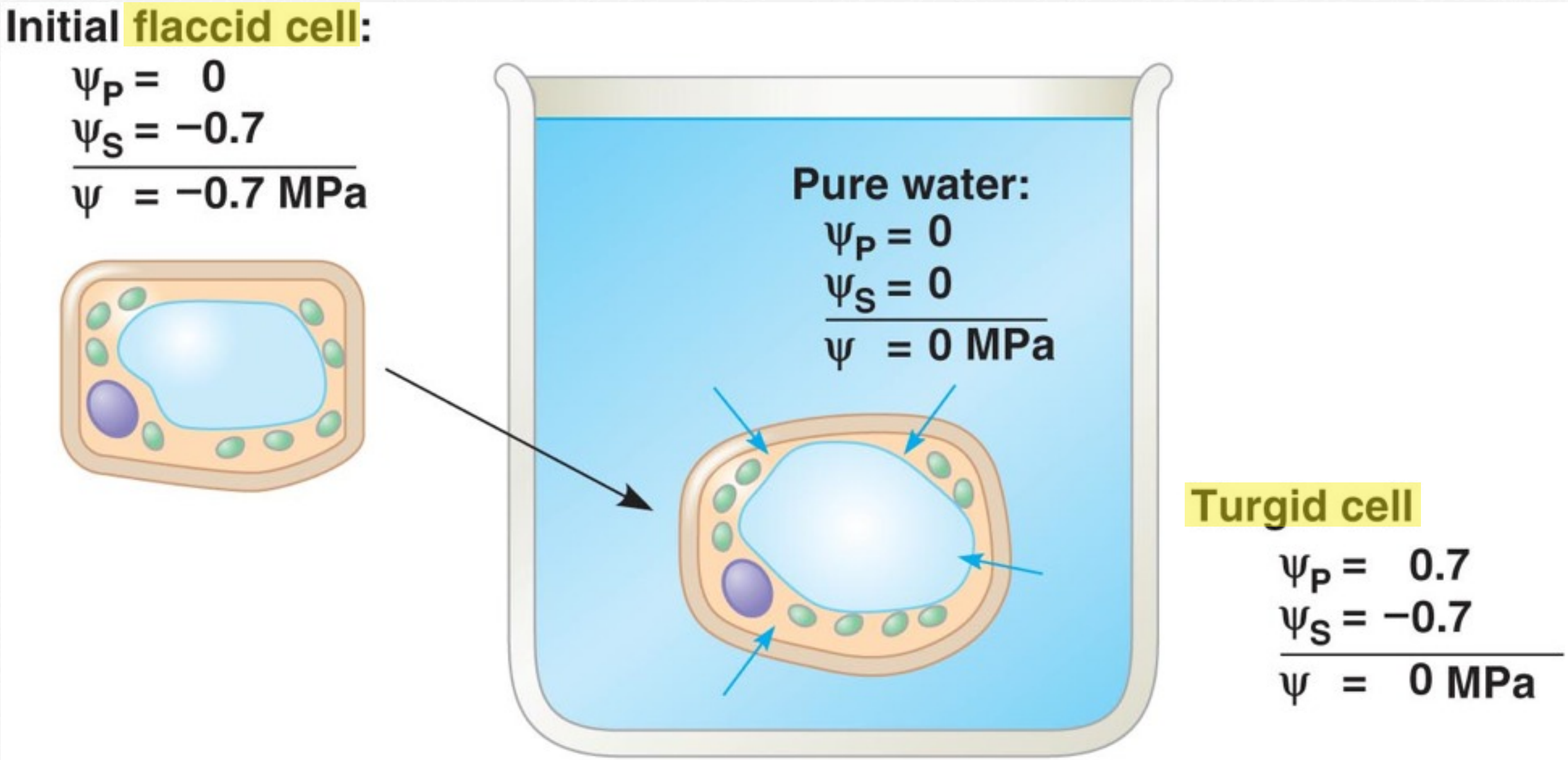


Moving Water across Plant Membranes

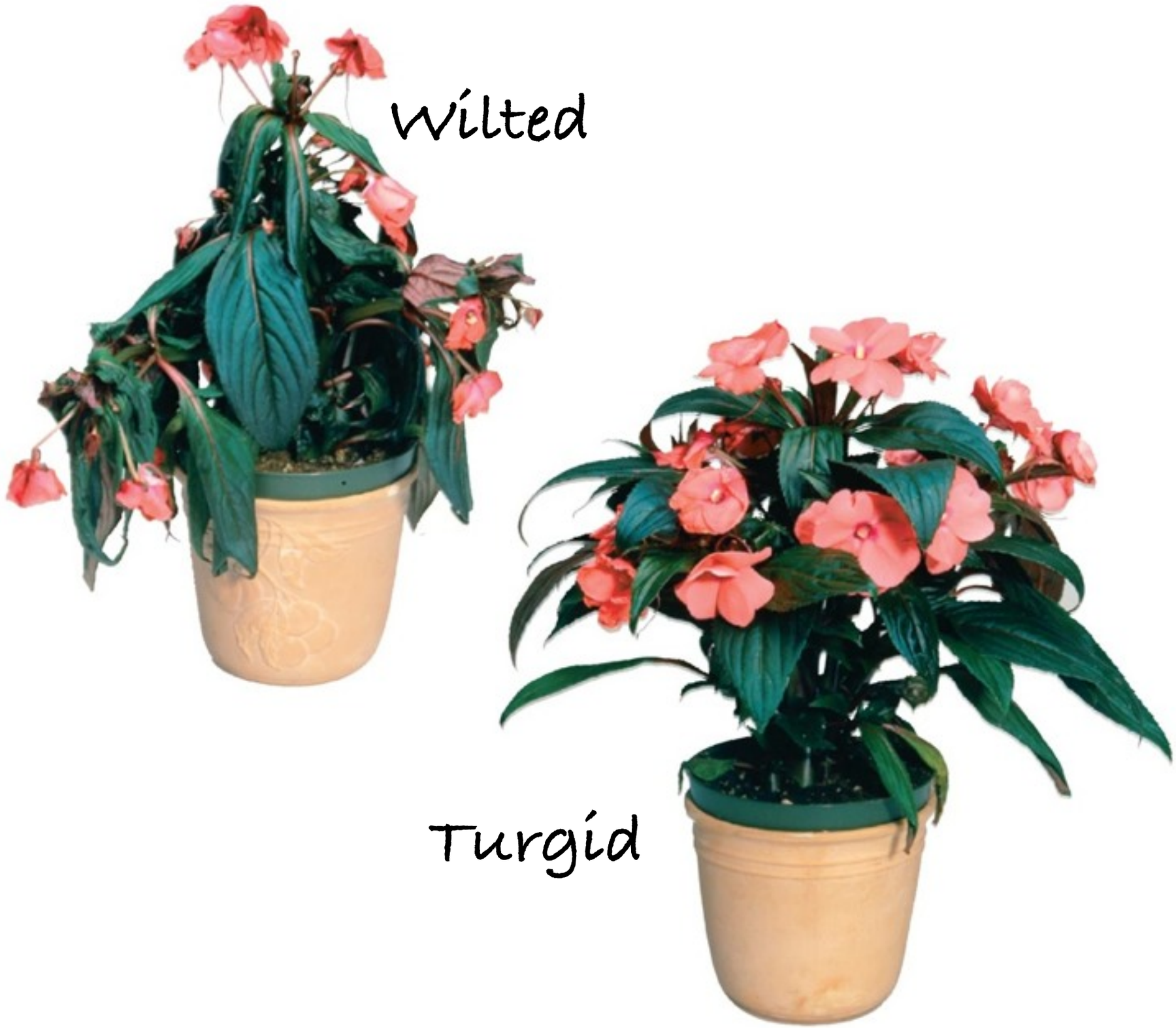


(a) Initial conditions: cellular ψ > environmental ψ

Moving Water across Plant Membranes



(b) Initial conditions: cellular ψ < environmental ψ



Moving Water across Plant Membranes

- Aquaporins are transport proteins that water molecules across membranes
- Water is small enough to diffuse on its own so aquaporins function to increase the RATE at which water moves

Moving Water Through the Plant Body: Long Distance

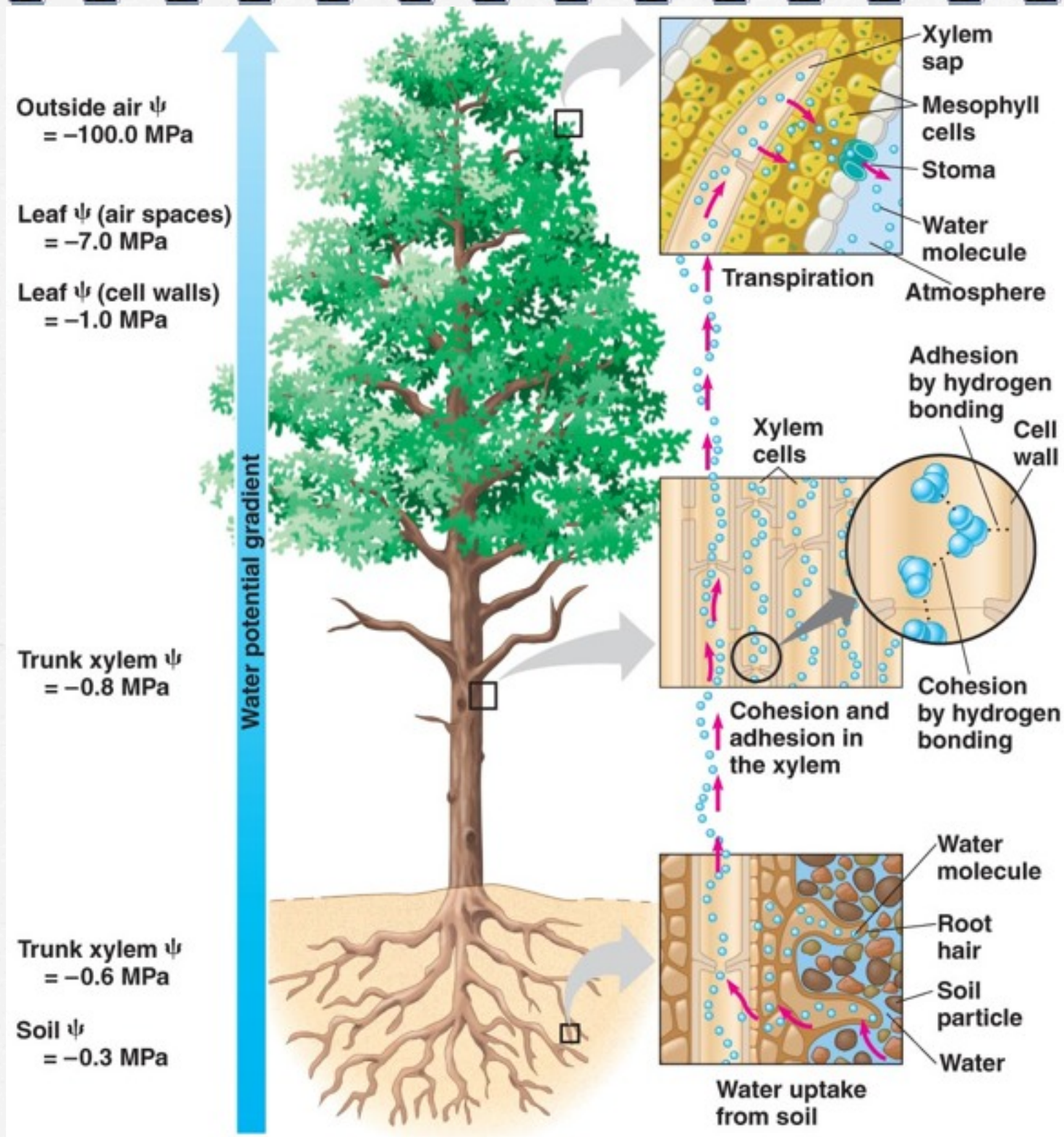
- Diffusion would be far too slow to move water long distances.
- BULK FLOW uses pressure gradients to move water over long distances
- using bulk flow, water moves from higher pressures to lower pressures
- Bulk flow is independent of solute concentration

Low pressure

Tension

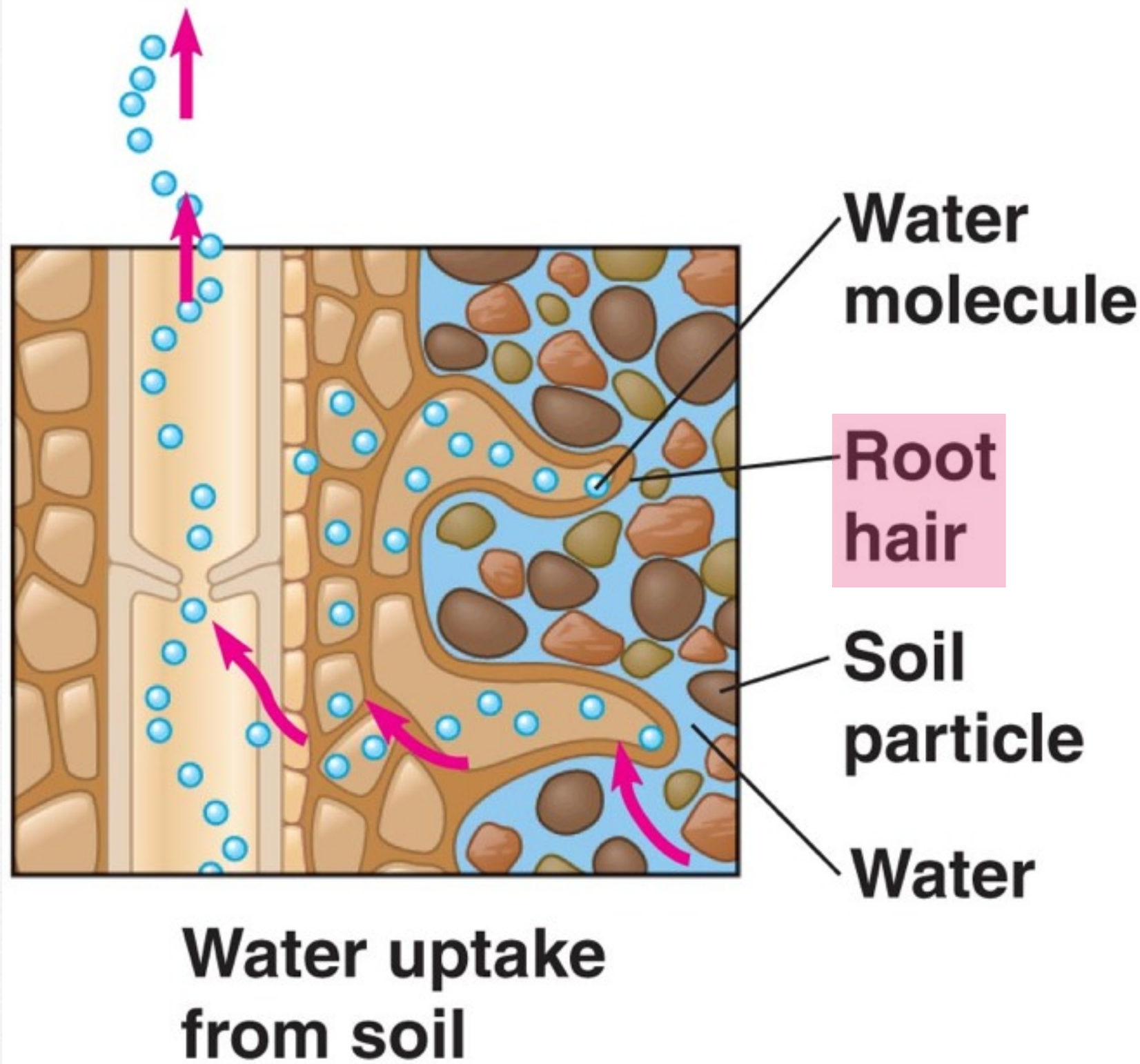
Water is pulled up

High pressure



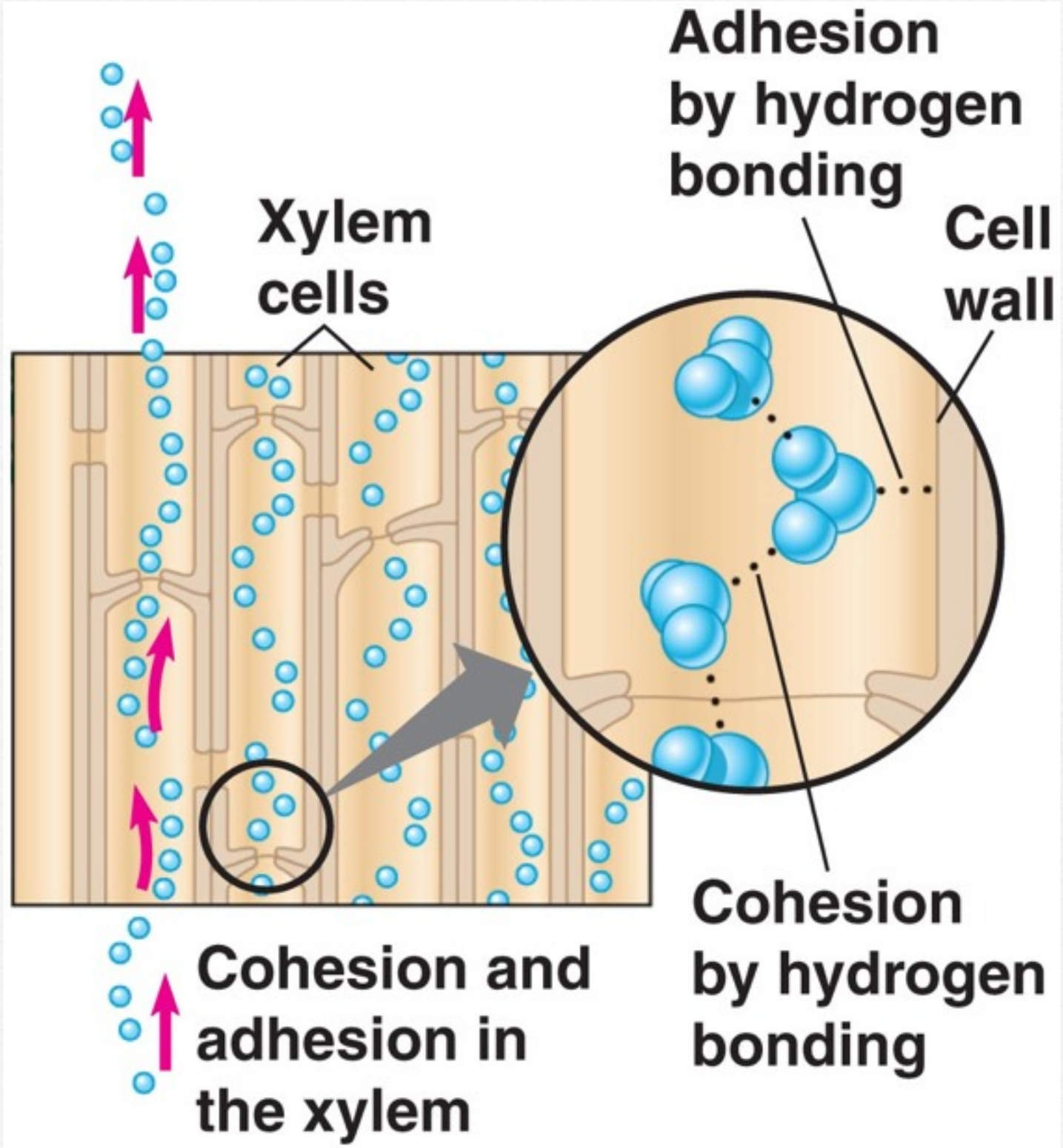
Absorption of water and minerals takes place at the tips of the roots, ROOT HAIRS (increase surface area)

Also aided by mycorrhizae

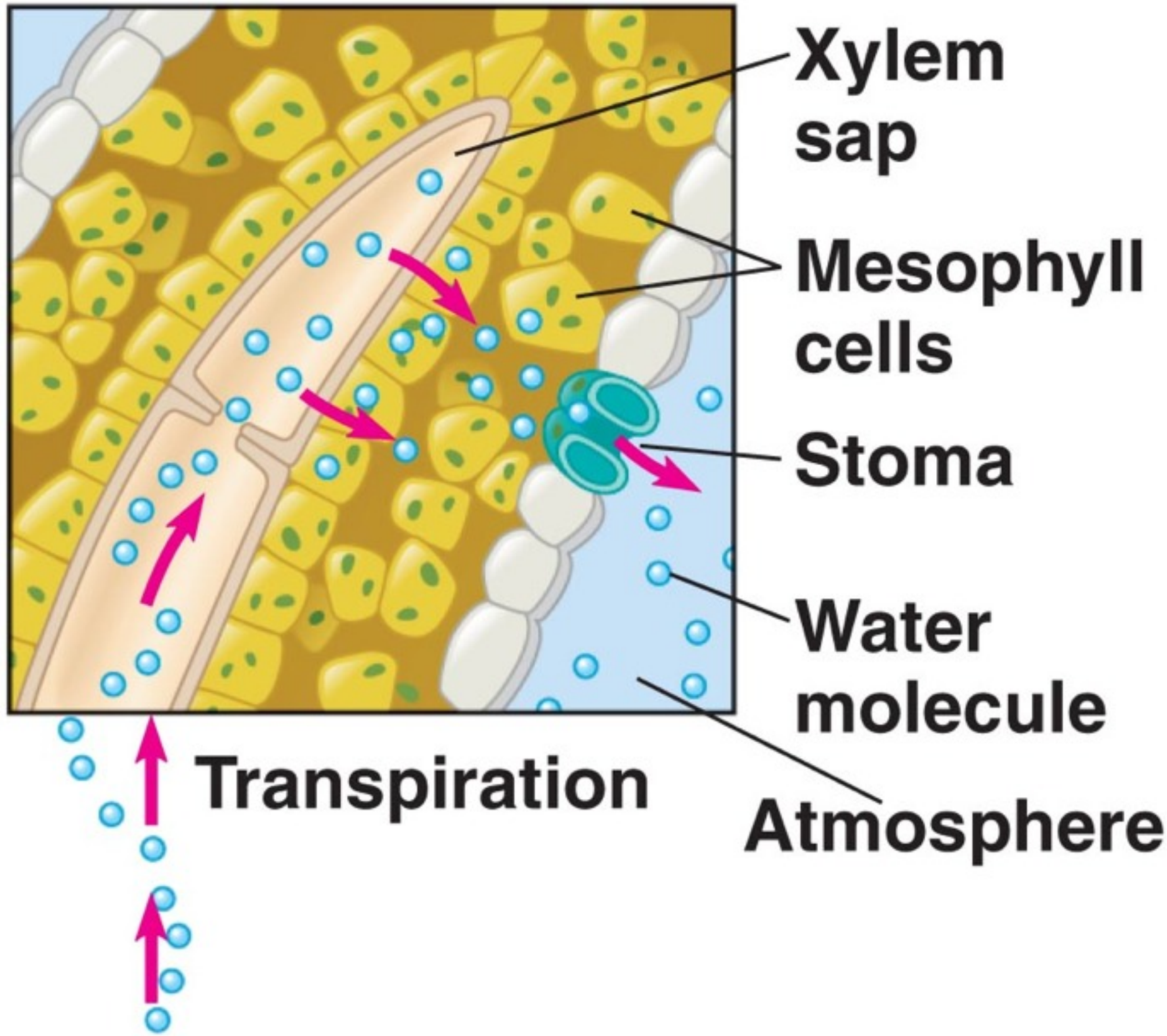


Water uptake from soil

Xylem cells are dead, hollow cells through which water (no sugars) is transported upward through the plant with no energy input

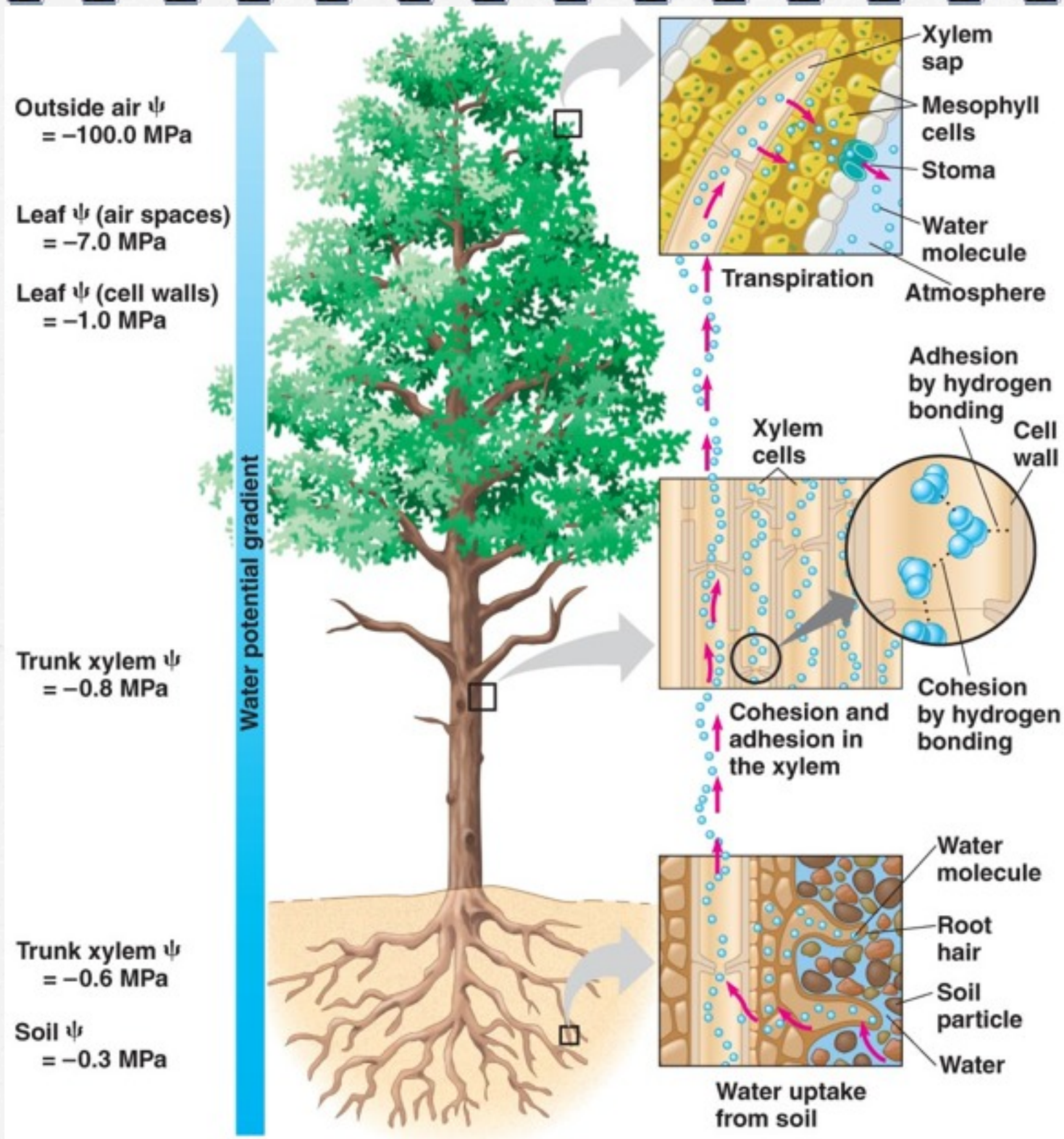


LEAF CROSS SECTION



Stoma are pores in the leaf that allow gas exchange, in this case water vapor

Transpiration will be greatest during bright, hot, dry and windy days. These conditions increase the rate of evaporation and subsequent transpiration. Assuming of course the soil has water.



Adaptations to Prevent Water Loss

No leaves or very small leaves

Ocotillo (leafless)

Ocotillo leaves

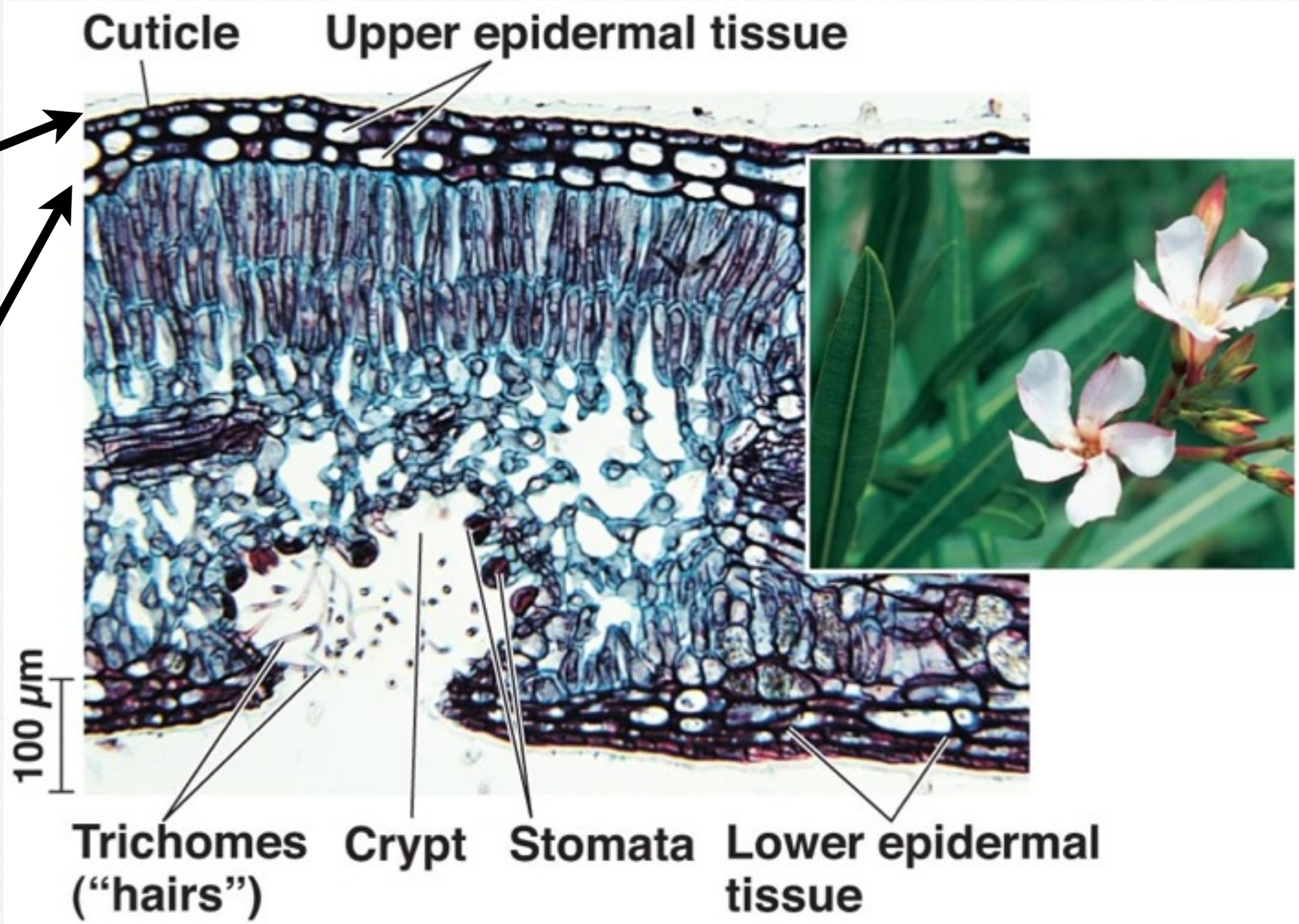
Ocotillo after heavy rain

Hair like bristles help reflect sun

Old man cactus

Thick waxy cuticle

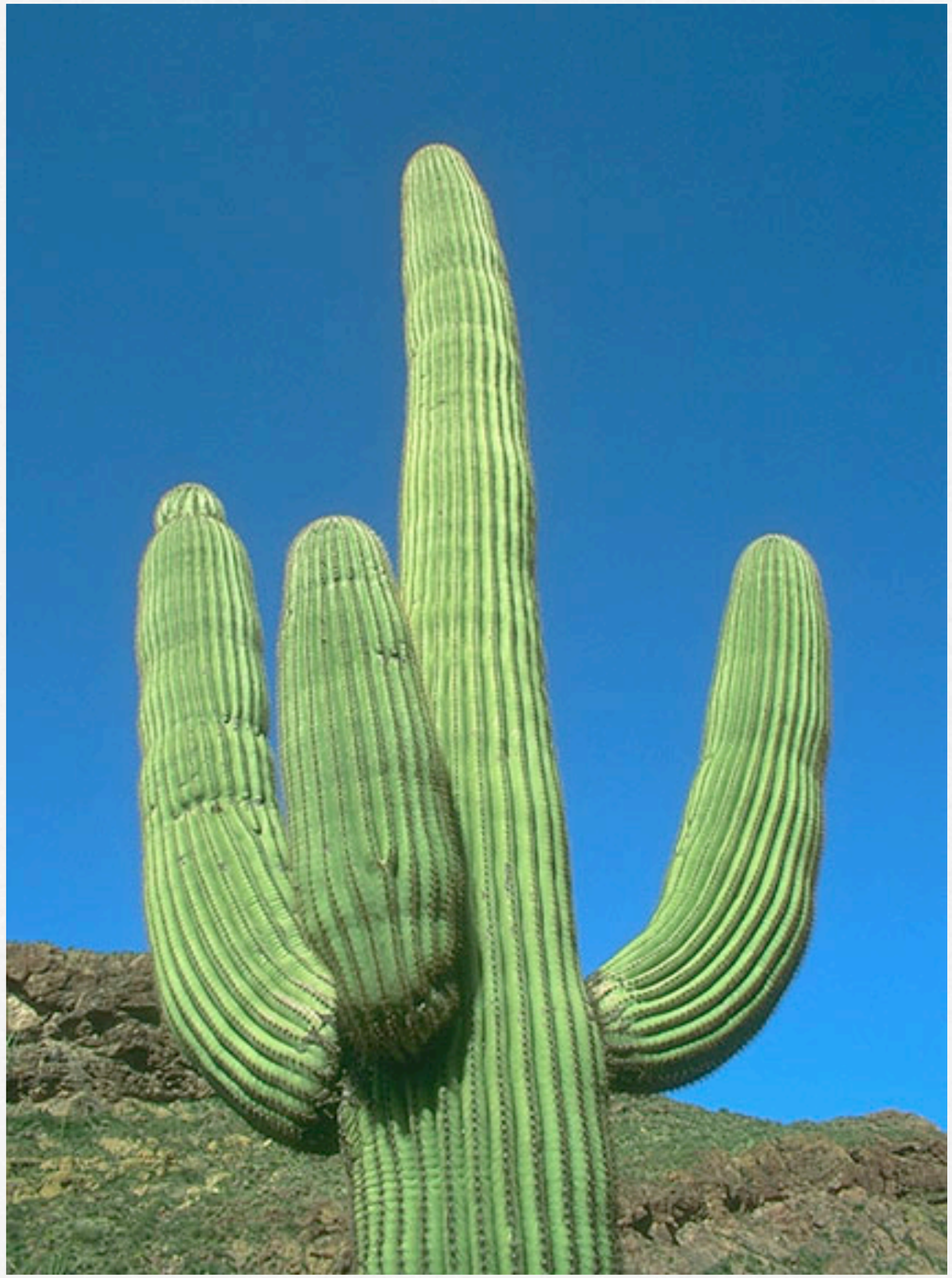
Multiple layers of epidermal tissue



Oleander leaf cross section and flowers

"Green" Stems carry out photosynthesis

"Fleshy" stems store water



Close stomates in the day

Deep Roots that extend into the water table

Responses to Environmental Stress

- Plants have also adapted to environmental stresses
  - Too little water over a long time-DROUGHT
  - Too much water over a long time-FLOODING
  - Too much salts in the soil

Drought

- 1. WILT-roll leaves to reduce transpiration (lower surface area)
- 2. SHED-drop leaves to reduce transpiration
- 3. REDUCE PHOTOSYNTHESIS-so that stomates might remain closed
- 4. INHIBIT ROOT GROWTH-stop growing shallow roots where soil is likely dry

Flooding

- Water logged soils can suffocate cells of the roots
- Note plant cells need oxygen for cell respiration!
- AERIAL ROOTS- grow upward and absorb oxygen from air above water line

Aerial Roots

A Tumibo Beach Scene - Jan. 2011

Photo: David de la Hyde

Salt Stress

- Excessive salts are particularly threatening for two reasons
- 1. salts lower the water potential and cause a water deficit even when water is abundant
- 2. salts and other ions are toxic to plants in high concentrations
- Most plants cannot survive salt stress for long

Salt Stress

- Halophytes are plants that can however tolerate salty soils.
- they have salt glands that actively pump salt out across the leaf surface.

Fungi

Water & Solute Regulation

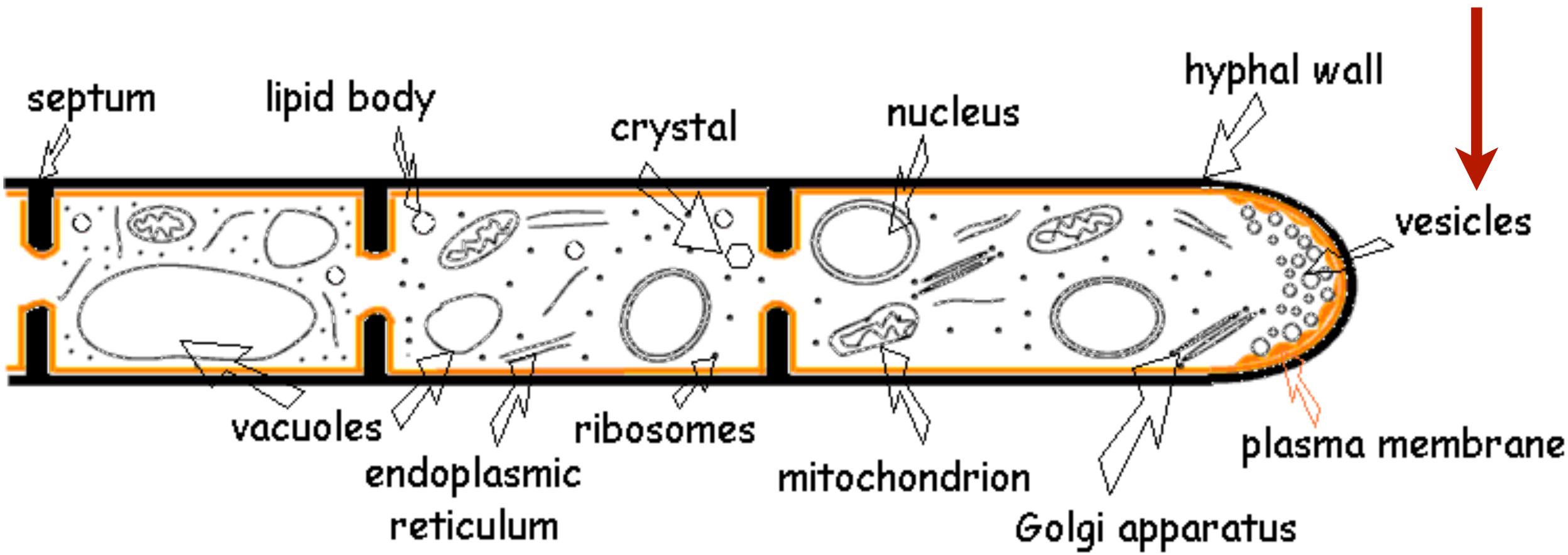
Excretion of Wastes: Fungi

WASTE	HOW IT IS FORMED	MECHANISM OF EXCRETION
Carbon Dioxide	cell respiration	diffusion
Water	cell respiration, dehydration synthesis	osmosis
Nitrogenous (ammonia)	removal of $-NH_2$ groups from amino acids leads to formation of NH_3	diffusion
Inorganic Salts	general metabolism	diffusion, active transport

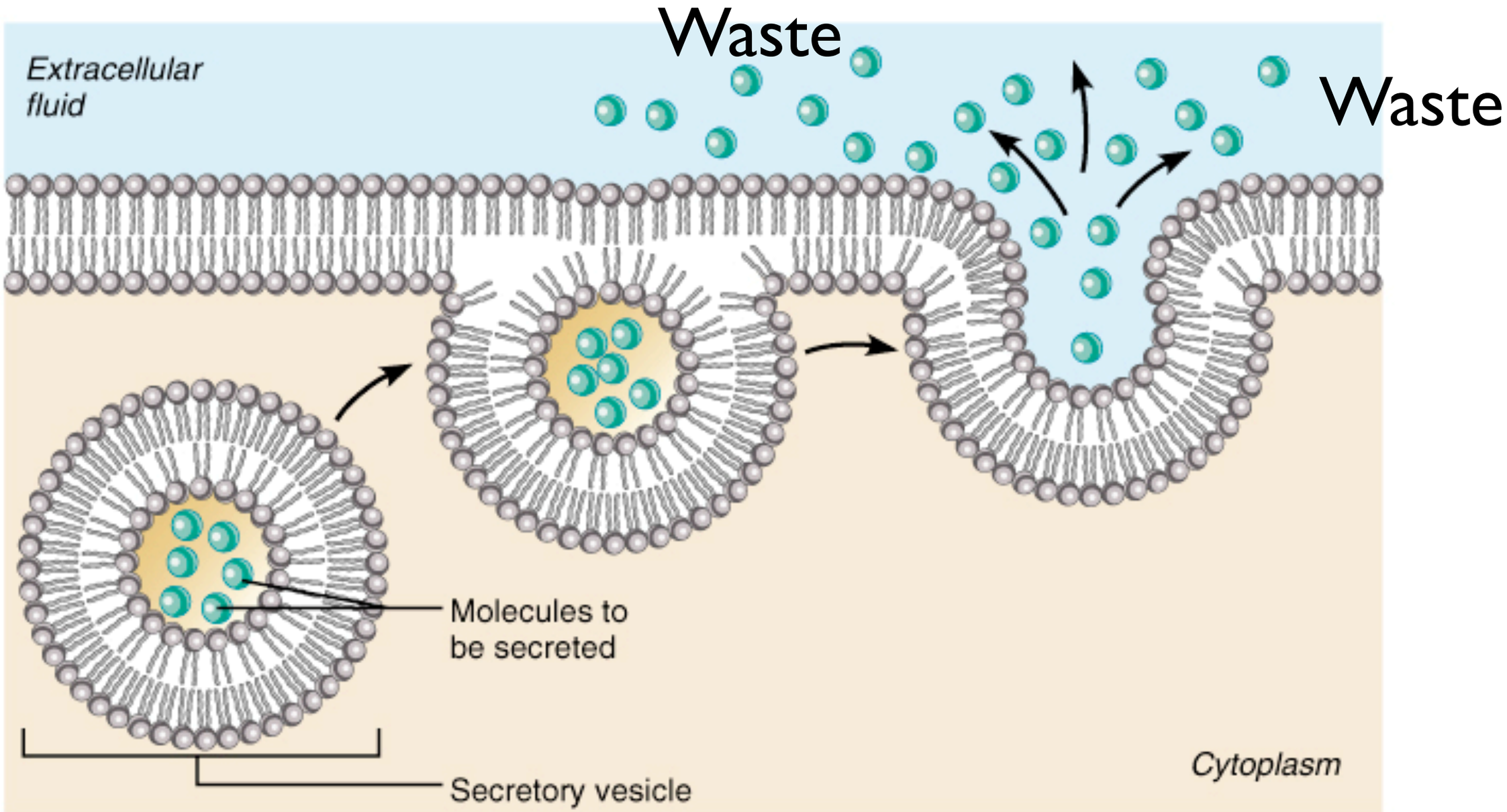
Removing Wastes

- Fungi have no excretory systems
- Although fungi are multicellular, the structure of their hyphae their cells exchange with the environment more like unicellular organisms
- Diffusion, Osmosis and Exocytosis rid the cells of their wastes

Endocytosis and Exocytosis



Exocytosis


Waste
Waste
Extracellular fluid
Molecules to be secreted
Secretory vesicle
Cytoplasm

REVIEW

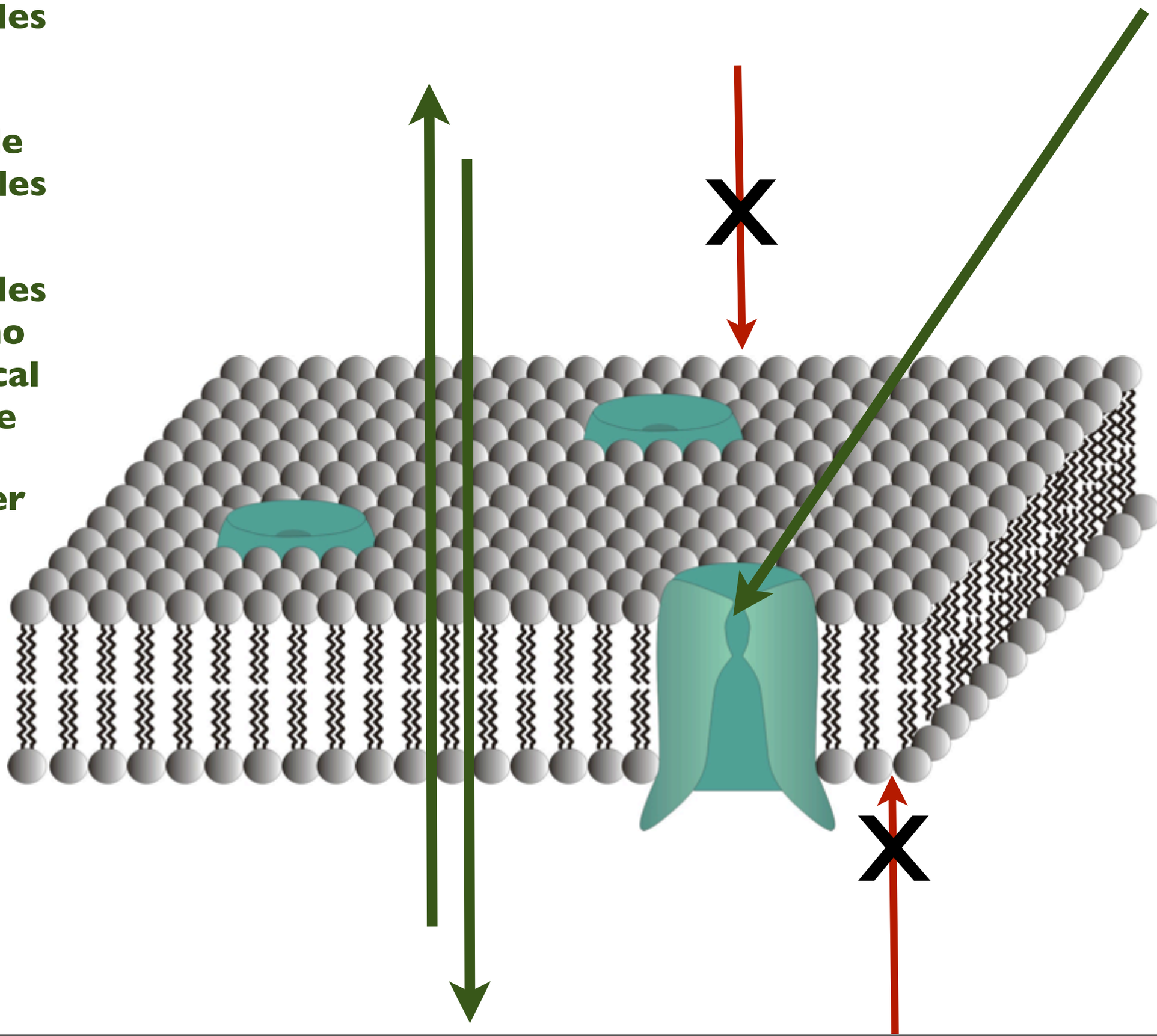
However
If cell permits

Small Molecules

Fat Soluble Molecules

Molecules with no electrical charge

***Water**



Large Molecules

Water Soluble Molecules

Molecules with electrical charges

Water and Solutes

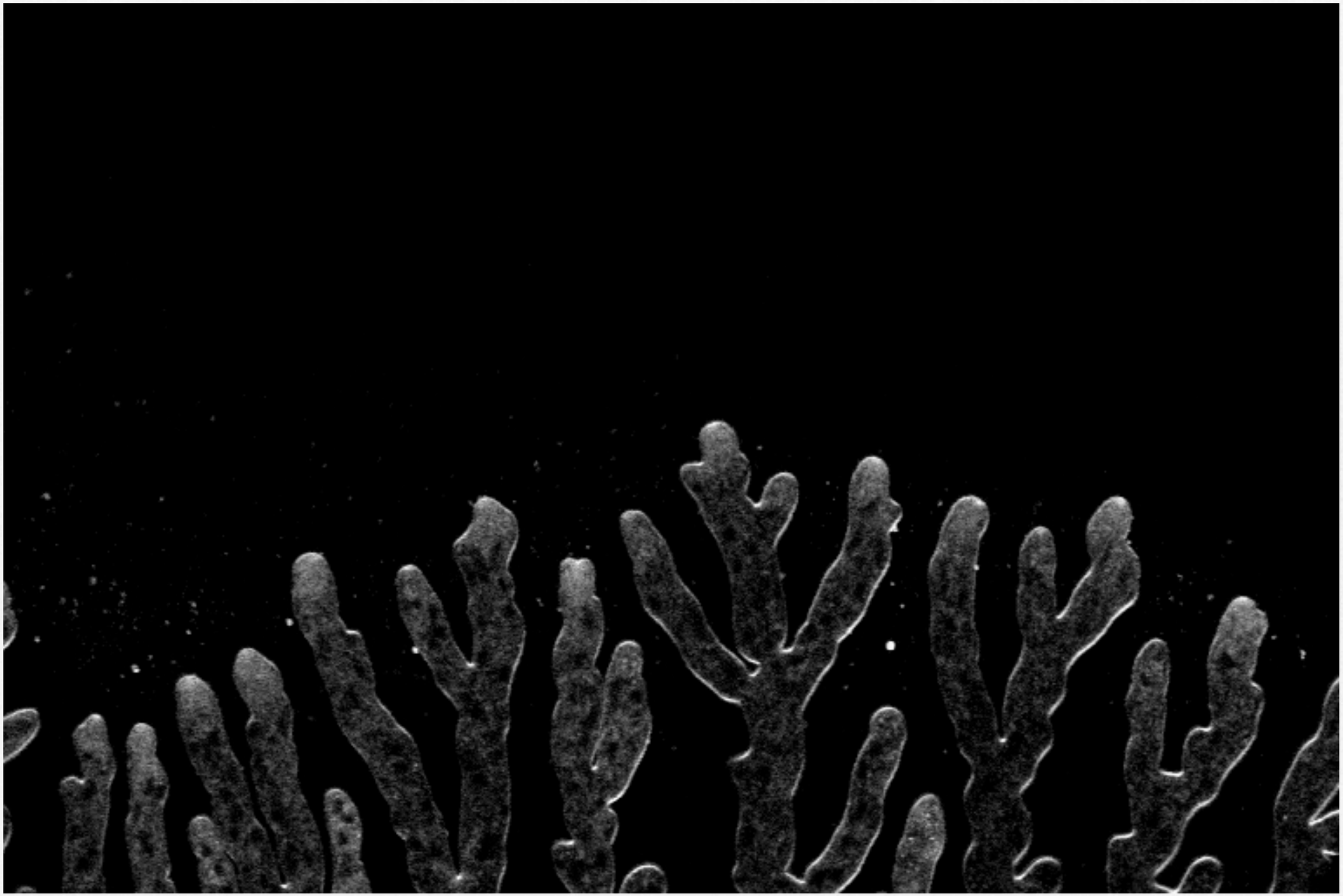
- All organisms need to balance to uptake and loss of water
- Water and solutes move together across membranes
- Thus the net effect is to balance both solutes and water at the same time
- Maintaining a fluid environment of cells and tissues requires keeping the relative concentrations of water and solutes within narrow limits

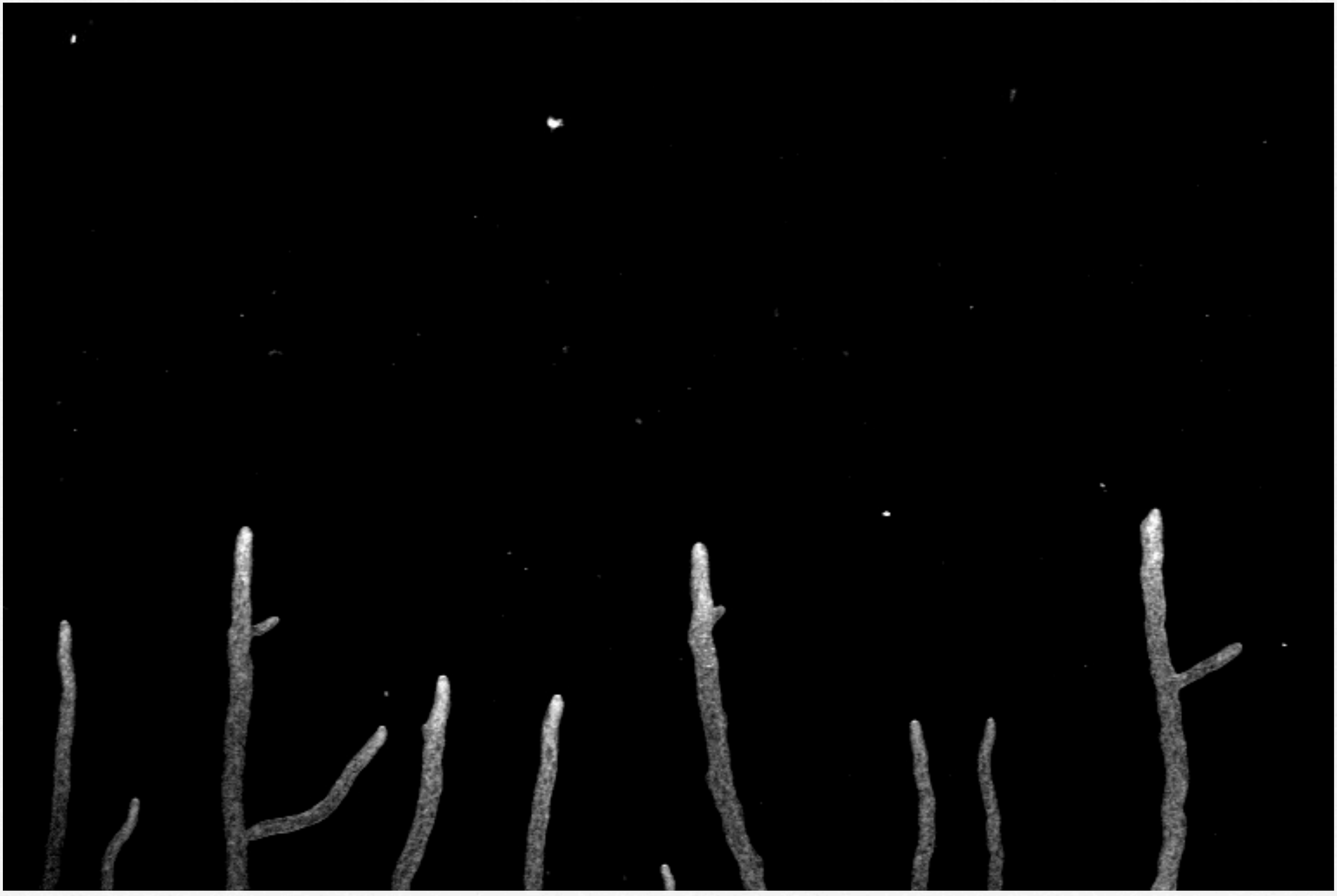
Osmoregulation

- The general term for the process by which organisms control solute concentrations and balance water loss and gain is called osmoregulation.
- A number of strategies have evolved, reflecting the varied and often severe osmoregulatory challenges presented by surroundings

Water Regulation

- Water is important for a variety of reasons one in particular is has to do with "growth"
- Fungi are similar to plants in that they have cell walls and require turgor pressure
- Recall that turgor pressure provided additional support for plants
- In the case of fungi they require turgor to grow, it is the internal pressure that pushes hyphae through soil





Thursday, September 20, 2012

Water Regulation

- With such diverse habitats the osmoregulation in fungi can be equally diverse
- However we can make some generalizations regarding osmoregulation in fungi
- Fungi have both short term and long term osmoregulation mechanisms
- Fungi will manipulate solute concentrations inside or outside the cell to move water in a directed way

Hypoosmotic Habitats

- Water will constantly move into cells
- Initially fungal response depends on the elastic nature of its cell wall
  - thus pressure is regulated through volume changes
    - Recall Pressure and Volume are inversely related!
- Eventually fungi will adjust internal solute and ion concentrations to adjust volume back to normal
  - solutes/ions concentration decreases inside cells, water will out

Hyperosmotic Habitats

- Water will constantly move out from cells
- Fungi are danger of having the cell wall pull away from the membrane (plasmolyze) just like plant cells
- Again fungi will adjust internal solute and ion concentrations in order to move water
  - solutes/ions concentration increases inside cells, water will move in

How are the solute/ion concentrations manipulated by fungal cells?

- Again specific examples are numerous but in all cases solutes/ions are transported across the membrane
  - This could mean simply opening or closing channels (passive transport)
  - Or it could mean pumping solutes in or out of the cell (active transport)
- Sometimes manipulating salts/ions is a poor choice because they interfere with normal cell activites

How are the solute/ion concentrations manipulated by fungal cells?

- Another mechanism involves making or degrading some organic molecules in order to change water potential
  - ex. sucrose, glycerol, inositol, proline
  - these are commonly used because they do not interfere with enzyme activity

Protists

Water & Solute Regulation

Excretion of Wastes: Protists

WASTE	HOW IT IS FORMED	MECHANISM OF EXCRETION
*Carbon Dioxide	cell respiration	diffusion
*Water	cell respiration, dehydration synthesis	osmosis, active transport or contractile vacuole (if present)
Nitrogenous (ammonia)	removal of $-NH_2$ groups from amino acids leads to formation of NH_3	unicellular organisms- diffusion & contractile vacuoles
Inorganic Salts	general metabolism	diffusion

*If autotrophic carbon dioxide and water can be used as reactants for photosynthesis

Removing Wastes

- Protists have no excretory systems
  - certain protists do have contractile vacuoles which will be discussed later
- Unicellular organisms exchange directly with their environment
- Diffusion, Osmosis and Exocytosis rid the cells of their wastes

Water and Solutes

- All organisms need to balance to uptake and loss of water
- Water and solutes move together across membranes
- Thus the net effect is to balance both solutes and water at the same time
- Maintaining a fluid environment of cells and tissues requires keeping the relative concentrations of water and solutes within narrow limits

Osmoregulation

- The general term for the process by which organisms control solute concentrations and balance water loss and gain is called osmoregulation.
- A number of strategies have evolved, reflecting the varied and often severe osmoregulatory challenges presented by surroundings

Water Regulation

- Water is important for a variety of reasons
- Some protists have cell walls, others do not
- Protists that have cell walls, require turgor pressure thus hypoosmotic environments
- Protists that do not have cell walls are danger of bursting (hypoosmotic environments) and shrinking (hyperosmotic environments), both unacceptable and potentially deadly

REVIEW


cellule d'épiderme d'oignon rouge
en présence d'eau salée.
page-svt.com
Jankowiak Ced. (2009)

Water Regulation

- With such diverse habitats the osmoregulation in protists can be equally diverse
- One unique feature is the present of contractile vacuoles present in some protists
- This vacuole absorbs excess water and excretes the excess thereby maintaining a balance
- However we can make some generalizations regarding osmoregulation in protists

CONTRACTILE VACUOLES

How are the solute/ion concentrations manipulated by protists?

- Again specific examples are numerous but in all cases solutes/ions are transported across the membrane
  - This could mean simply opening or closing channels (passive transport)
  - Or it could mean pumping solutes in or out of the cell (active transport)
- Sometimes manipulating salts/ions is a poor choice because they interfere with normal cell activites

Bacteria

Water & Solute Regulation

Excretion of Wastes: Bacteria

WASTE	HOW IT IS FORMED	MECHANISM OF EXCRETION
*Carbon Dioxide	cell respiration	diffusion
*Water	cell respiration, dehydration synthesis	osmosis, active transport
Nitrogenous (ammonia)	removal of $-NH_2$ groups from amino acids leads to formation of NH_3	diffusion
Inorganic Salts	general metabolism	diffusion, active transport

*If autotrophic carbon dioxide and water can be used as reactants for photosynthesis

Removing Wastes

- Bacteria have no excretory systems
- Unicellular organisms exchange directly with their environment
- Diffusion, Osmosis and Exocytosis rid the cells of their wastes

Water and Solutes

- All organisms need to balance to uptake and loss of water
- Water and solutes move together across membranes
- Thus the net effect is to balance both solutes and water at the same time
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Osmoregulation

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- A number of strategies have evolved, reflecting the varied and often severe osmoregulatory challenges presented by surroundings

Water Regulation

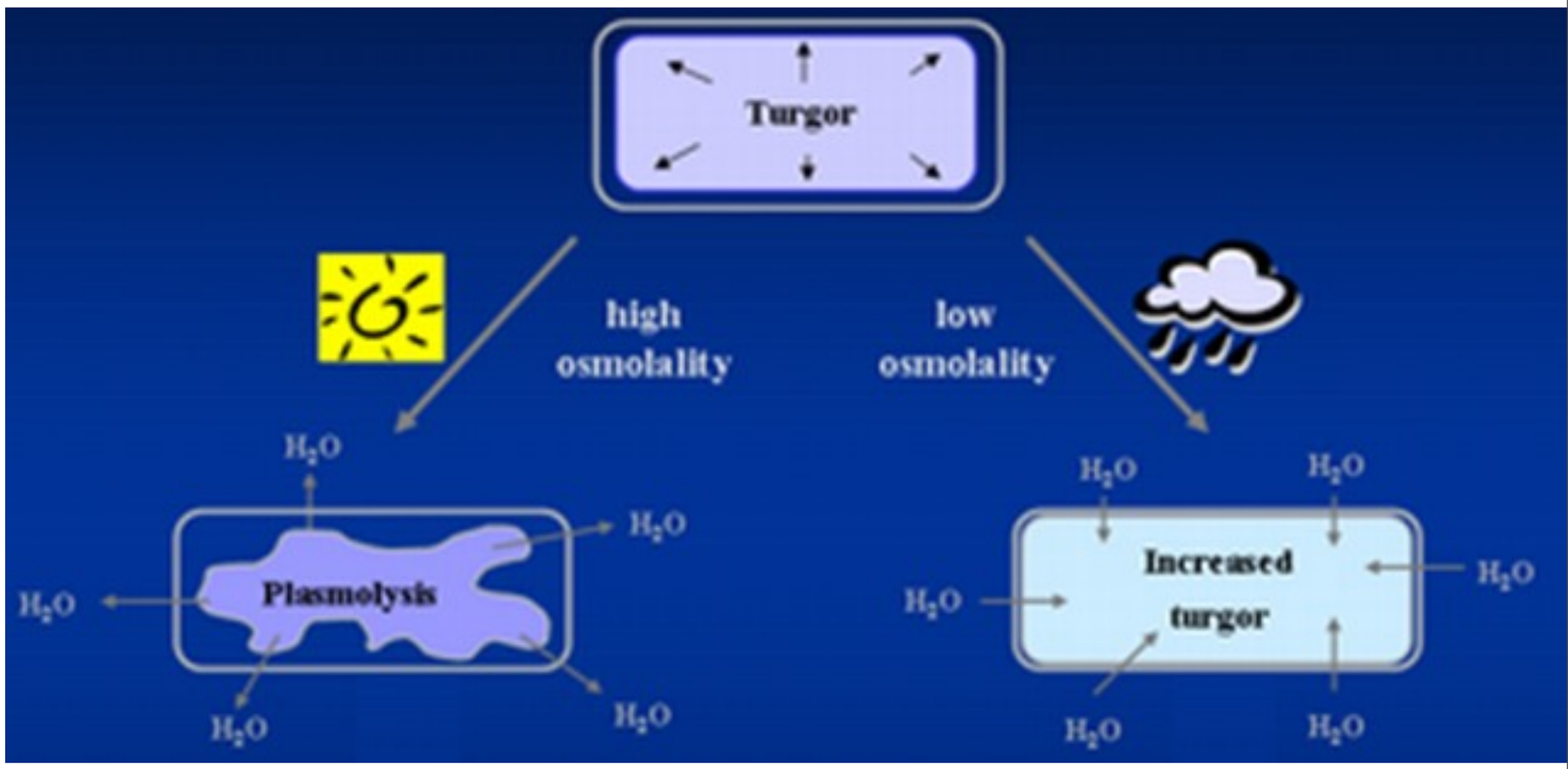
- Water is important for a variety of reasons
- Bacteria have cell walls
- Bacteria require turgor similar to plants
- Like plant cells bacteria can plasmolyze in hyperosmotic conditions

Water Regulation

- With such diverse habitats the osmoregulation in protists can be equally diverse
- One unique feature is the present of contractile vacuoles present in some protists
- This vacuole absorbs excess water and excretes the excess thereby maintaining a balance
- However we can make some generalizations regarding osmoregulation in protists

Responses of Bacteria to Hypertonicity

- If cell is in a hypertonic environment, water leaves the cell.



Decrease of intracellular water causes proteins, etc. to precipitate out of solution, stop functioning. Bacteria respond by increasing the concentration of “compatible solutes” to partially balance the higher external solute concentration.

How are the solute/ion concentrations manipulated by bacteria?

- Again specific examples are numerous but in all cases solutes/ions are transported across the membrane
  - This could mean simply opening or closing channels (passive transport)
  - Or it could mean pumping solutes in or out of the cell (active transport)
- Sometimes manipulating salts/ions is a poor choice because they interfere with normal cell activites

How are the solute/ion concentrations manipulated by bacteria?

- Like fungi bacteria can make or degrade organic molecules in order to change water potential
- molecules commonly used do not interfere with enzyme activity and other cell functions