New Jersey Center for Teaching and Learning

Progressive Science Initiative

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AP BIOLOGY

Big Idea 2
Part A

October 2012

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Big Idea 2:

Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Big Idea 2

The following is the AP's explanation of the second Big Idea:

"Living systems require free energy and matter to maintain order, grow and reproduce. Organisms employ various strategies to capture, use and store free energy and other vital resources. Energy deficiencies are not only detrimental to individual organisms; they also can cause disruptions at the population and ecosystem levels...

Big Idea 2

"Autotrophic cells capture free energy through photosynthesis and chemosynthesis. Photosynthesis traps free energy present in sunlight that, in turn, is used to produce carbohydrates from carbon dioxide. Chemosynthesis captures energy present in inorganic chemicals. Cellular respiration and fermentation harvest free energy from sugars to produce free energy carriers, including ATP. The free energy available in sugars drives metabolic pathways in cells. Photosynthesis and respiration are interdependent processes."

Big Idea 2: Part A

Click on the topic to go to that section

Cell Membranes: Diffusion & Osmosis

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Biological Membranes

The term membrane most commonly refers to a thin, film-like structure that separates two fluids.

Membranes act as a container for biological systems.

The primary component of biological membranes are the organic molecule phospholipids. Their properties lend to the building of membranes.

Biological Membranes

The video below shows experiments done at a laboratory in France to study the properties of lipids. The only substances used in the making of this video are **lipids, water and dye**. The lipids and dye were mixed and then injected into aqueous solution.

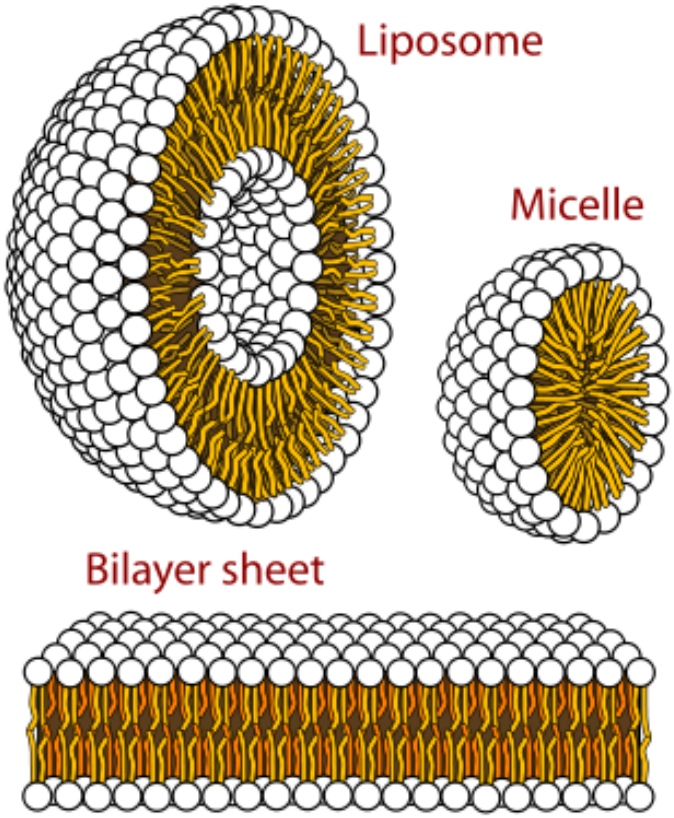
Try to figure out some of the properties that make lipids useful as membranes by watching the video.

Click here for the video

Biological Membranes

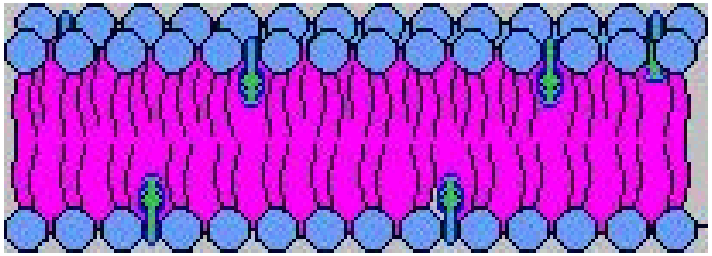
The most important lipid that composes the majority of biological membranes is the **phospholipid**.

As we saw in the previous chapter, they will naturally form a spherical bilayer.



Lipids and the Membrane

Phospholipids form two parallel lines with their hydrophobic ends in between. The hydrophobic ends are protected from the water by the hydrophilic ends, creating a bilayer.

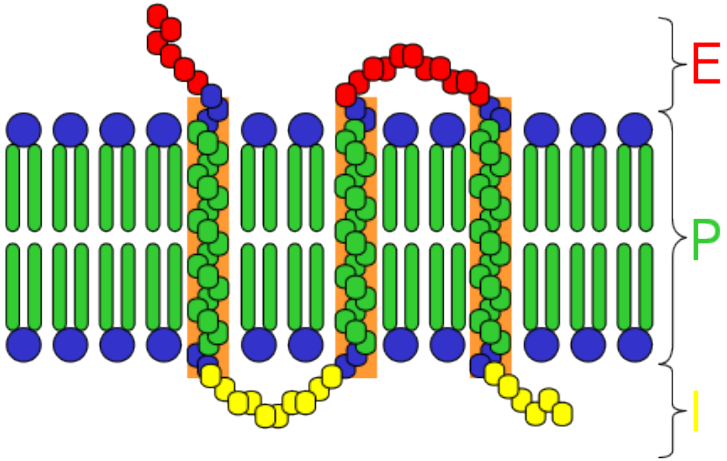


Cholesterol inserts itself into the membrane in the same orientation as the phospholipid. Cholesterol immobilizes the first few hydrocarbons in the phospholipid, making the bilayer more stable, and impenetrable to water molecules. Cholesterol is only found in animal cell membranes.

Types of Membrane Proteins

Peripheral proteins stay on only one side of the membrane.

Integral proteins pass through the hydrophobic core and often span the membrane from one end to the other.

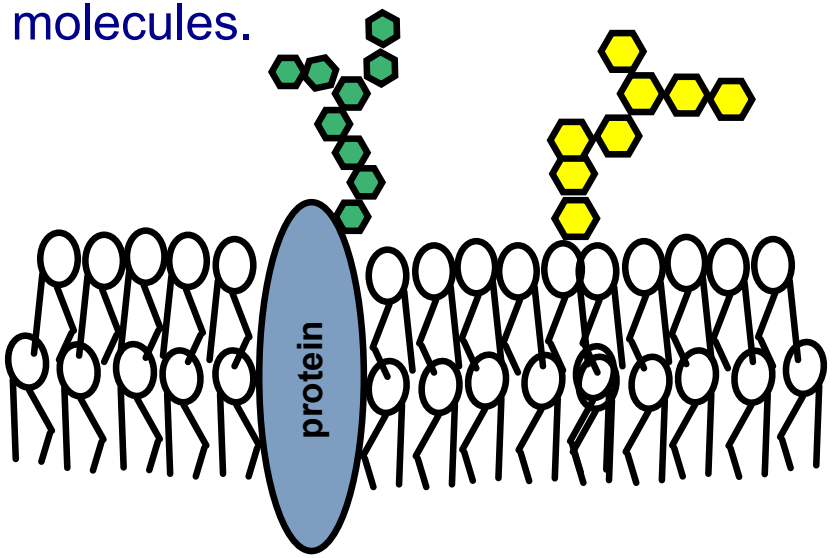


Proteins in the plasma membrane can drift within the bilayer. They are much larger than lipids and move more slowly throughout the fluid mosaic.

Carbohydrates and the Membrane

Glycoproteins have a carbohydrate attached to a protein and serve as points of attachment for other cells, bacteria, hormones, and many other molecules.

Glycolipids are lipids with a carbohydrate attached. Their purpose is to provide energy and to act in cellular recognition.



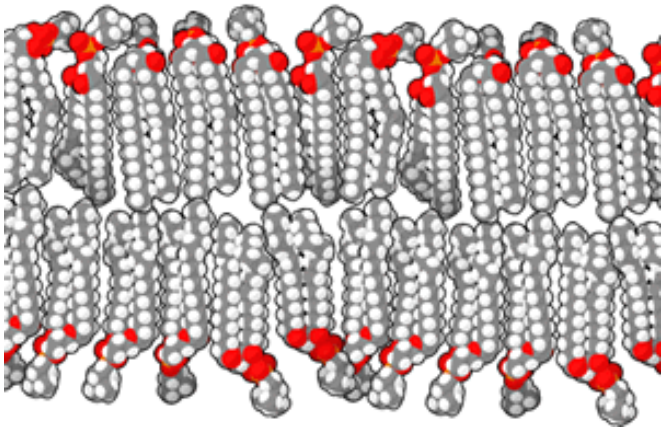
Biological Membranes

Membranes act as **selectively permeable** barriers, allowing some particles or chemicals to pass through, but not others.

The properties of the phospholipid bilayer dictate what can pass through a membrane.

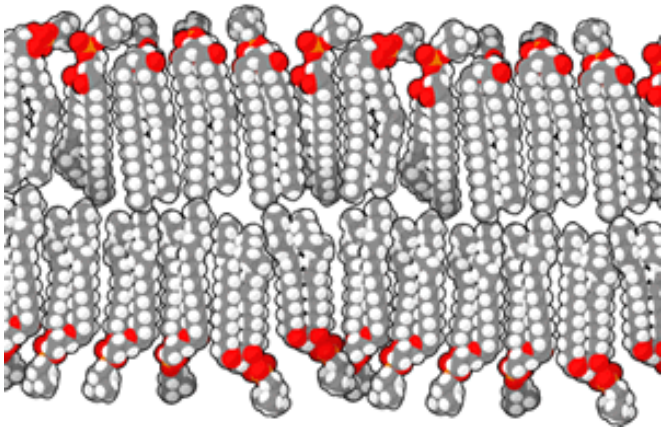
Selective Permeability

When phospholipids come together, they create a wall that is tightly packed with a core that is nonpolar. However the individual molecules are not fixed and small gaps form as they fluidly move around in the membrane.



Selective Permeability

So what molecules CAN pass through a membrane made of just phospholipids?



1 Will O_2 pass through?

- Yes
- No

Why?

2 Will H_2O pass through?

- Yes
- No

Why?

3 Will Na^+ pass through?

- Yes
- No

Why?

4 Will $C_6H_{12}O_6$ pass through?

- Yes
- No

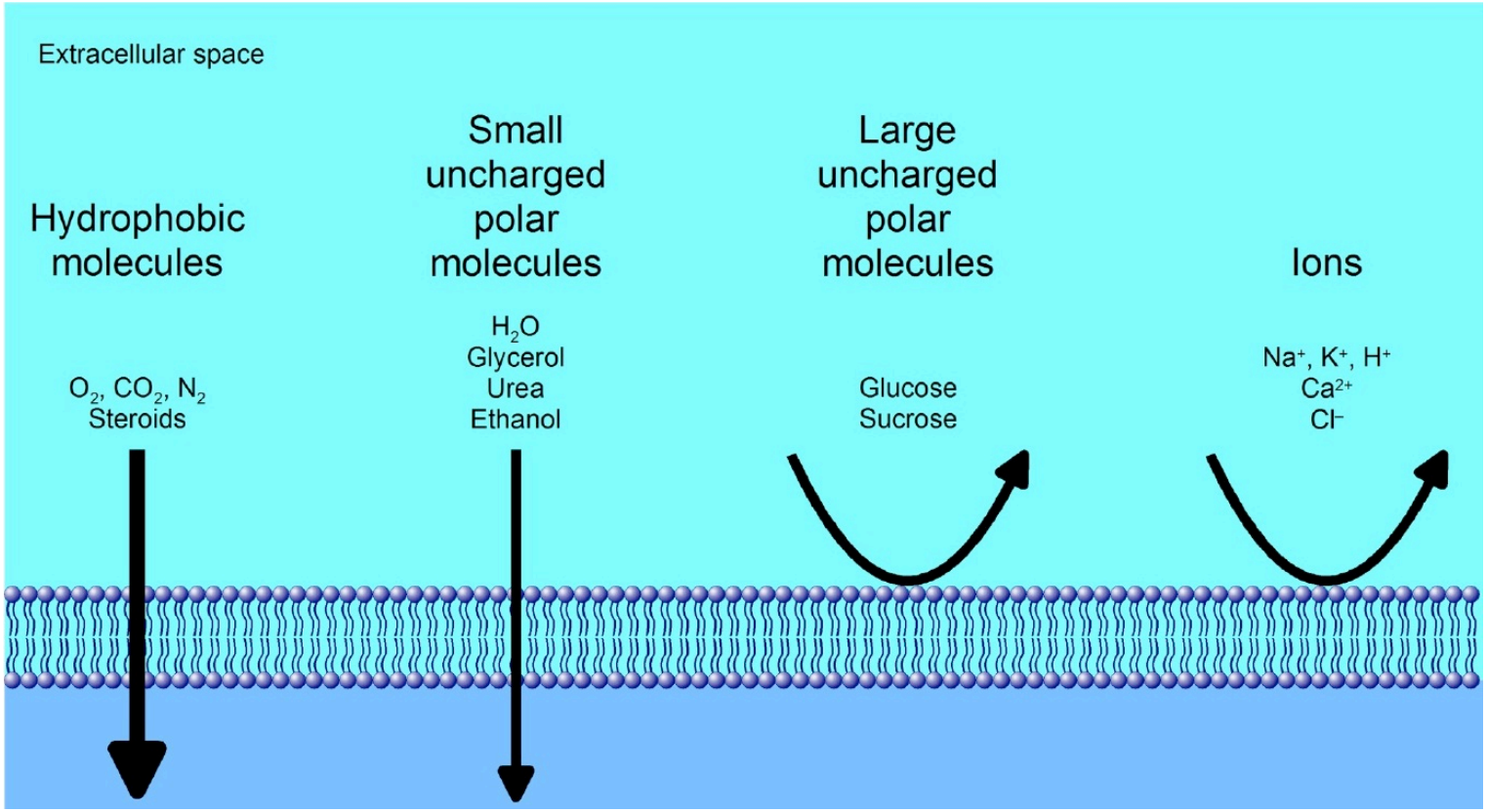
Why?

Selective Permeability

To recap...

Large molecules or charged molecules will not make it through a lipid bilayer.

Some examples: sugars, ions, nucleic acids, proteins



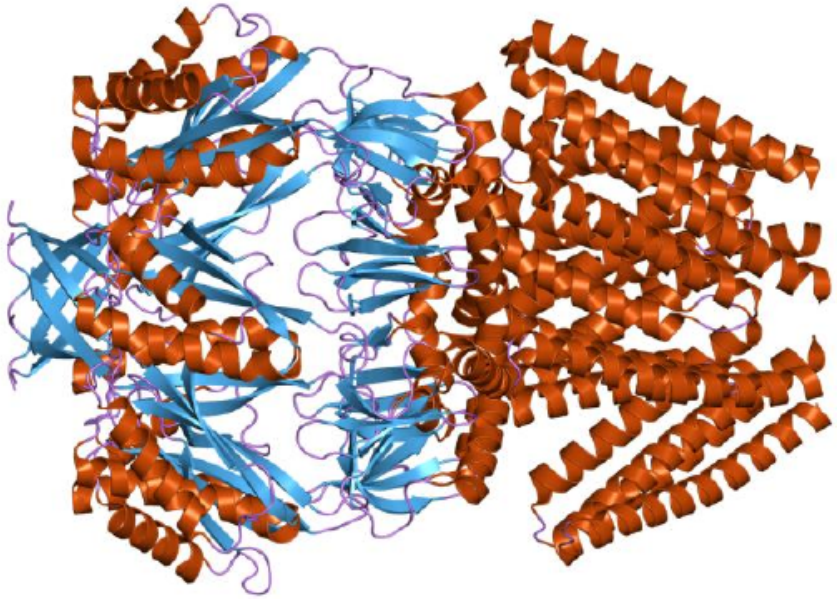
How do cells get what they need?

We know that cell membranes are made of lipid bilayers, and we know that cells require things like sugar and nucleic acids and proteins and sodium that can't pass through this barrier.

So how do cells get the materials they need?

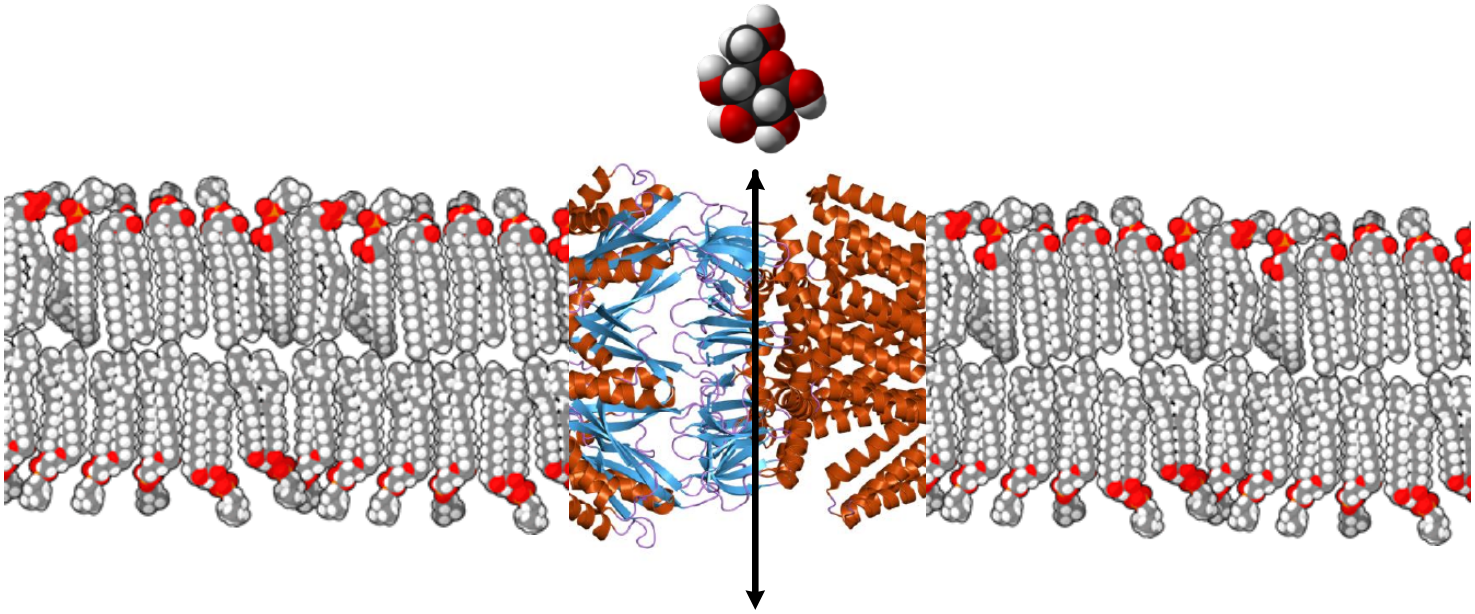
Proteins Regulate What is in a Cell

Proteins are long chains of amino acids that fold up on each other to form useful structures in biological systems. Below is a **ribbon diagram** of an amino acid chain that forms a **channel protein.**



Proteins Regulate What is in a Cell

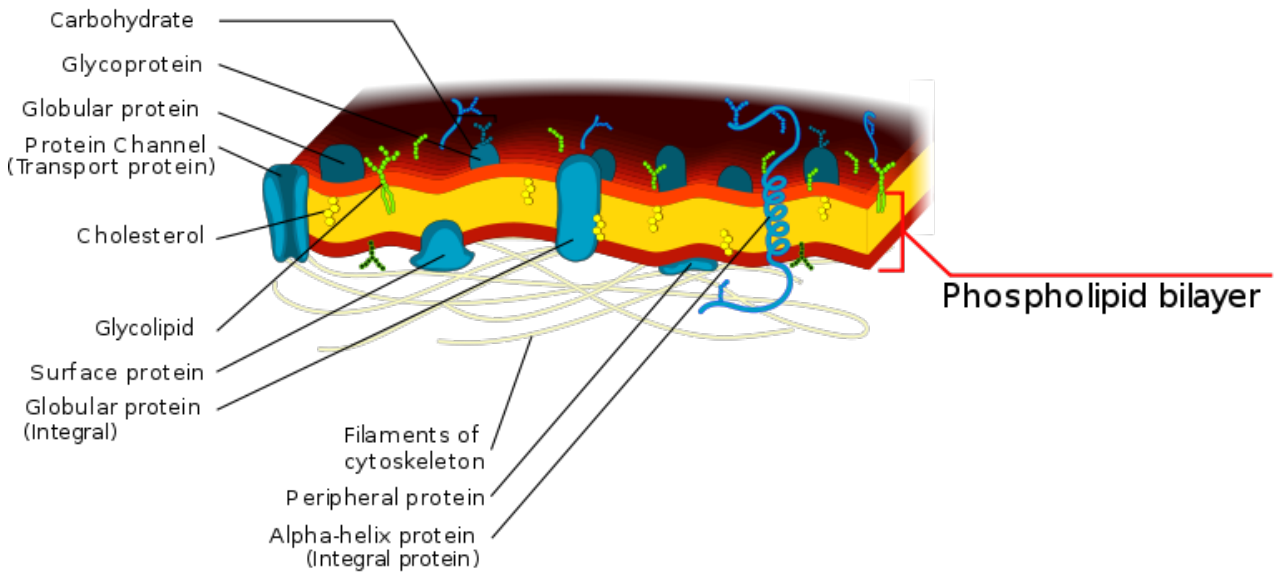
When this structure is placed into a membrane it forms a **pore** that allows specific substances to diffuse across the membrane, even if they are large or have charge.



Fluid Mosaic

Fluid mosaic is a term that describes what cell membranes actually are. They are a mixture of lipids and proteins that can direct the traffic of materials flowing in and out of the cell.

By doing this, the internal chemistry of the cell becomes far different than its surroundings.



Review Membrane Transport

Watch this video to review the way in which membranes can regulate by transport.

Click here for a review of solute moving through membranes

If further review is needed please see NJCTL's first year biology course.

Membranes First Year Course

Glucose

5 When diffusion has occurred until there is no longer a concentration gradient, then _____ has been reached.

- A equilibrium
- B selective permeability
- C phospholipid bilayer
- D homeostasis

answer

6 In Osmosis, water molecules diffuse from

- A inside the plasma membrane to outside only
- B outside the plasma membrane to inside only
- C from areas of high solute concentration to areas of low solute concentration
- D from areas of low solute concentration to areas of high solute concentration

answer

7 What type of environment has a higher concentration of solutes outside the plasma membrane than inside the plasma membrane?

- A hypertonic
- B isotonic
- C normal
- D hypotonic

answer

8 What type of solution has a greater flow of water to the inside of the plasma membrane?

- A hypertonic
- B isotonic
- C normal
- D hypotonic

answer

9 A red blood cell will lyse when placed in which of the following kinds of solution?

- A hypertonic
- B hypotonic
- C isotonic
- D any of these

answer

Cell Membranes: Facilitated Diffusion & Active Transport

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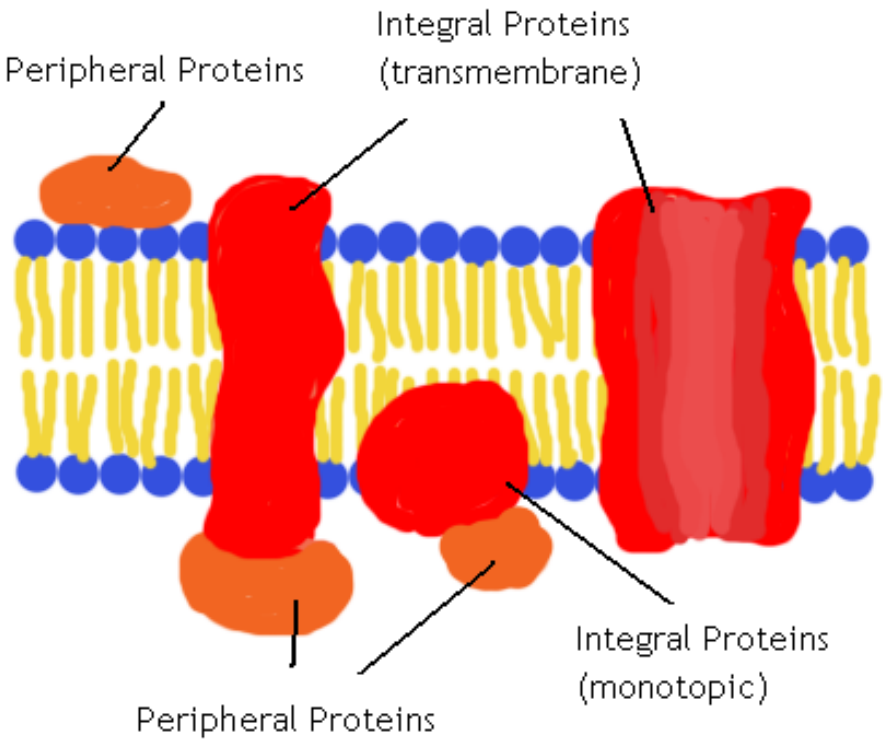
Plasma Membranes of Cells



Proteins in the plasma membrane can drift within the bilayer.

Proteins are much larger than lipids and move more slowly throughout the fluid mosaic.

10 Which of the following statements about the role of phospholipids in forming membranes is correct?

- A They are completely insoluble in water.
- B They form a single sheet in water.
- C They form a structure in which the hydrophobic portion faces outward.
- D They form a selectively permeable structure.

answer

11 The fluid-mosaic model of membrane structure refers to _____.

A the fluidity of phospholipids and the pattern of proteins in the membrane

B the fluidity of proteins and the pattern of phospholipids in the membrane

C the ability of proteins to switch sides in the membranes

D the fluidity of hydrophobic regions, proteins, and the mosaic pattern of hydrophillic regions

answer

Facilitated Diffusion

Selective permeability is based on the types of transport proteins embedded in a cell's lipid bilayer

Small molecules like O_2 and CO_2 readily diffuse through all plasma membranes because they are small and non-polar; they can squeeze between the phospholipids.

However.....

Facilitated Diffusion

Larger molecules and ions, charged particles, cannot squeeze between the phospholipids, they need the help of a transport protein. This is called **Facilitated Diffusion**.

In Facilitated Diffusion, particles move from an area of high to low concentration with the help of a transport protein. Since the substances are going with the natural concentration gradient, this is a type of Passive Transport: no energy is needed.

Examples of Transport Proteins

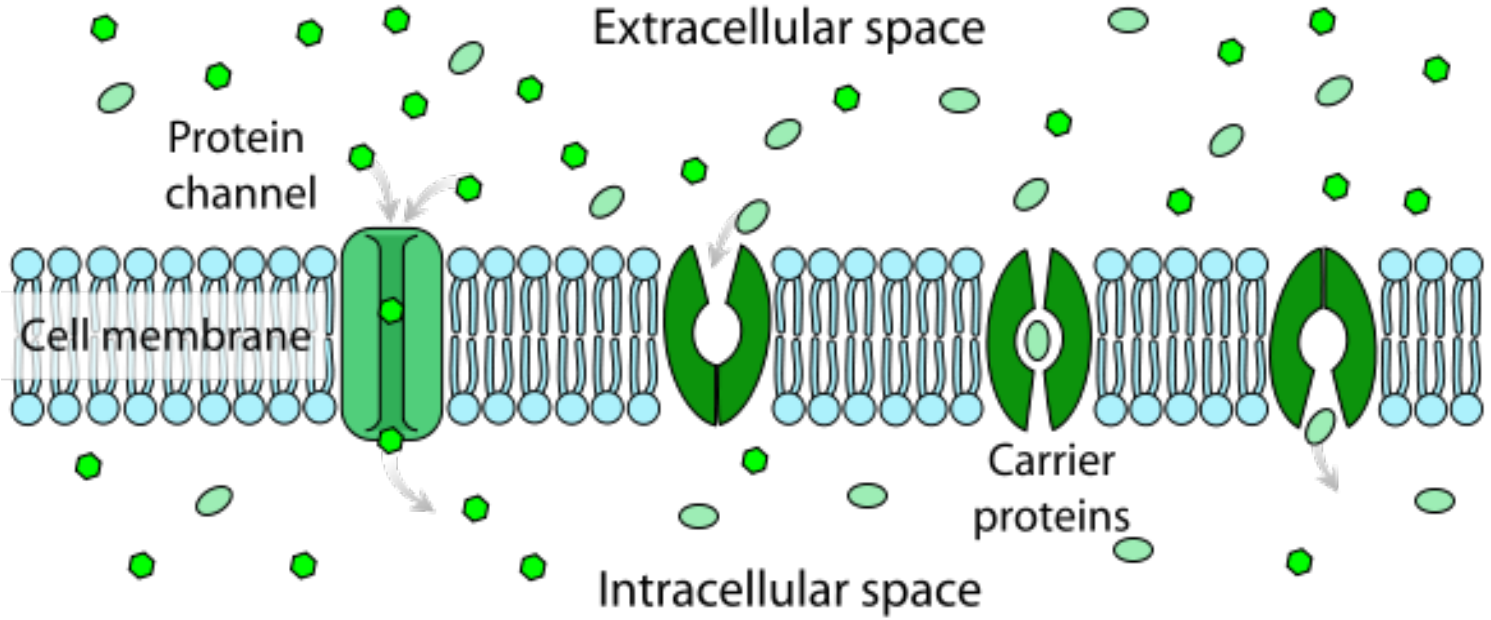
In facilitated diffusion, transport proteins speed the passive transport of molecules across the plasma membrane.

Transport proteins allow passage of hydrophilic substances across the membrane.

Channel proteins, are one type of transmembrane transport proteins that provide corridors that allow a specific molecule or ion to cross the membrane.

Carrier proteins, are another type of transmembrane transport proteins that change shape slightly when a specific molecule binds to it in order to help move that molecule across the membrane.

Facilitated Diffusion



12 Which of the following molecules is most likely to diffuse freely across the lipid bilayer of the plasma membrane without the involvement of a transport protein?

- ○ A carbon dioxide
- ○ B glucose
- ○ C sodium ion
- ○ D DNA
- ○ E all of the above

answer

13 Which of the following processes includes all others?

- A osmosis
- B diffusion of a solute across a membrane
- C facilitated diffusion
- D passive transport

answer

14 Facilitated diffusion moves molecules _____.

- A against their concentration gradients using energy
- B against their concentration gradients without the use of energy
- C with their concentration gradients using energy
- D with their concentration gradients without the use of energy

answer

15 Carrier proteins are an example of integral proteins.

- ○ True
- ○ False

answer

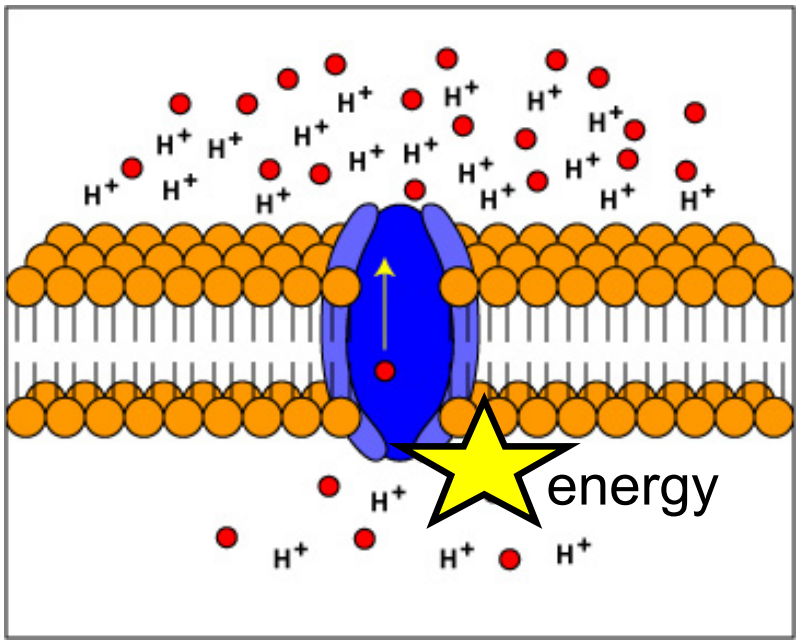
Active Transport

Active Transport uses energy to move solutes through a transport protein against their gradients.

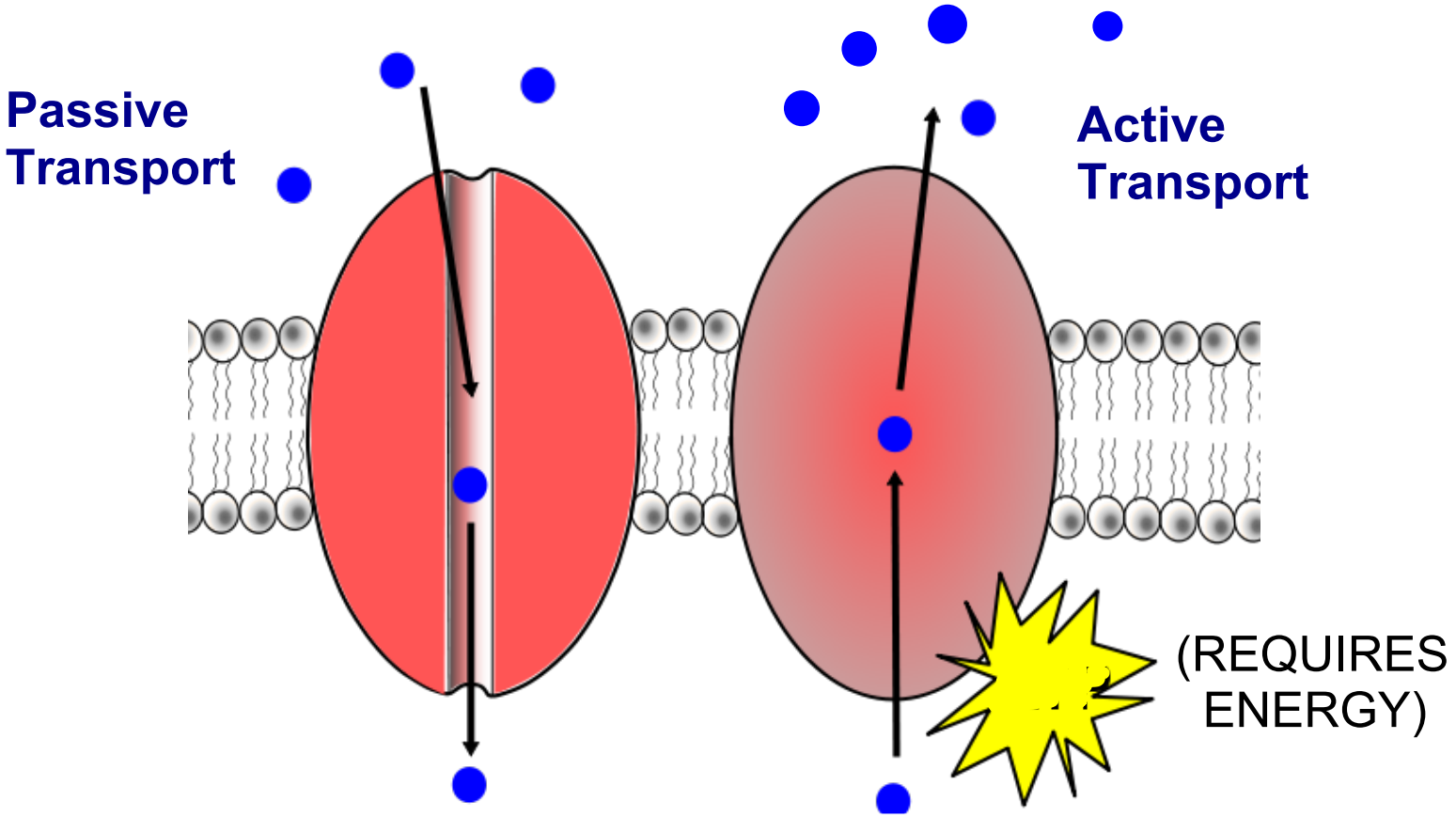
Active transport requires energy.

Active transport is performed by specific proteins embedded in the membranes.

Carrier proteins can also be used in active transport when they are moving specific molecules against their concentration gradients.



Comparing Passive and ActiveTransport



16 Which one of the following is not in some way involved in facilitated diffusion?

- A a concentration gradient
- B a membrane
- C a protein
- D an energy source
- E all of the above are components of facilitated diffusion

answer

17 Active transport moves molecule _____.

- A against their concentration gradients using energy
- B against their concentration gradients without the use of energy
- C with their concentration gradients using energy
- D with their concentration gradients without the use of energy

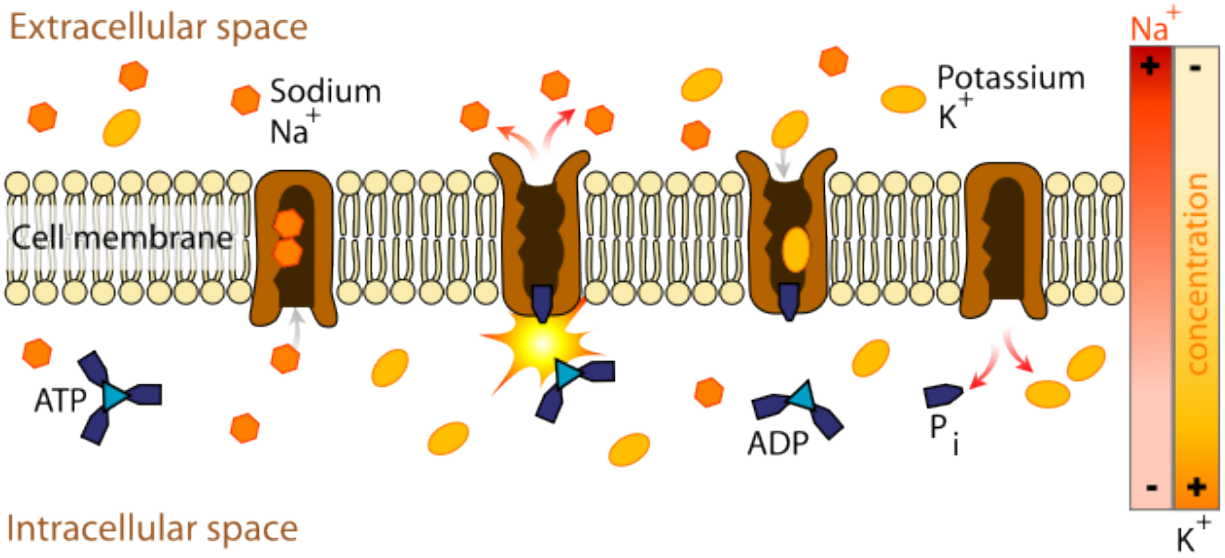
answer

18 Which protein can be used for both active and passive transport?

- A carrier protein
- B channel protein
- C any integral protein
- D any transmembrane protein

answer

Sodium Potassium Pump



The sodium potassium pump is an active transport mechanism that requires energy and works through a series of conformational changes in an integral protein.

Sodium Potassium Pump

1) The pump, binds ATP, and then binds 3 intracellular Na+ ions.

2) ATP is hydrolyzed, leading to phosphorylation of the pump and subsequent release of ADP.

3) A conformational change in the pump exposes the Na+ ions to the outside. The phosphorylated form of the pump has a low affinity for Na+ ions, so they are released.

4)The pump binds 2 extracellular K+ ions. This causes the dephosphorylation of the pump, reverting it to its previous conformational state, transporting the K+ ions into the cell.

5) The unphosphorylated form of the pump has a higher affinity for Na+ ions than K+ ions, so the two bound K+ ions are released. ATP binds, and the process starts again.

19 The sodium-potassium pump is a major contributor in establishing the _____ of a cell.

- A pump direction
- B ion concentrations
- C ATP
- D membrane potential

answer

20 In the sodium potassium pump, ___ sodium ions initially bind to the transport protein.

- A 1
- B 2
- C 3
- D 4

answer

21 The sodium potassium pump passes:

A more Na^+ out than K^+ in

B K^+ out and Na^+ in on a one-for-one basis

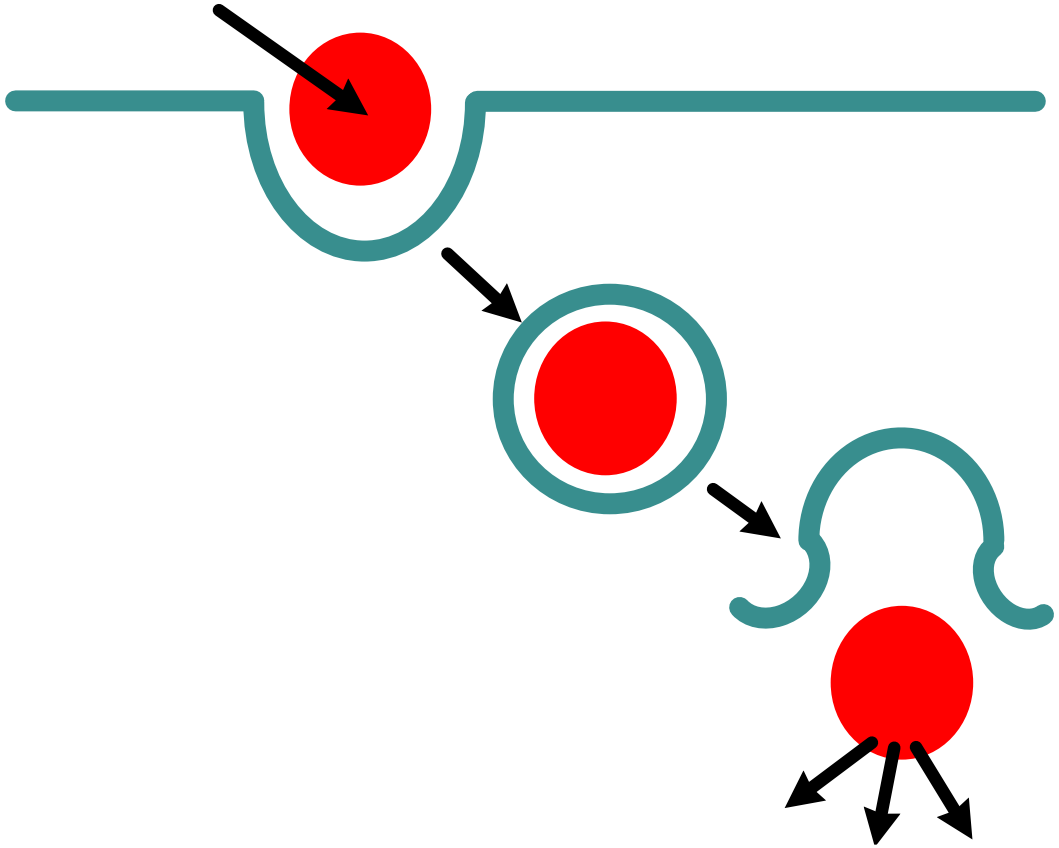
C Na^+ out and K^+ in on a one-for-one basis

D K^+ and Na^+ in the same direction

answer

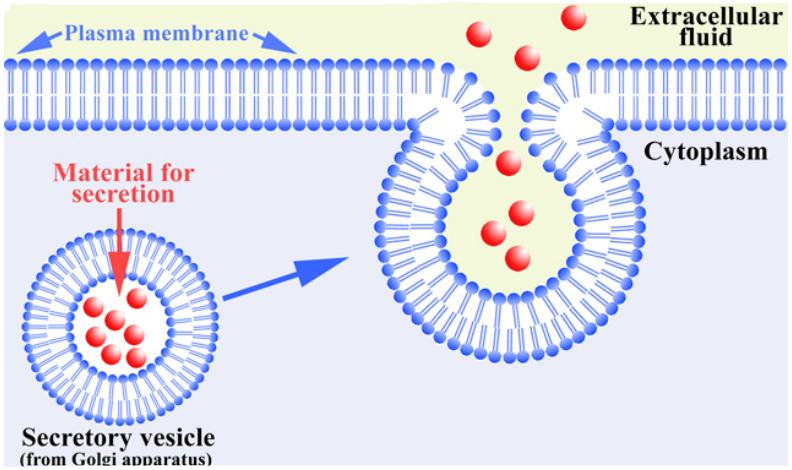
Large Molecules and the Plasma Membrane

If a substance or molecule is too large to use transport proteins to get through the membrane, it must enter or exit by **fusing with the plasma membrane.**



Exocytosis

The vesicles that enclose the products a cell makes will fuse with the plasma membrane and then open up and spill their contents outside of the cell.

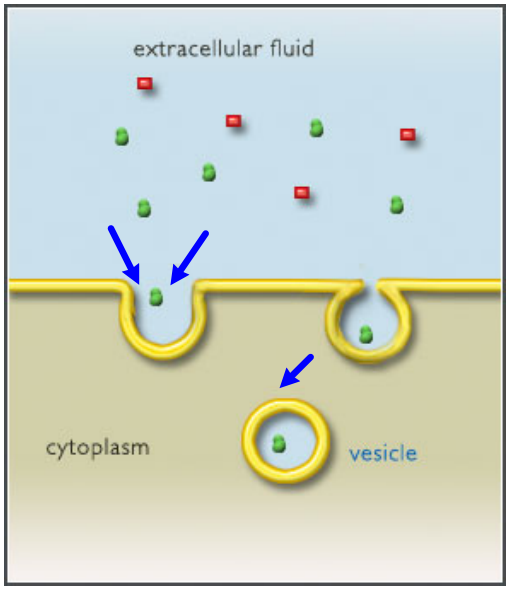


This process is known as **exocytosis**. The vesicle will become part of the cell membrane

Endocytosis

The opposite of exocytosis is **endocytosis**.

The cell takes in macromolecules or other particles by forming vesicles from its plasma membrane.



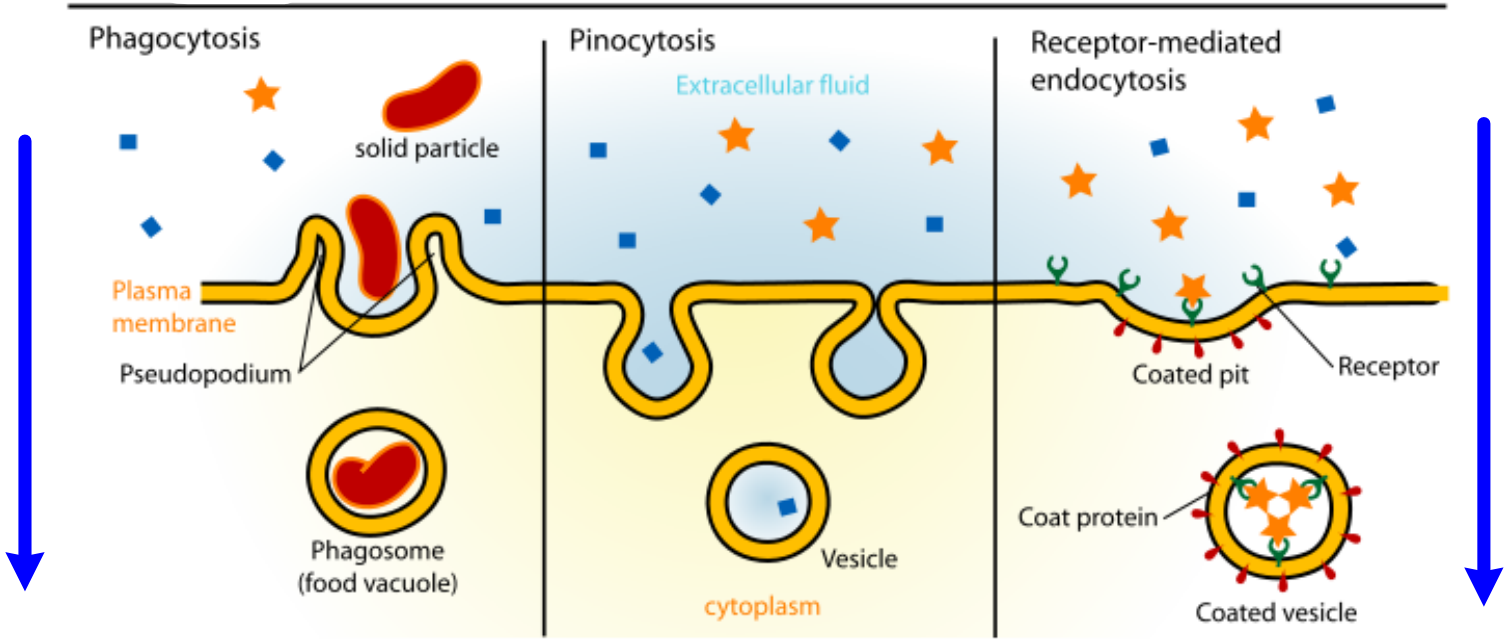
3 Types of Endocytosis

Phagocytosis involves taking in solid particles.

Pinocytosis involves taking in substances dissolved in liquids.

Receptor-mediated endocytosis requires the help of a protein coat and receptor on the membrane for the vesicle to get through.

3 Types of Endocytosis



22 The process by which a cell ingests large solid particles, therefore it is known as "cell eating".

- A Pinocytosis
- B Phagocytosis
- C Exocytosis
- D Osmoregulation

answer

23 Protein coated vesicles move through the plasma membrane via this process:

- A Phagocytosis
- B Active Transport
- C Receptor-Mediated Endocytosis
- D Pinocytosis

answer

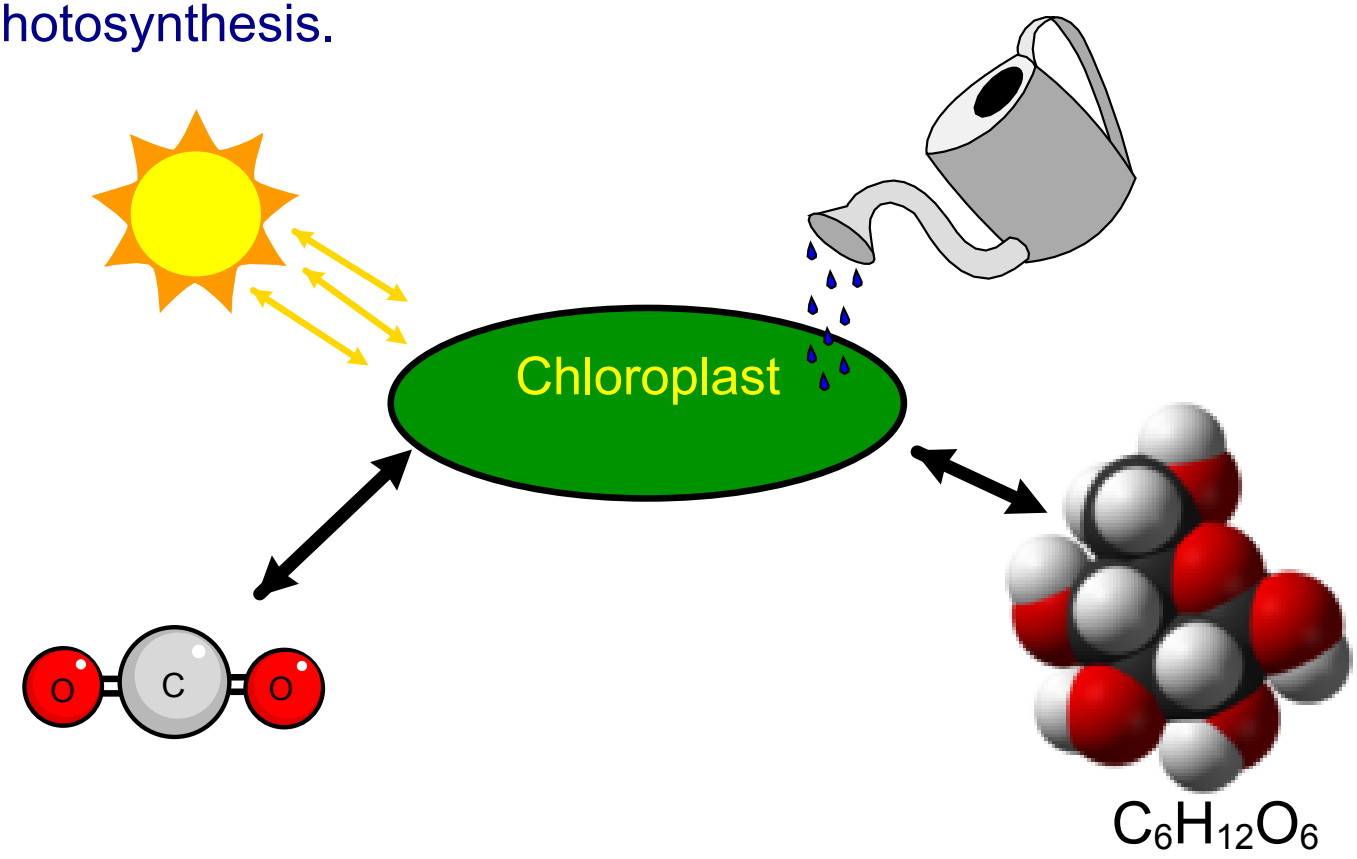
24 Four of the five answers below are related by energy requirements. Pick the exception.

- A active transport
- B endocytosis
- C facilitated diffusion
- D exocytosis
- E sodium-potassium pump

answer

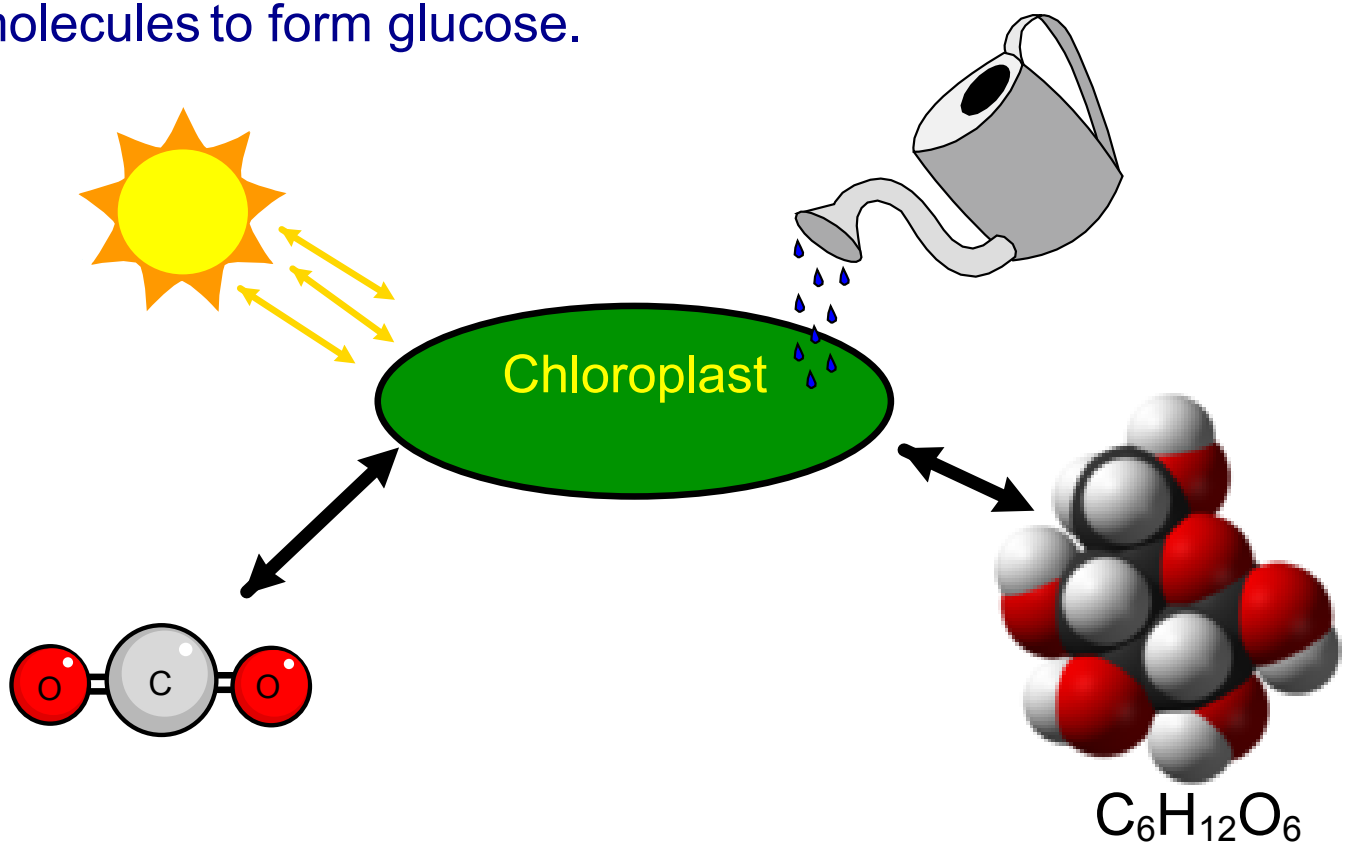
Homeostasis Example

Lets look at a chloroplast, which is a tiny molecular machine that produces sugar when exposed to sunlight, carbon dioxide and water. You may recall this process to be photosynthesis.



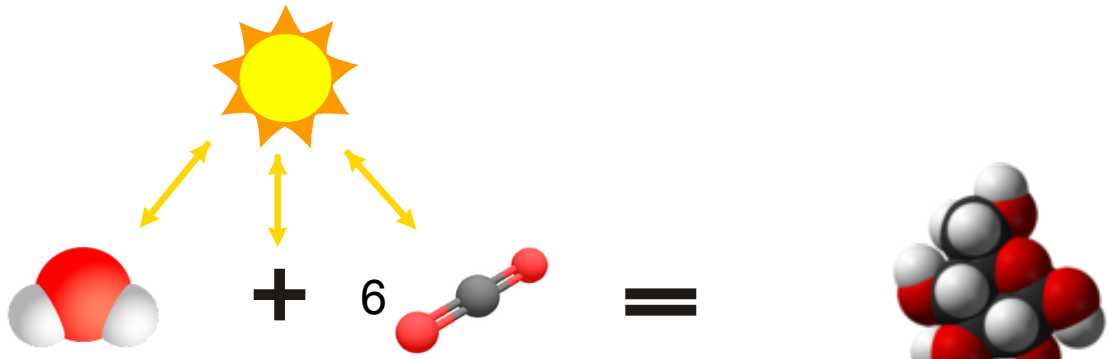
Homeostasis Example

The energy from the sunlight and the electrons from the water are used to bind together the carbon in 6 CO_2 molecules to form glucose.



Homeostasis Example

The water and carbon dioxide are always being used to make glucose so there is always decreasing amounts of water and carbon dioxide in the chloroplast.



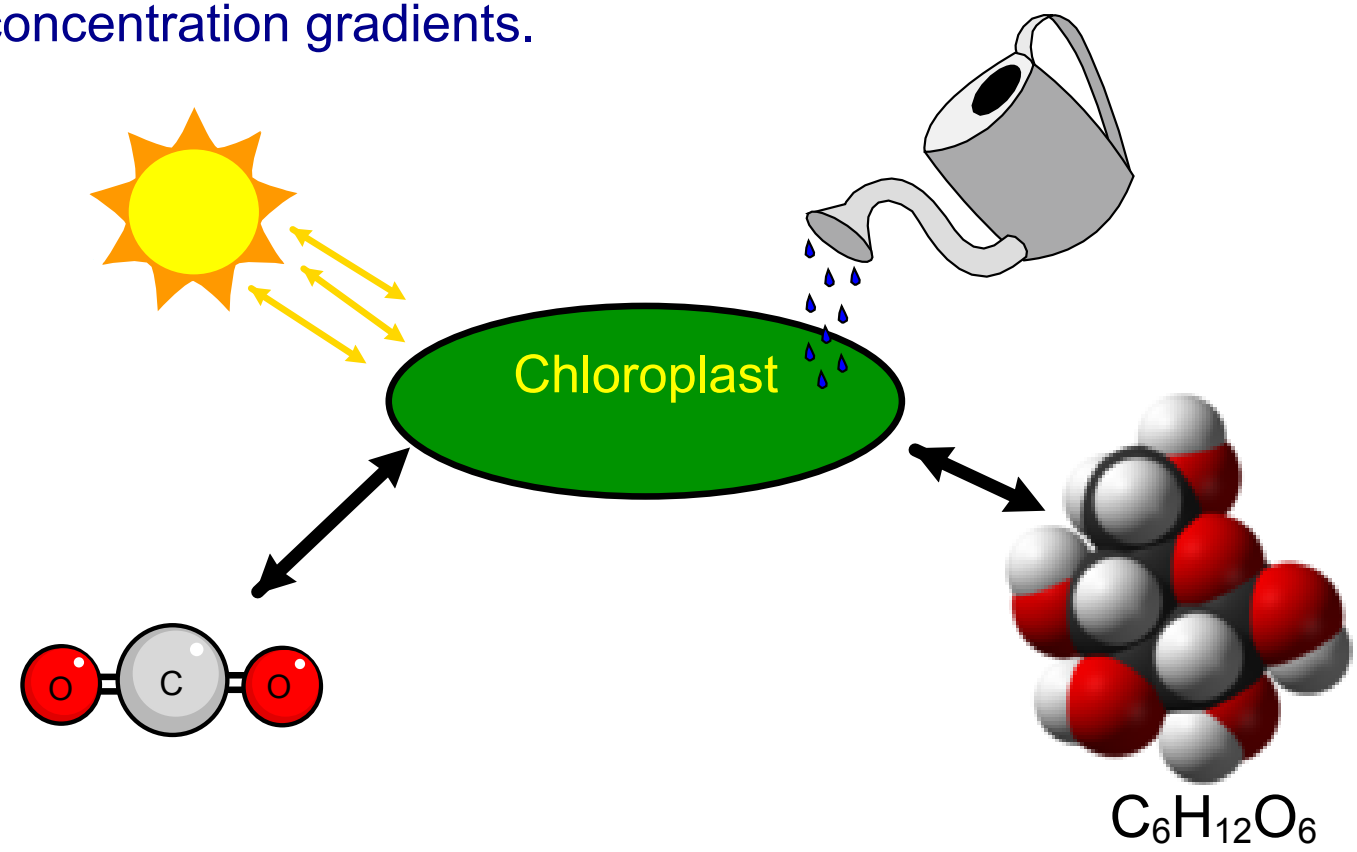
Water used up and concentration decreases

Carbon dioxide used up and concentration decreases

Glucose formed so concentration increases

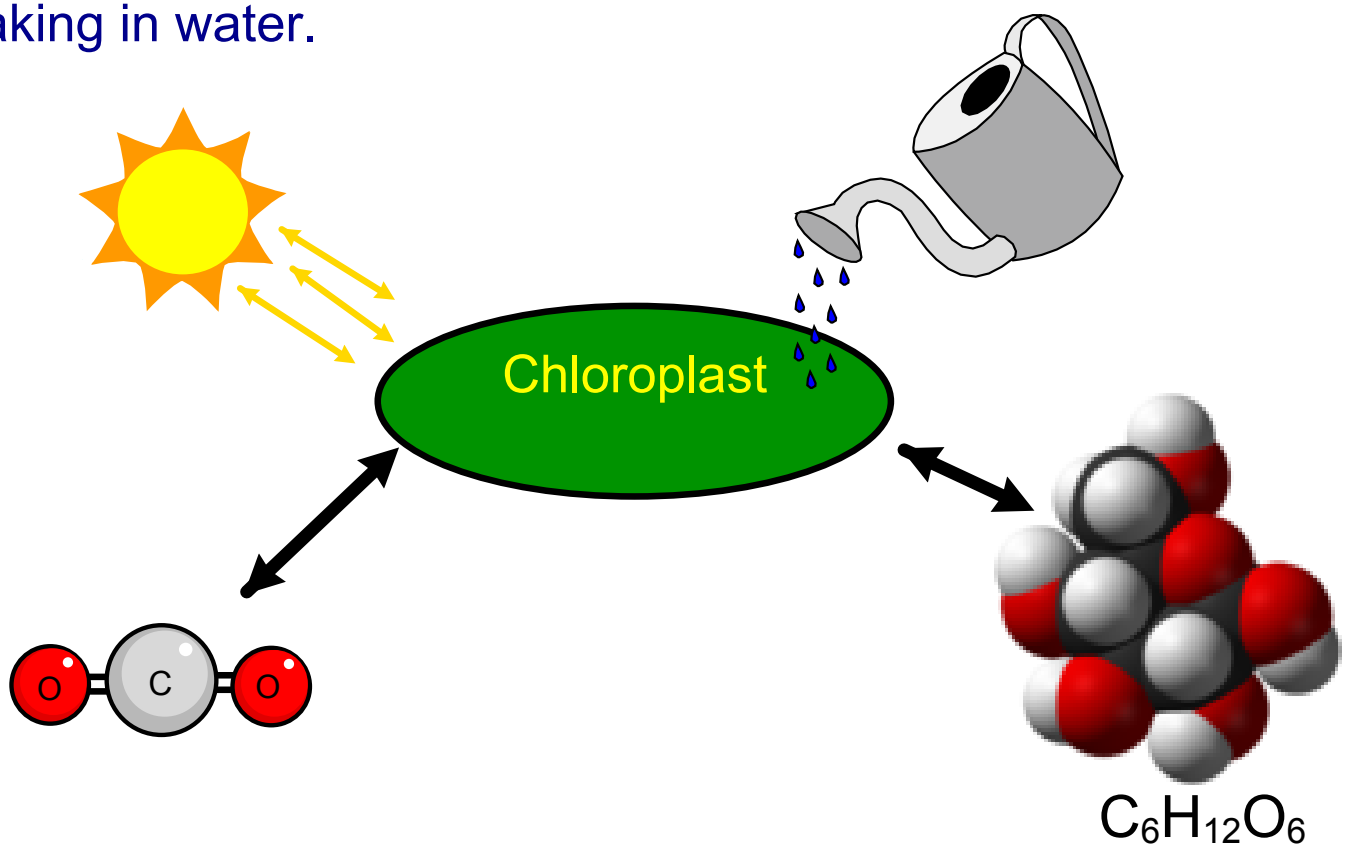
Homeostasis Example

Looking at this another way, the membrane is using diffusion to allow substances to enter and exit the cell based on concentration gradients.



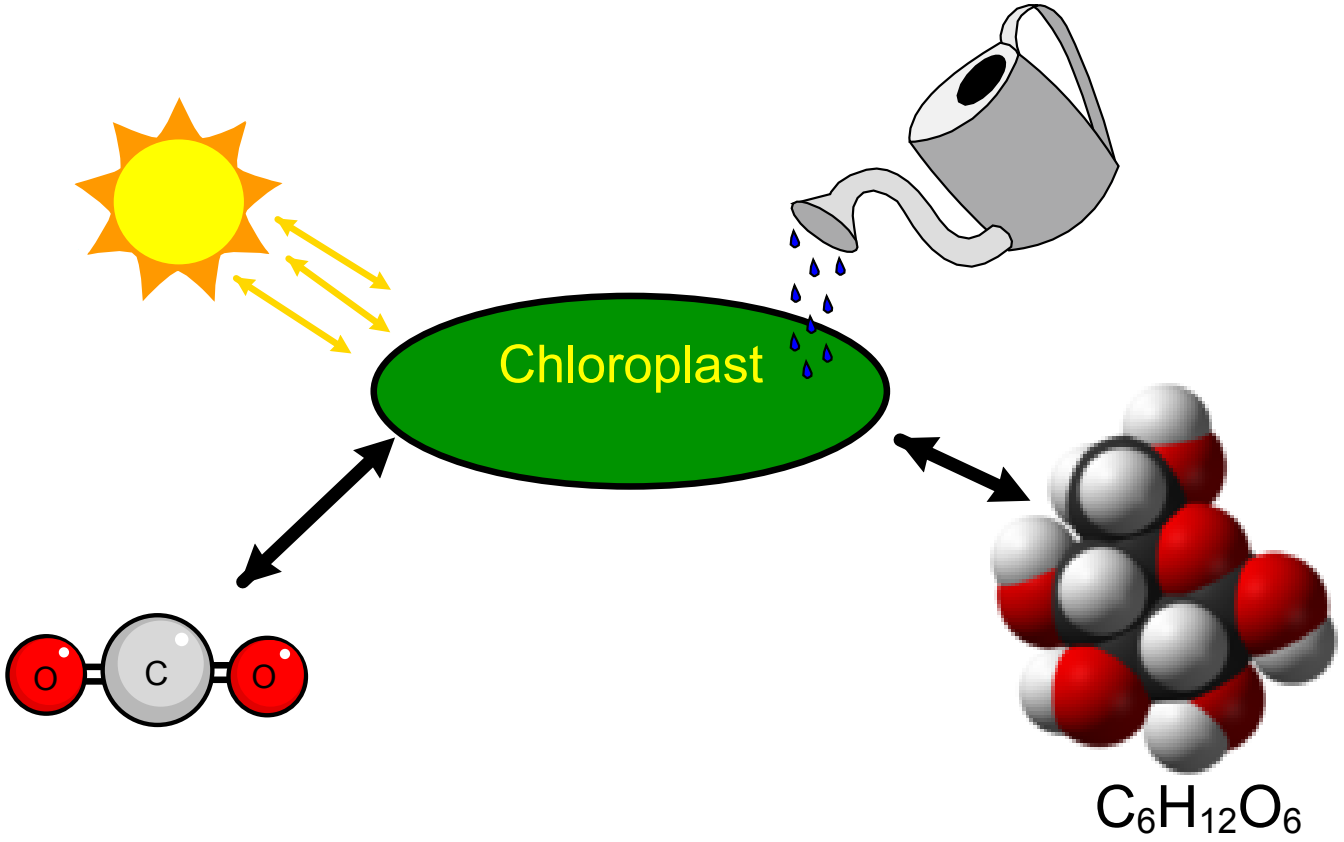
Homeostasis Example

If the external environment of the cell was lacking carbon dioxide, explain why the chloroplast would eventually stop taking in water.



Homeostasis Example

If there were a very high concentration of glucose outside the chloroplast what would happen to this process? Why?



Homeostasis

What we see by this example is that a membrane enclosed area can adjust its chemical processes or regulate its internal condition by simple physical laws such as diffusion.

When more complex regulations are added, ones that use active transport for example, homeostasis can be more tightly controlled, allowing for more complex biological systems.

Metabolism in Cells

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Energy Management

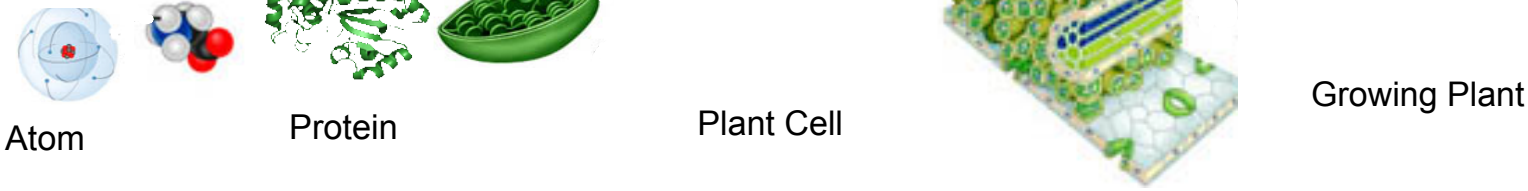
The most important part of homeostasis is the utilization of energy. Without the production and use of energy homeostasis could not be **dynamically** regulated.

In other words, the process of homeostasis is one that is constantly changing to adjust to the constantly changing external environment. This change requires biological systems to do work.

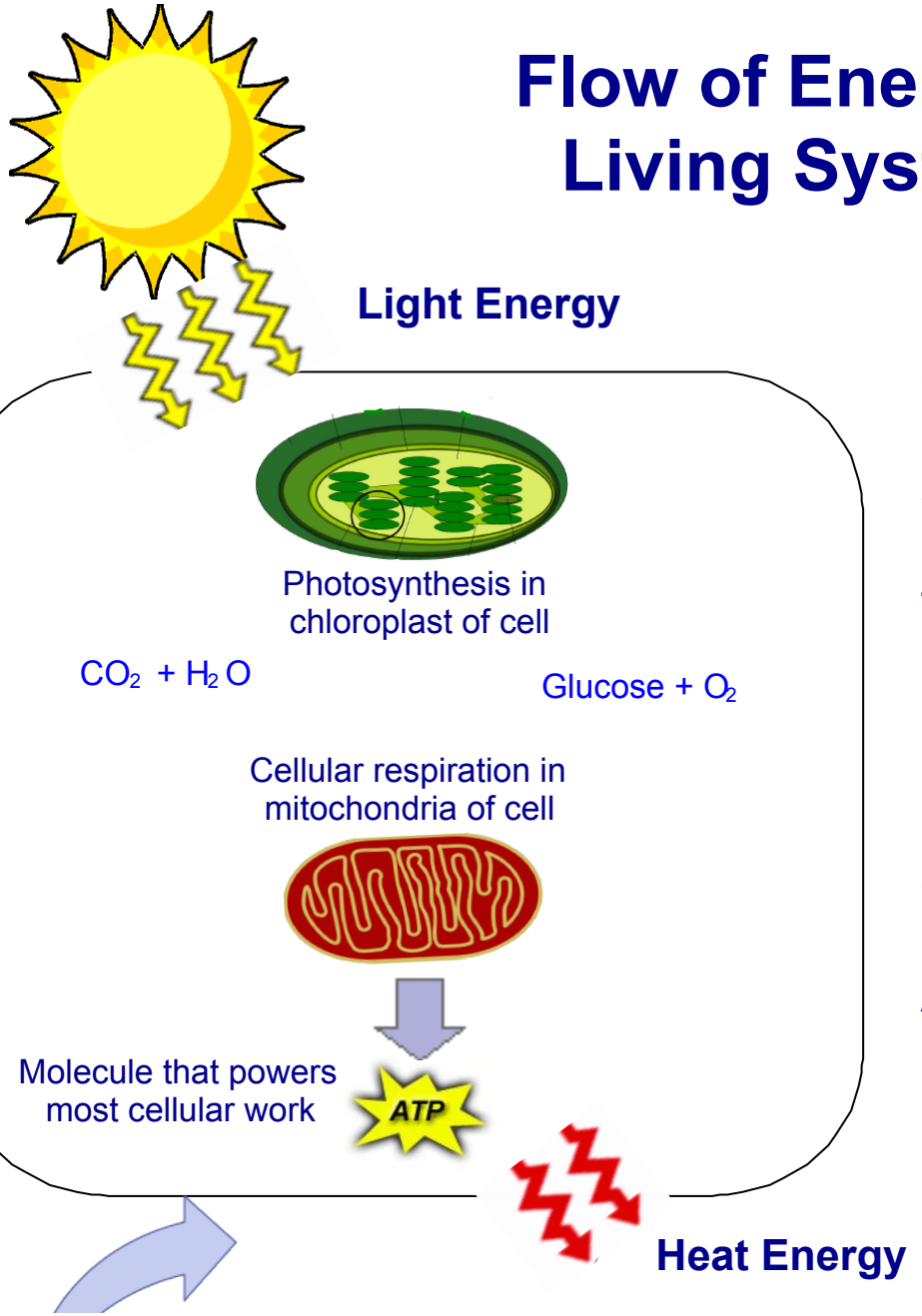
Life Processes

Biological systems utilize free energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

The organization and complexity of life requires a constant input of energy to power life processes.



Flow of Energy in Living Systems



In living systems, radiant energy is transformed into chemical energy in a series of chemical reactions that take place in the cell.

Energy is released from chemical bonds to power life processes. Some energy escapes as heat.

All living organisms rely on chemical reactions to drive life processes.

Metabolism

Metabolism is the totality of an organism's chemical reactions.
Metabolism is a property of all life.

There are two types of metabolic pathways:

Catabolic pathways
release energy by breaking down complex molecules into simpler compounds.

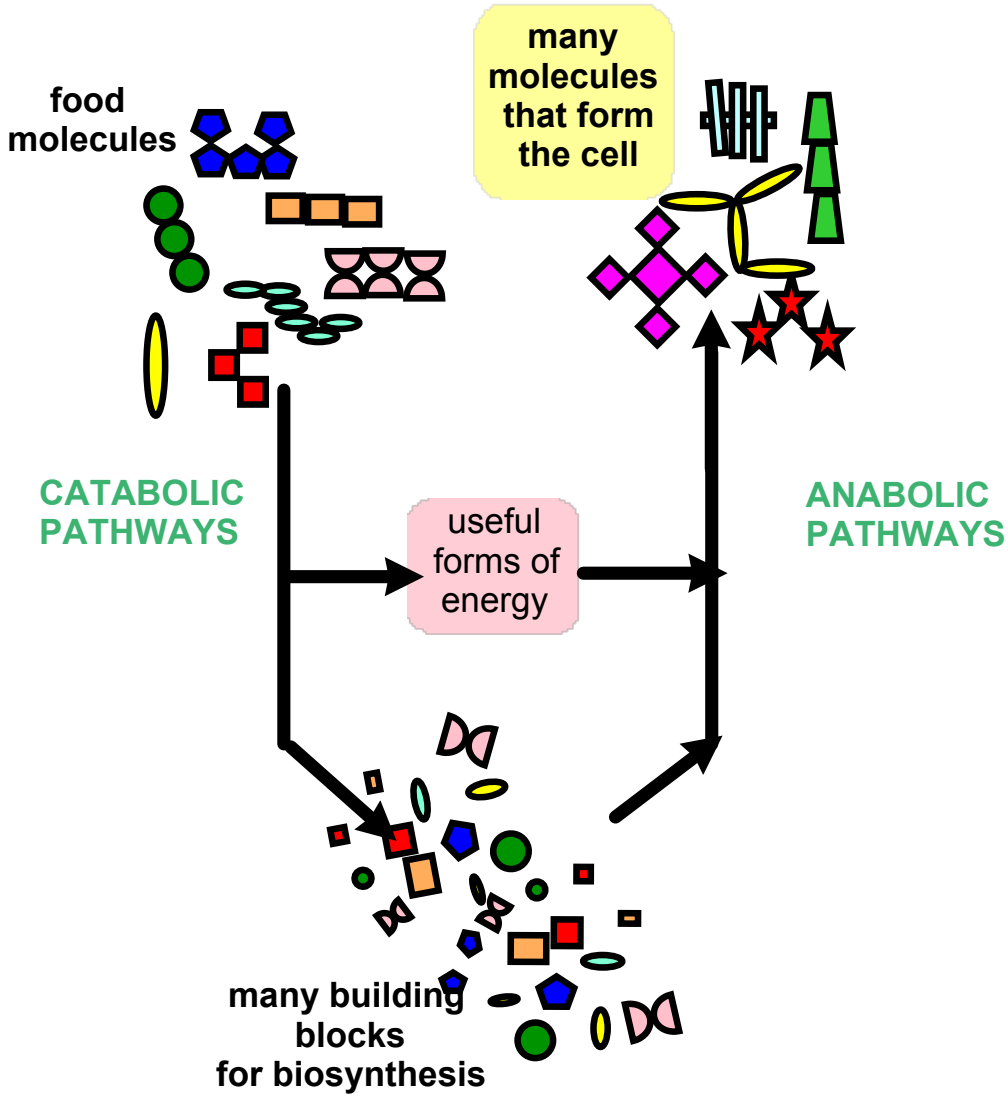
Anabolic pathways
consume energy to build complex molecules from simpler ones.

Biological Energy Flow

Living things use anabolic pathways to synthesize more complex organic molecules using the energy derived from catabolic pathways.

Molecules from the environment are broken down and their **energy and matter** are used to build structures in the organism and drive processes within them.

Living things still obey the **Laws of Thermodynamics.**



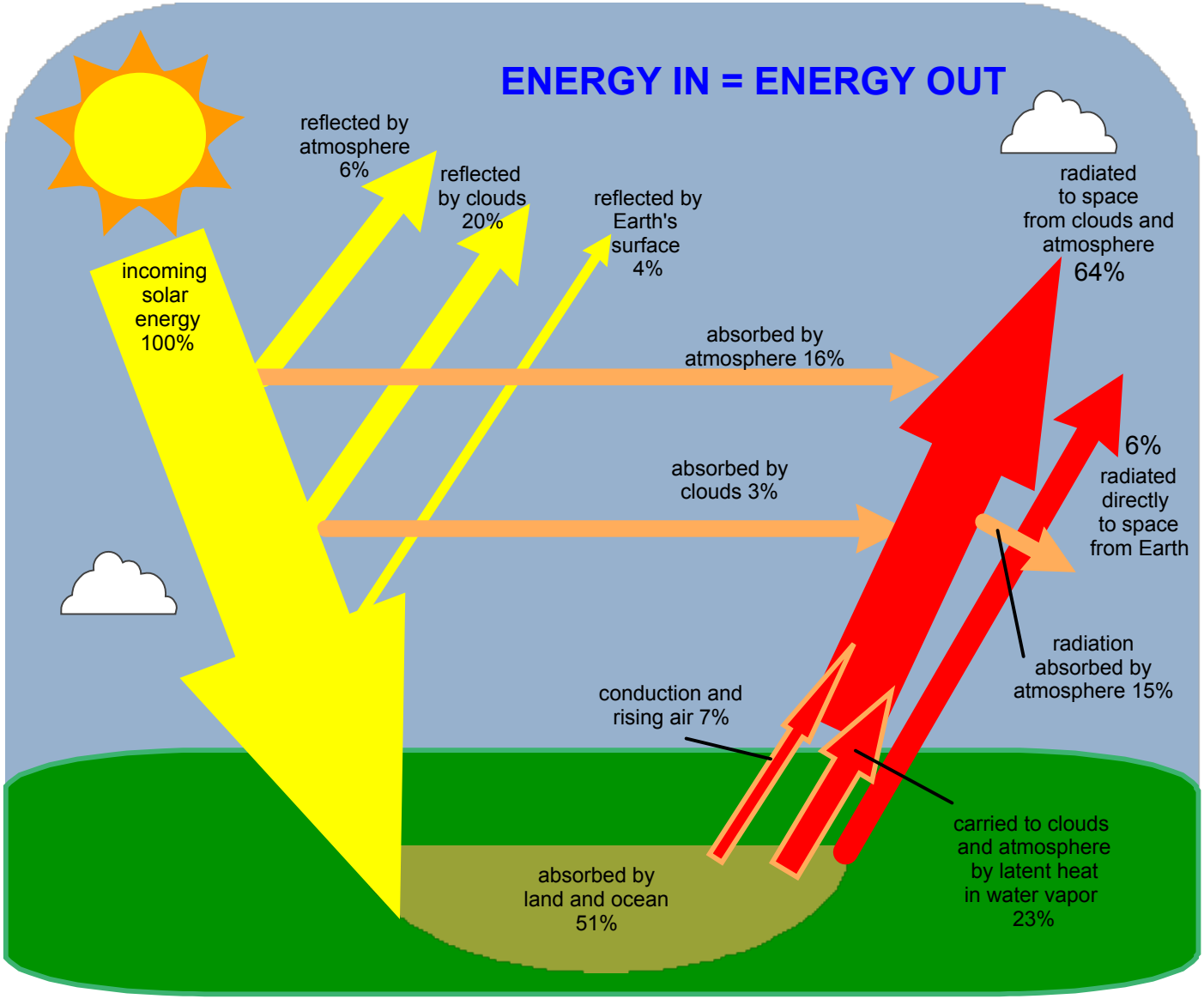
The First Law of Thermodynamics

$$\Delta E = w + q$$

Energy is neither created nor destroyed.

The total energy of the universe is a constant; if a system loses energy, it must be gained by the surroundings, and vice versa.

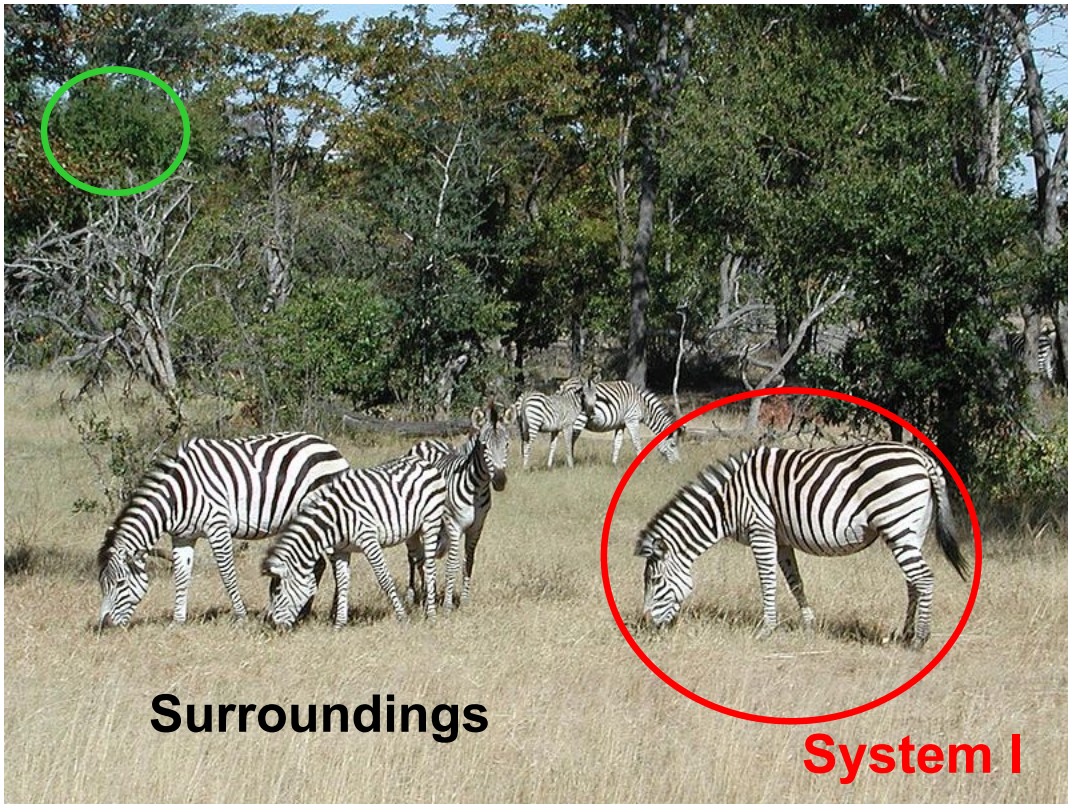
The First Law of Thermodynamics



System and Surroundings

The **system** includes whatever we want to study, living or non-living. The **surroundings** are everything else.

System II



25 In the previous slide, which of the following could be included in a study of system I?

- A Bacteria living in the intestine of the zebra
- B Heat loss due to water evaporation in zebras
- C Average rainfall in the savanna
- D Digestion and fermentation in the zebra gut

answer

Biological Order and Disorder

Entropy is a measure of the randomness or disorder of a system.

All life requires a very highly ordered system. Any loss of order or free energy flow will result in death. This order is maintained by constant free energy input into the system.

Increased disorder and entropy are always offset by biological processes that maintain or increase order. Life creates ordered structures from less ordered materials in **anabolic reactions.** Life also consumes ordered forms of matter and breaks them down, releasing energy, with **catabolic reactions.**

26 If an organism starts experiencing a loss of free energy flow, _____ can result.

- A decreased entropy
- B breakdown of polymers into monomers
- C death
- D anabolic reactions

answer

Biological Order and Disorder

Organisms increase the disorder of the universe in order to increase their own order.

Entropy may decrease in an organism, but the universe's total entropy increases. Energy input must exceed the energy lost to entropy to maintain order.

Life obeys the **Second Law of Thermodynamics.**

The Second Law of Thermodynamics

The Second Law is a statement about which processes occur and which do not.

· Heat can flow spontaneously from a hot object to a cold object; but not from a cold object to a hot object.

· The universe always gets more disordered with time.

· Your bedroom will get increasingly messy*unless you keep cleaning it up.*

Order to Disorder

Natural processes tend to move toward a state of greater disorder.

· When a tornado hits a building, there is major damage. You never see a tornado pass through a pile of rubble and leave a building behind.

· You never walk past a lake on a summer day and see a puff of steam rise up, leaving a frozen lake behind.

The First Law says all of these could happen, the Second Law says they won't.

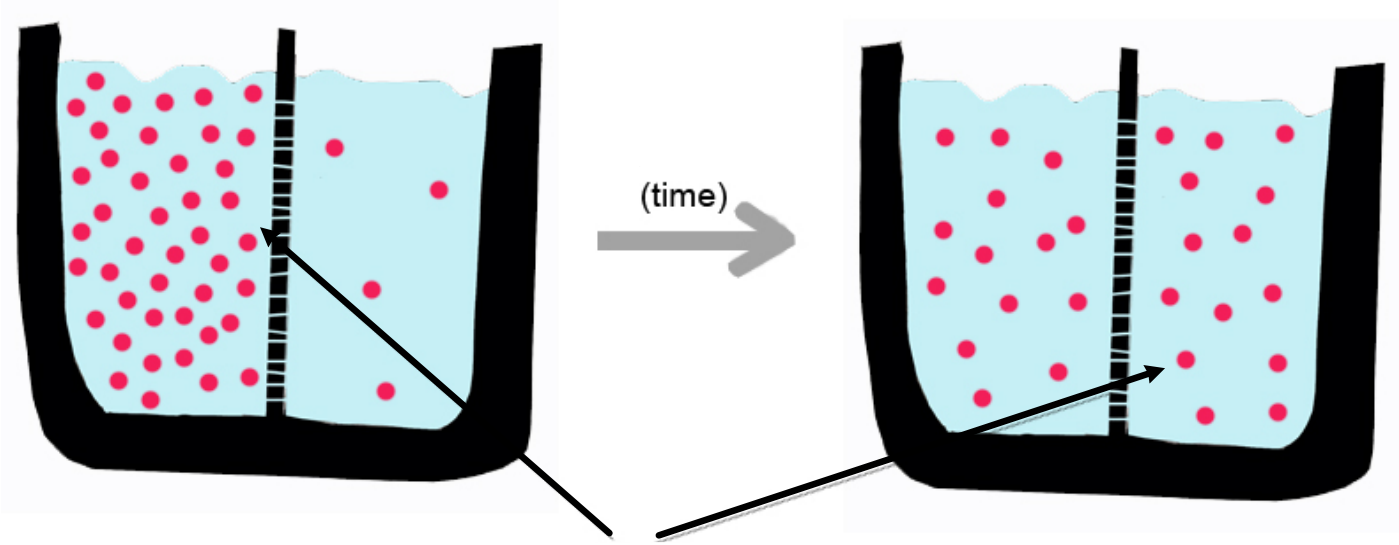
Spontaneous Processes and the Second Law

The Second Law tells us what will happen spontaneously, without outside intervention.

Spontaneous doesn't mean fast, it just means that it will naturally occur if a system is left on its own.

Spontaneous Processes

Processes that are spontaneous in one direction are nonspontaneous in the reverse direction.



diffusion is a spontaneous process

27 A reaction that is spontaneous _____.

- A is always very rapid
- B will proceed without any intervention
- C is always also spontaneous in the reverse direction
- D is always very slow

answer

28 The entropy of the universe is _____.

- A constant
- B continually decreasing
- C continually increasing
- D zero
- E the same as the energy, E

answer

29 Growth of an individual, and evolution of a species are both processes of increasing order. Do they violate the second law of thermodynamics?

- Yes
- No

30 If the entropy of a living organism is decreasing, which of the following is most likely to be occurring simultaneously?

A The entropy of the organism's environment must also be decreasing.

B Heat is being used by the organism as a source of energy.

C Energy input into the organism must be occuring in order to drive the decrease in entropy.

D In this situation, the second law of thermodynamics must not apply.

answer

31 According to the second law of thermodynamics, which of the following is true?

- A Energy conversions increase the order in the universe.
- B The total amount of energy in the universe is constant.
- C The decrease in entropy in life must be offset by an increase in entropy in the environment.
- D The entropy of the universe is constantly decreasing.

answer

Spontaneous Reactions

Biologists want to know which reactions occur spontaneously and which require the input of energy.

To do so, they need to determine the energy and entropy changes that must occur or what is known as the change in Gibbs Free Energy: ΔG.

Spontaneous Processes

A process will occur spontaneously if the result is a reduction of the **Gibbs Free Energy** (G) of the system. G takes into account the resulting change in the **energy** of a system **and** the change in its **entropy**.

G = Gibbs Free Energy
H = Enthalpy (total energy)
S = Entropy
T = Temperature

$$\Delta G = \Delta H - T\Delta S$$

Spontaneous Processes

If the effect of a reaction is to reduce G, the process will proceed spontaneously.

If ΔG is **negative**, the reaction **will** occur spontaneously.
If ΔG is **zero or positive**, it **will not** occur spontaneously.

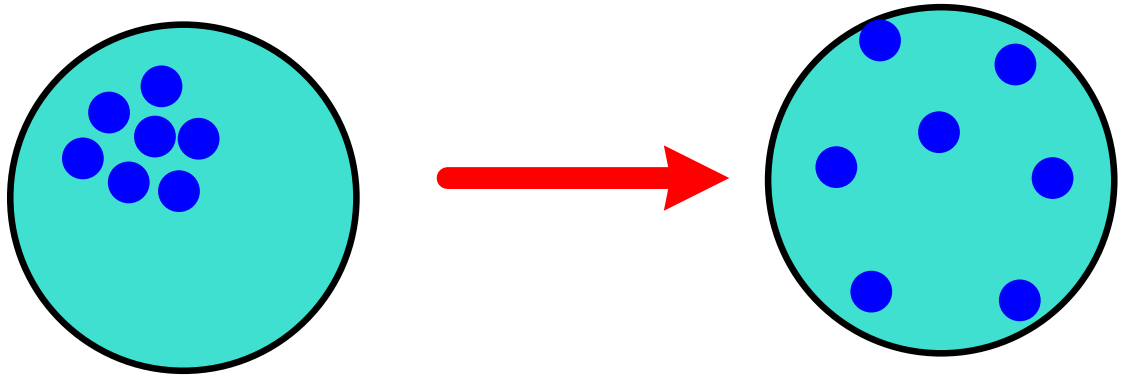
$$\Delta G = \Delta H - T\Delta S$$

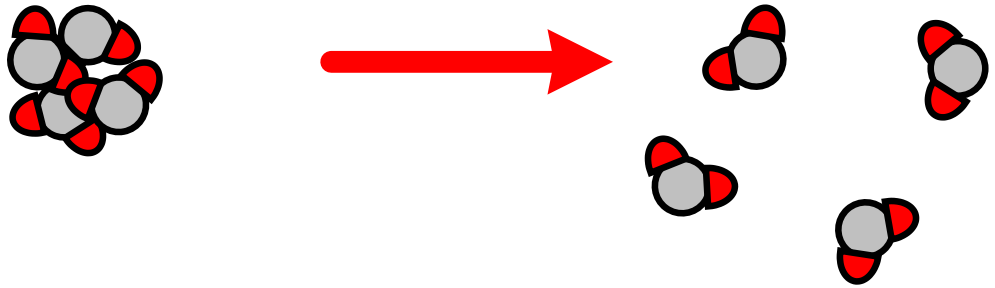
Free-Energy Change: ΔG

Exergonic reactions have a negative ΔG and occur spontaneously

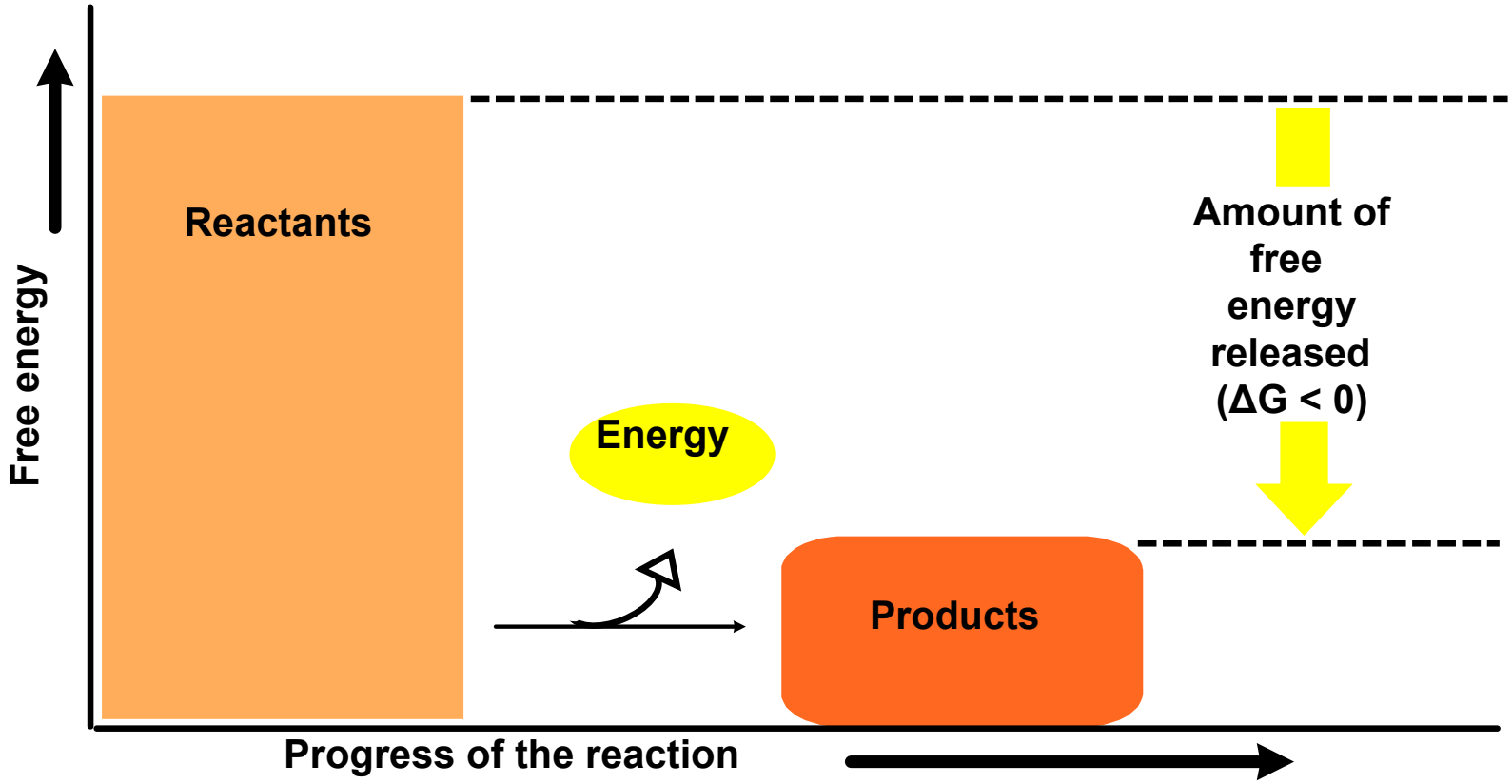
Endergonic reactions have a positive ΔG and do not occur spontaneously

Spontaneous (Exergonic) Processes

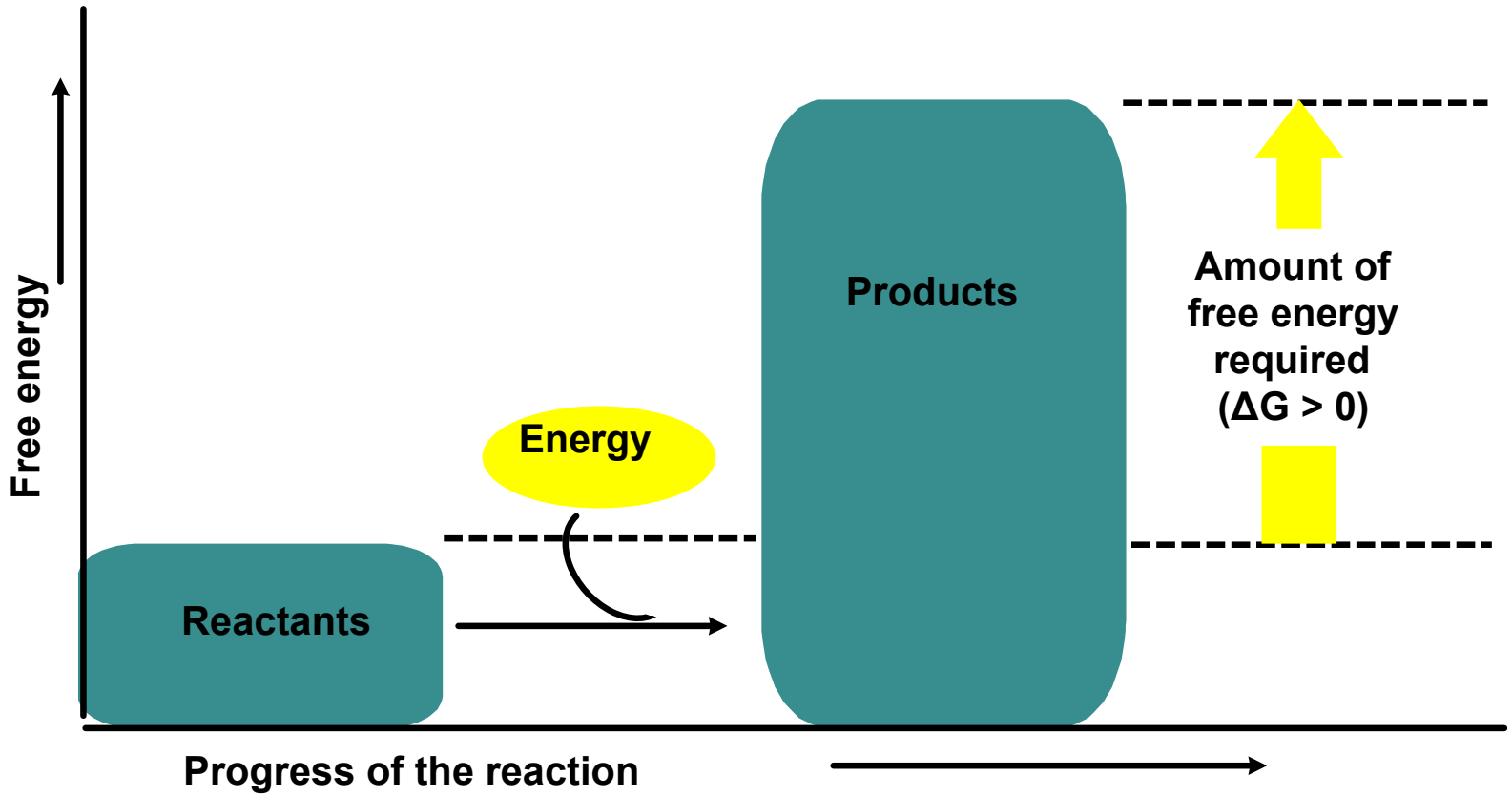




Exergonic Reaction



Endergonic Reaction



32 A spontaneous reaction _____.

- A occurs only when an enzyme or other catalyst is present
- B cannot occur outside of a living cell
- C releases free energy when proceeding in the forward direction
- D leads to a decrease in the entropy of the universe

answer

Free Energy and Metabolism

The concept of free energy applies to life:

Processes in living systems that lower the Gibbs free energy are **spontaneous;** they are **exergonic.**

Processes that raise the Gibbs free energy are **nonspontaneous;** they are **endergonic.**

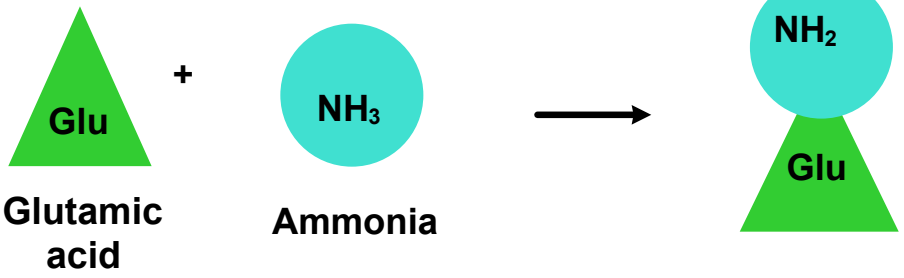
Free Energy and Metabolism

Biological systems often need an endergonic reaction to occur; on it's own, it won't proceed spontaneously.

But if it is **coupled** to a reaction that is exergonic, so that **together**, they are exergonic, it will take place.

Coupled Reactions

Non-spontaneous reaction: # *G* is positive



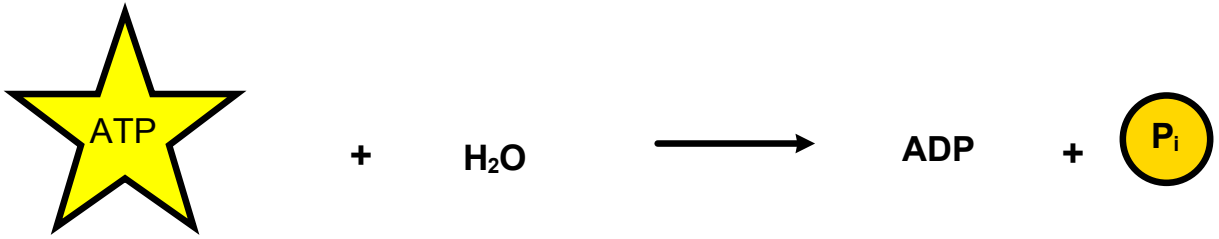
Glutamic acid

Ammonia

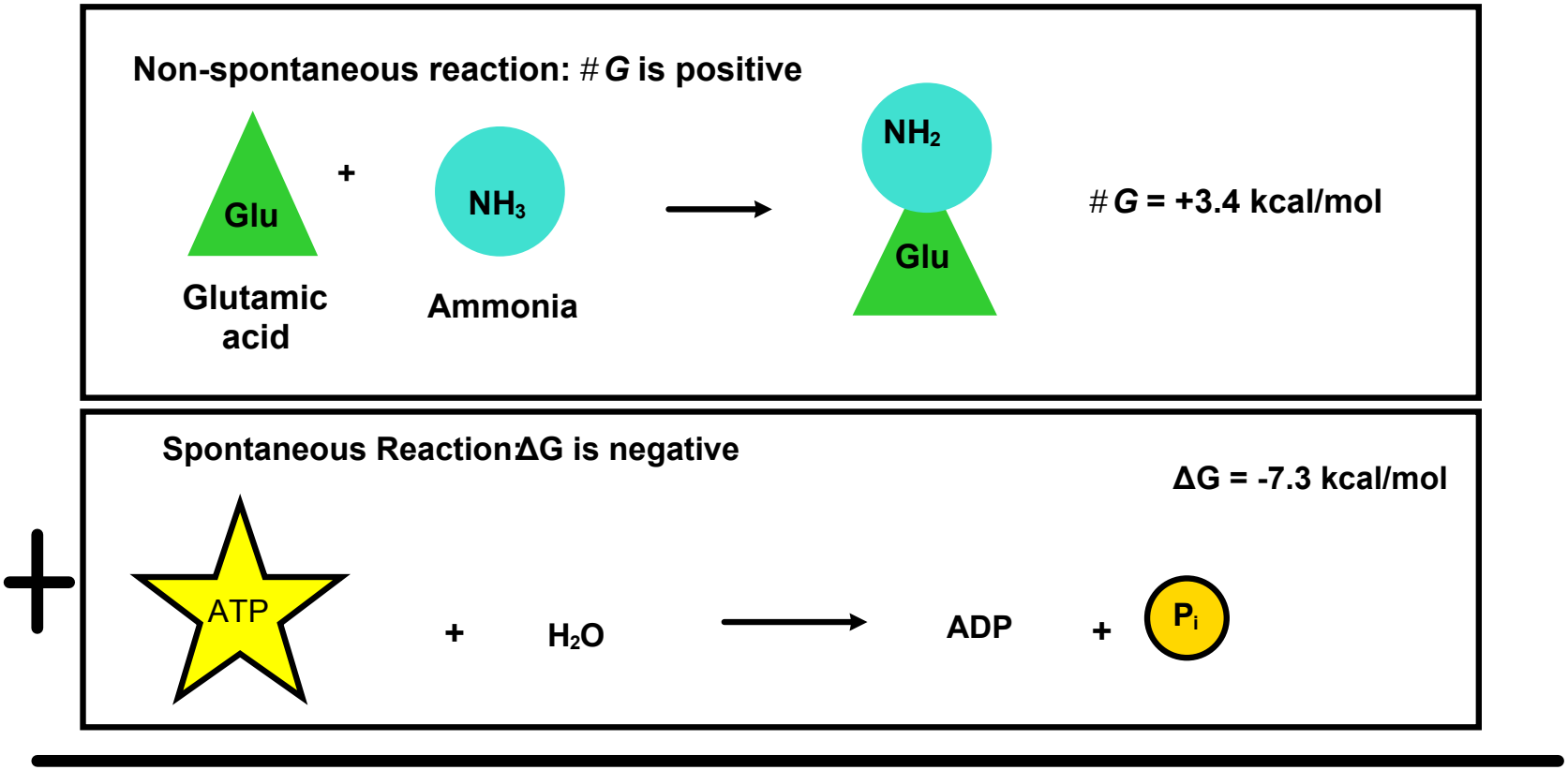
 # *G* = +3.4 kcal/mol

Spontaneous Reaction: ΔG is negative

ΔG = -7.3 kcal/mol



Adding Coupled Reactions



together, reactions are spontaneous

#*G* = –3.9 kcal/mol

33 Which of the following correctly states the relationship between anabolic and catabolic pathways?

A Degradation of organic molecules by anabolic pathways provides the energy to drive catabolic pathways.

B Energy derived from catabolic pathways is used to drive the breakdown of organic molecules in anabolic pathways.

C Anabolic pathways synthesize more complex organic molecules using the energy derived from catabolic pathways.

answer

Free Energy and Metabolism

A cell does three main kinds of work:

- Mechanical (motion)
- Transport (crossing a barrier)
- Chemical (changing a molecule)

To do work, cells manage energy resources by energy coupling, **using an exergonic reaction to drive an endergonic one**

NOTE: both processes don't have to occur at the same time, it's *possible to store the energy from an exergonic process to drive an endergonic process at a later time.*

Equilibrium and Metabolism

Reactions in a closed system eventually reach equilibrium and then stop.

Life is not in equilibrium

Life is an open system, experiencing a constant flow of materials and energy.

Life cannot survive without connection to the environment.

Role of Enzymes in Cell Metabolism

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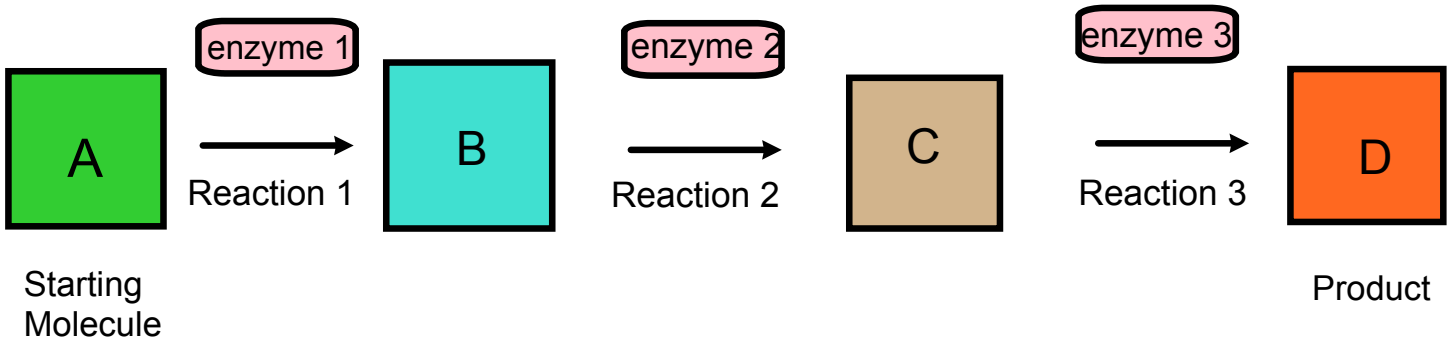
Metabolic Pathways

A **metabolic pathway** begins with a specific molecule and ends with a product.

Each step is catalyzed by a specific **enzyme.**

No enzyme = no reaction



Review of Enzymes

Enzymes are protiens that act as catalysts in biological systems.

This video covers an example of enzymes that is frequently used on the AP tests and reviews the function of enzymes.

Click here for a review of catalase

If further review is needed please see NJCTL's first year biology course.

Enzymess First Year Course

34 Which of the following is not part of allosteric regulation?

- A other substrate molecules compete for the active site
- B regulatory molecules bind to a site separate from the active site
- C inhibitors and activators may compete with one another
- D a naturally occuring molecule stabilizes an active conformation

answer

35 In allosteric regulation both an inhibitor and an activator can bind to one substrate complex at the same time.

- ○ True
- ○ False

answer

36 Feedback inhibition is a type of _____.

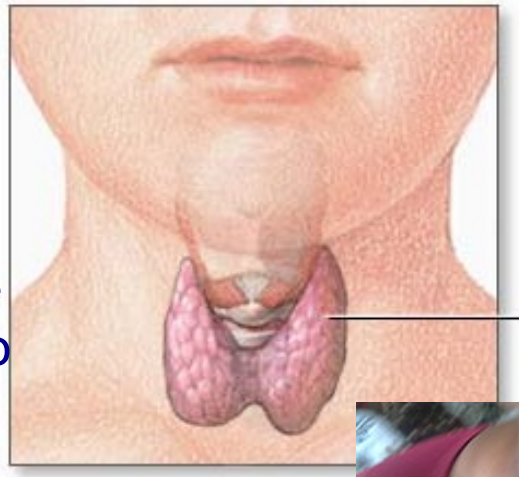
- A competitive inhibition
- B product
- C allosteric regulation
- D enzyme

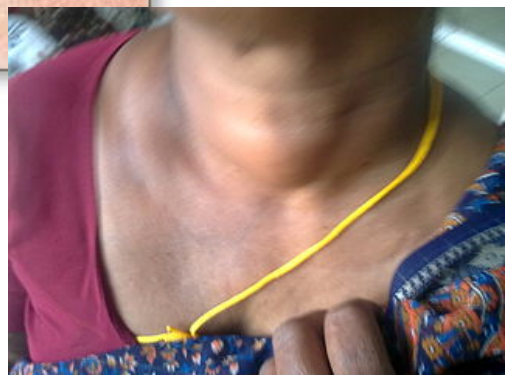
answer

Practicing Enzyme Metabolism Control

"Hyperthyroidism is a condition in which the thyroid gland makes too much thyroid hormone. The condition is often referred to as an overactive thyroid."
- US department of Health and Human Services

This disease effects more than 5% of woman in the United States (10x the rate in men).



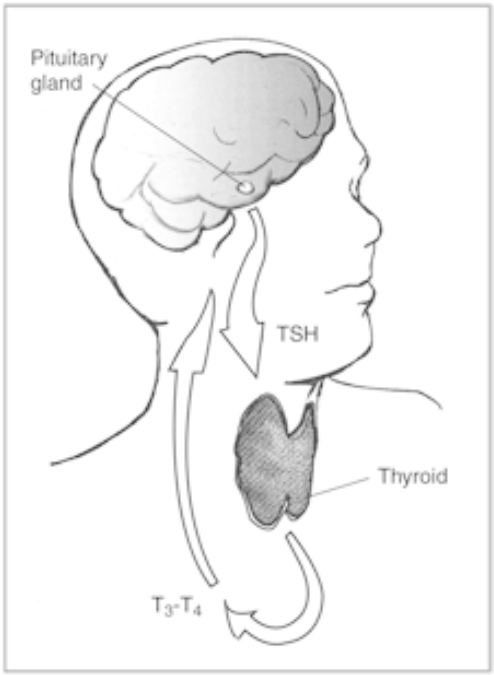


Swelling of the thyroid gland is a sign of hyperthyroidism.

Practicing Enzyme Metabolism Control

The thyroid gland controls how much energy is being produced by the body, by increasing or decreasing the amount of Thyroid hormone (T3) that is circulating in the blood.

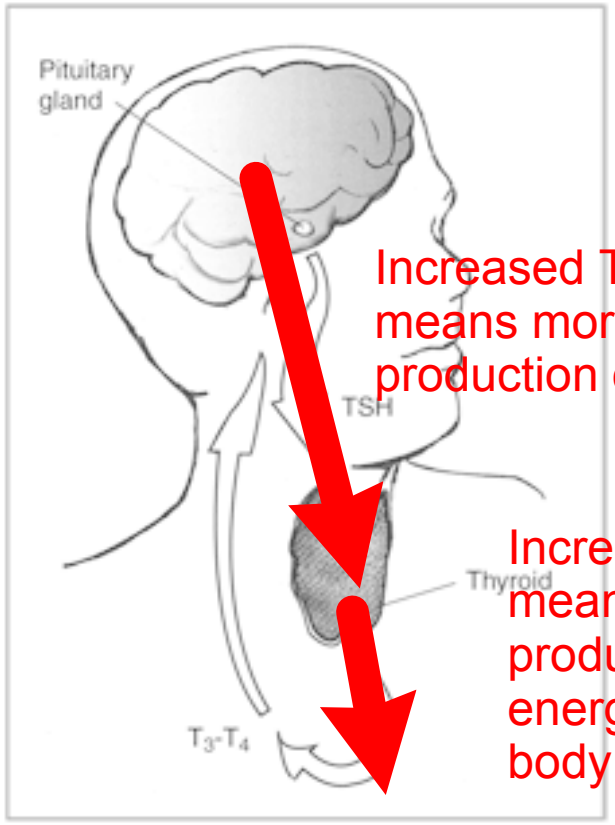
The thyroid is controlled by the brain which monitors levels of thyroid hormone and adjusts its signal to the thyroid accordingly.



lhttp://www.endocrine.niddk.nih.gov/pubs/Hyperthyroidism/

Practicing Enzyme Metabolism Control

This is known as a **feedback loop** Thyroid stimulating hormone (TSH) acts as a **co-enzyme** in thyroid cells that activates the metabolic pathway for production of T3.



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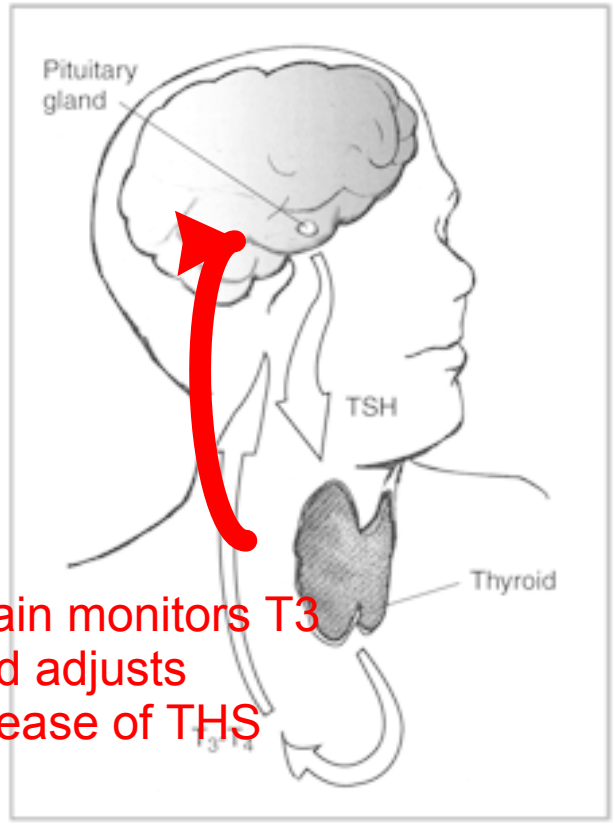
Practicing Enzyme Metabolism Control

When the brain has determined that there is sufficient T3 in the blood, it slows the release of TSH so the thyroid reduces the amount of T3 it is producing.

In this way, the brain is exhibiting **allosteric regulation** of the enzymes in the thyroid via release of a co-enzyme (TSH).



lhttp://www.endocrine.niddk.nih.gov/pubs/Hyperthyroidism/

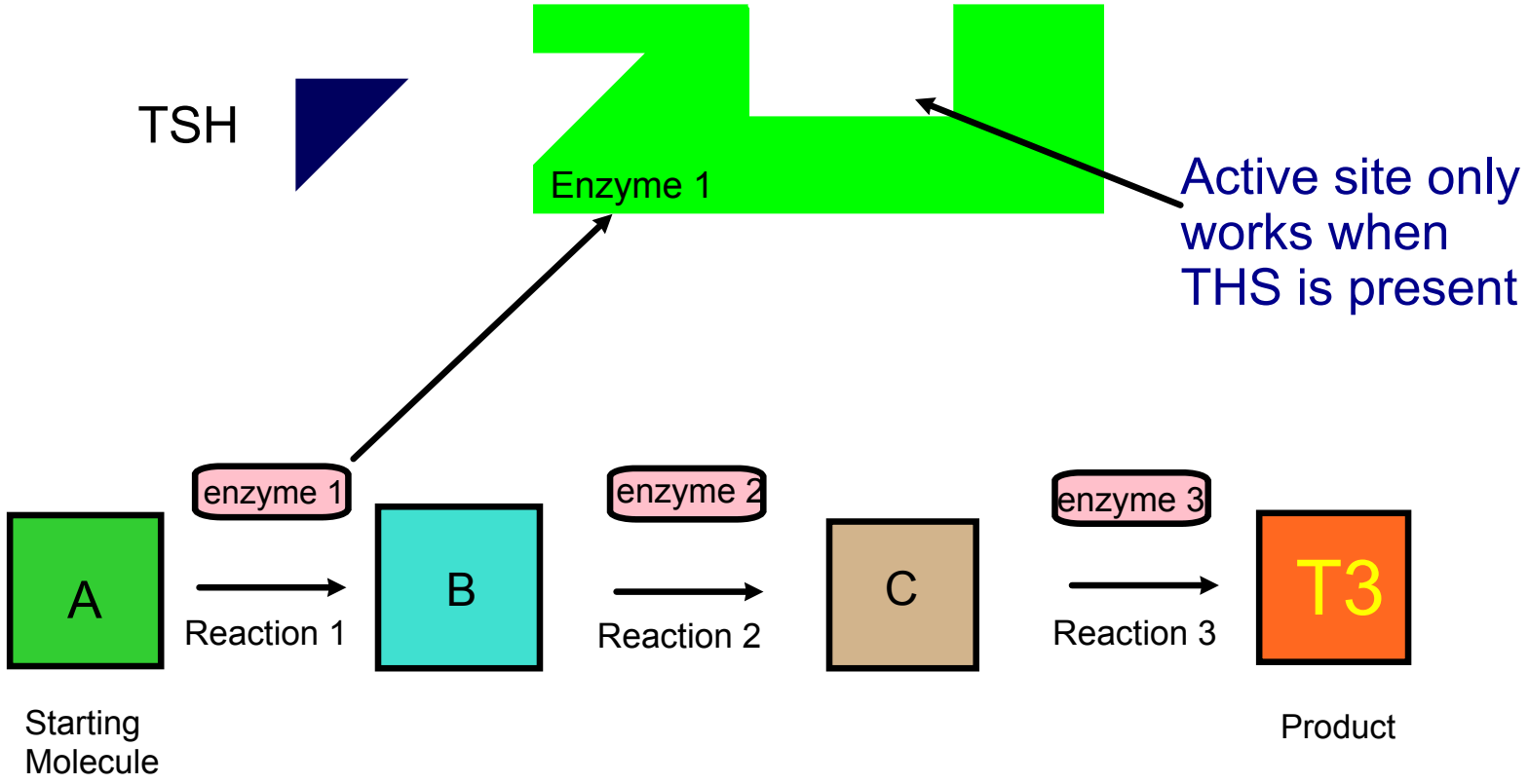
37 Organic molecules that aid in the action of the enzyme are called _____.

- A products
- B coenzymes
- C substrates
- D helpers

answer

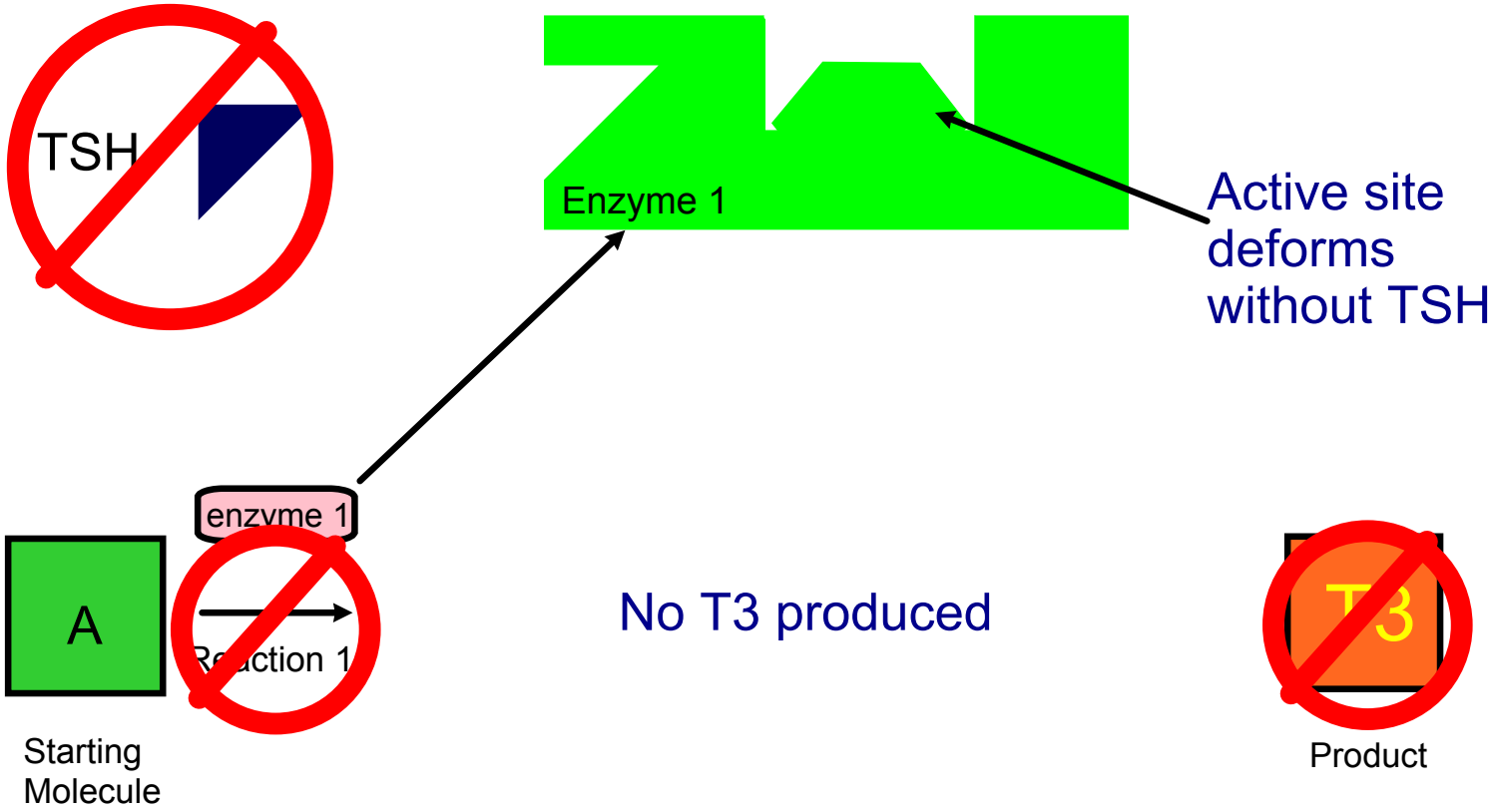
Allosteric Control

The enzyme at the start of the metabolic pathway that produces T3 requires TSH to work. TSH stabilizes the active site of the enzyme allowing it to bind with substrate A.



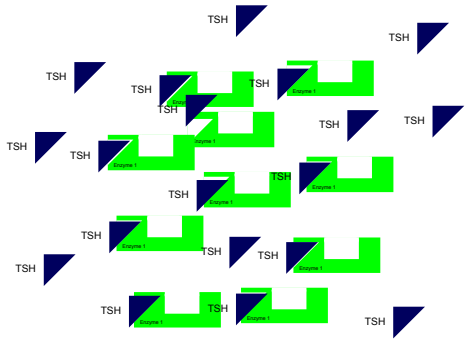
Allosteric Control

Without TSH, substrate B can not be produced and the pathway is shut down.

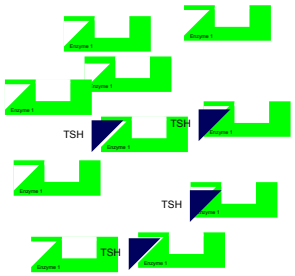


Enzyme Concentration

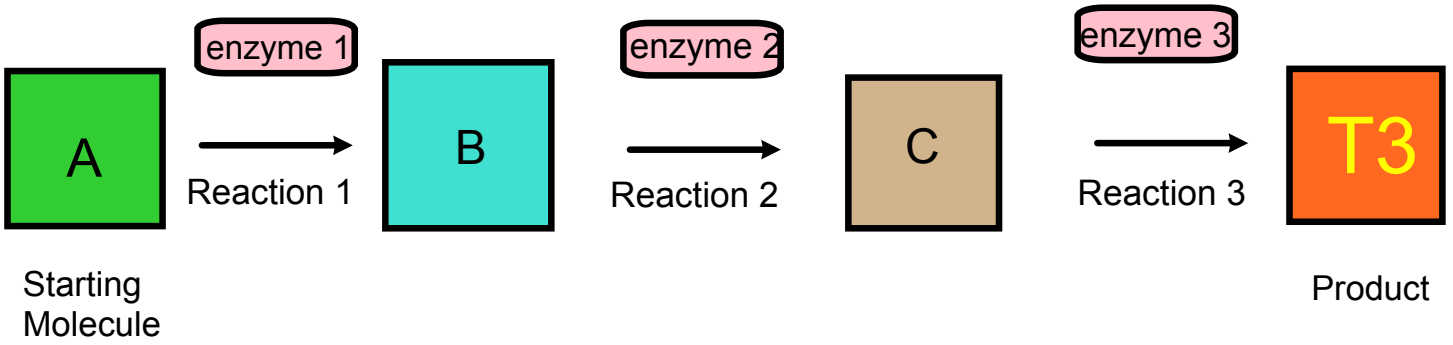
Remember that there are millions of enzymes so the amount of TSH dictates how much T3 the pathway will produce



Excess TSH = Highest production of T3



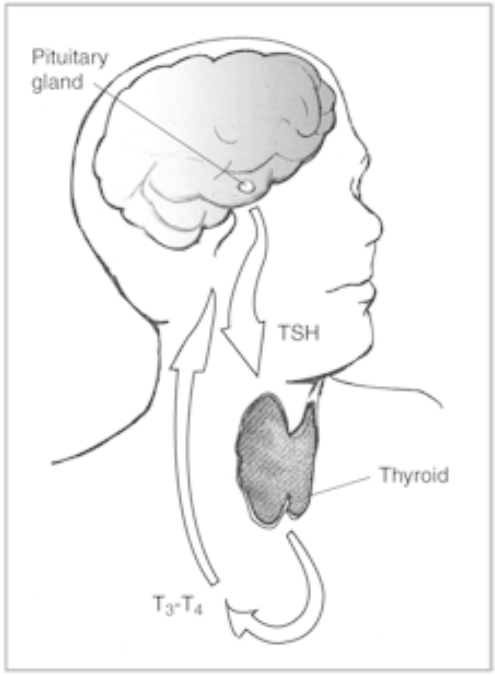
Only a small amount = less production



Back to Hyperthyroid

Now that you understand the process of thyroid control, suggest ways in which this regulation may be lost, thus producing hyperthyroidism.

Work with a partner or group to suggest at least 2 ways that this may happen.



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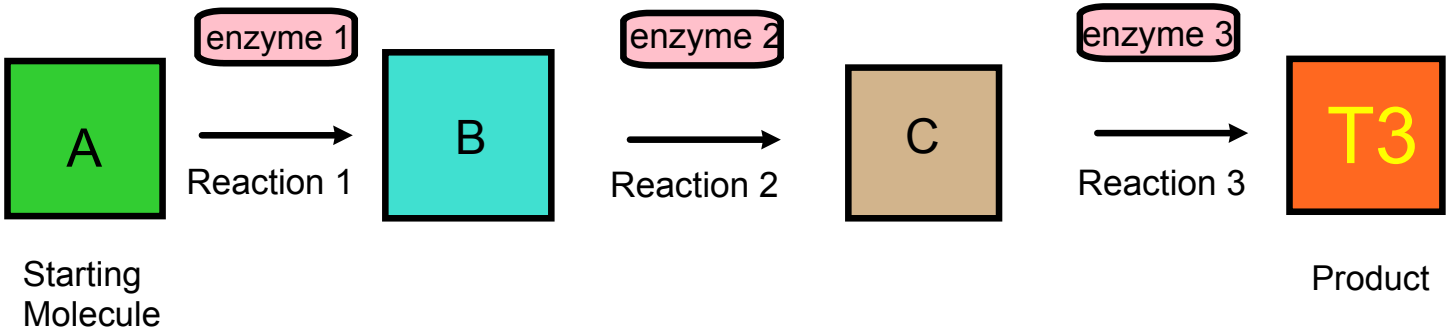
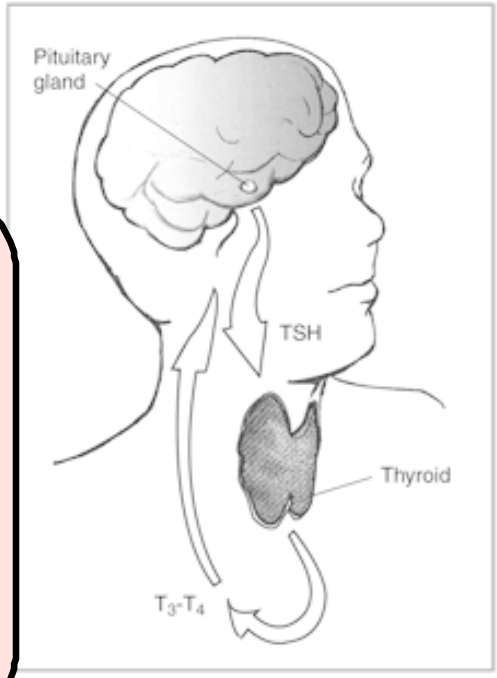


Back to Hyperthyroid

Some actual reasons for the disease...



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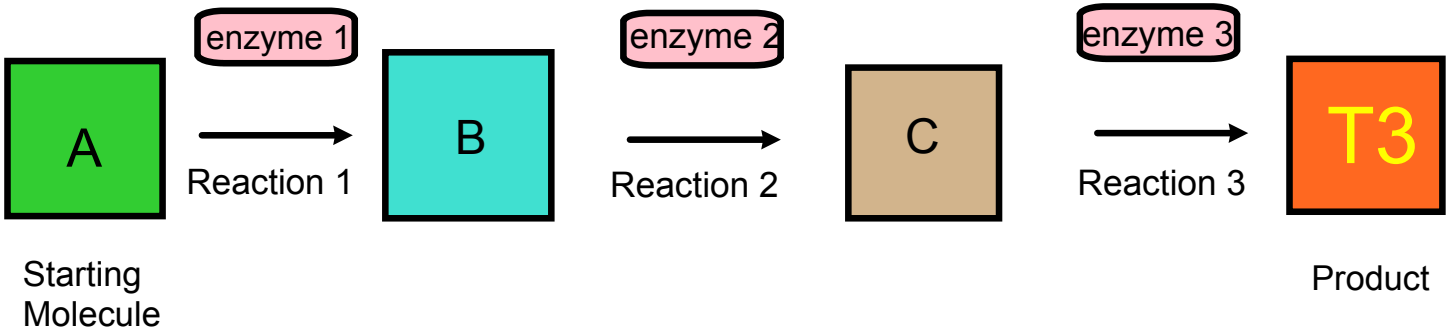
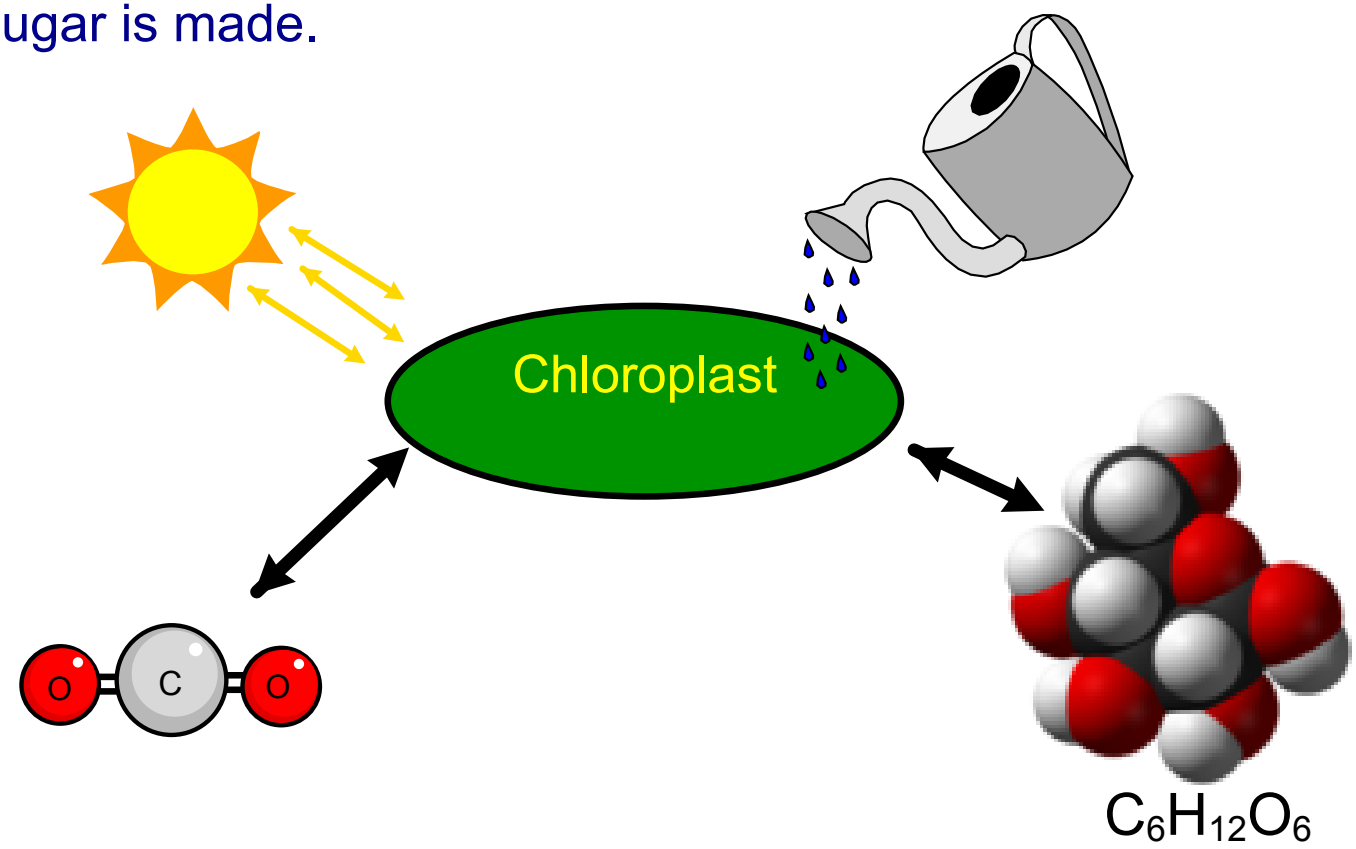


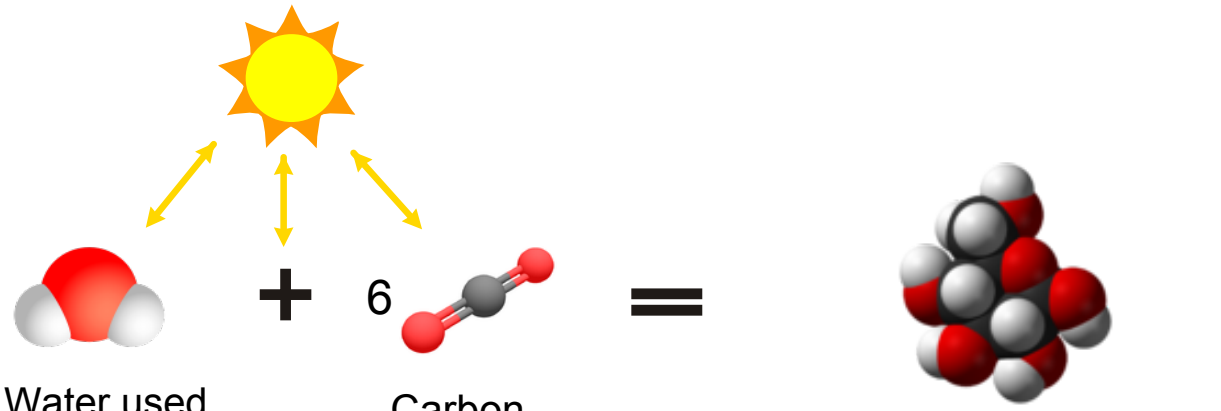
Enzymes in a Chloroplast

Recall our simple diagram of a chloroplast. Imagine it is part of a larger biological system that needs to control when sugar is made.



Enzymes in a Chloroplast

We will need to expand this simple diagram to understand how this biological system can control the reaction



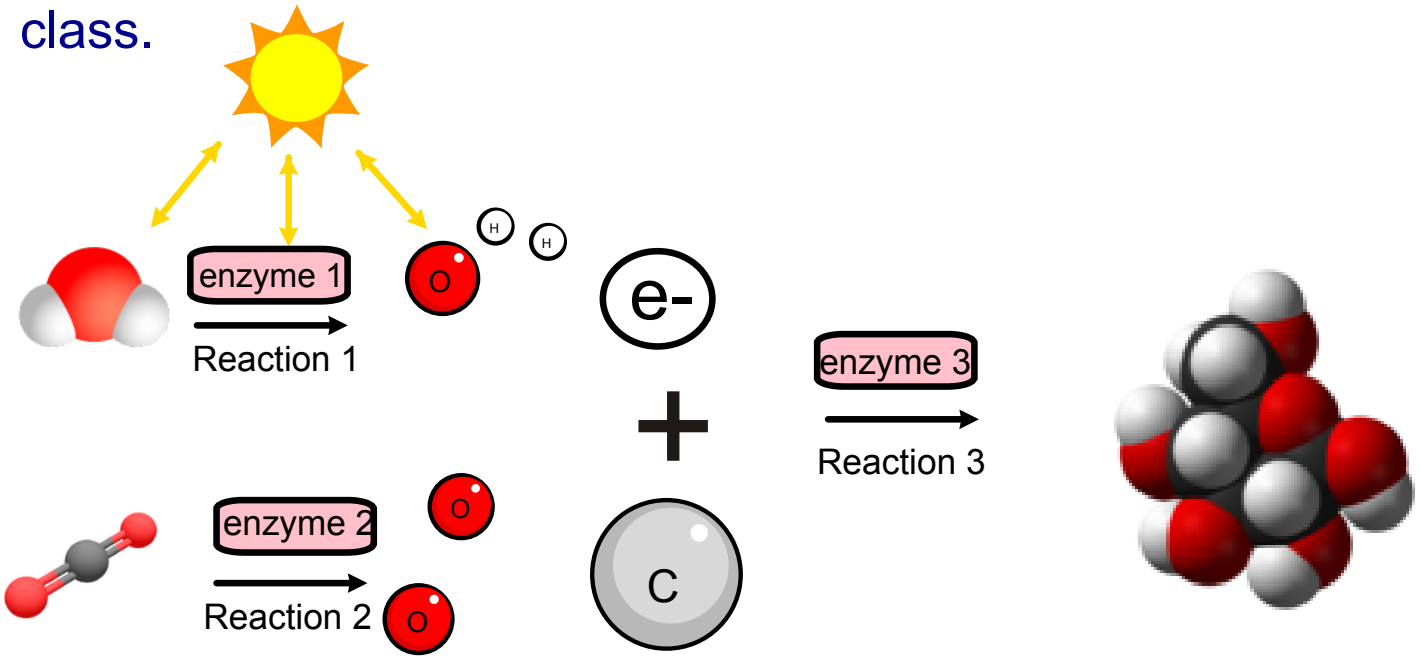
Water used up and concentration decreases

Carbon dioxide used up and concentration decreases

Glucose formed so concentration increases

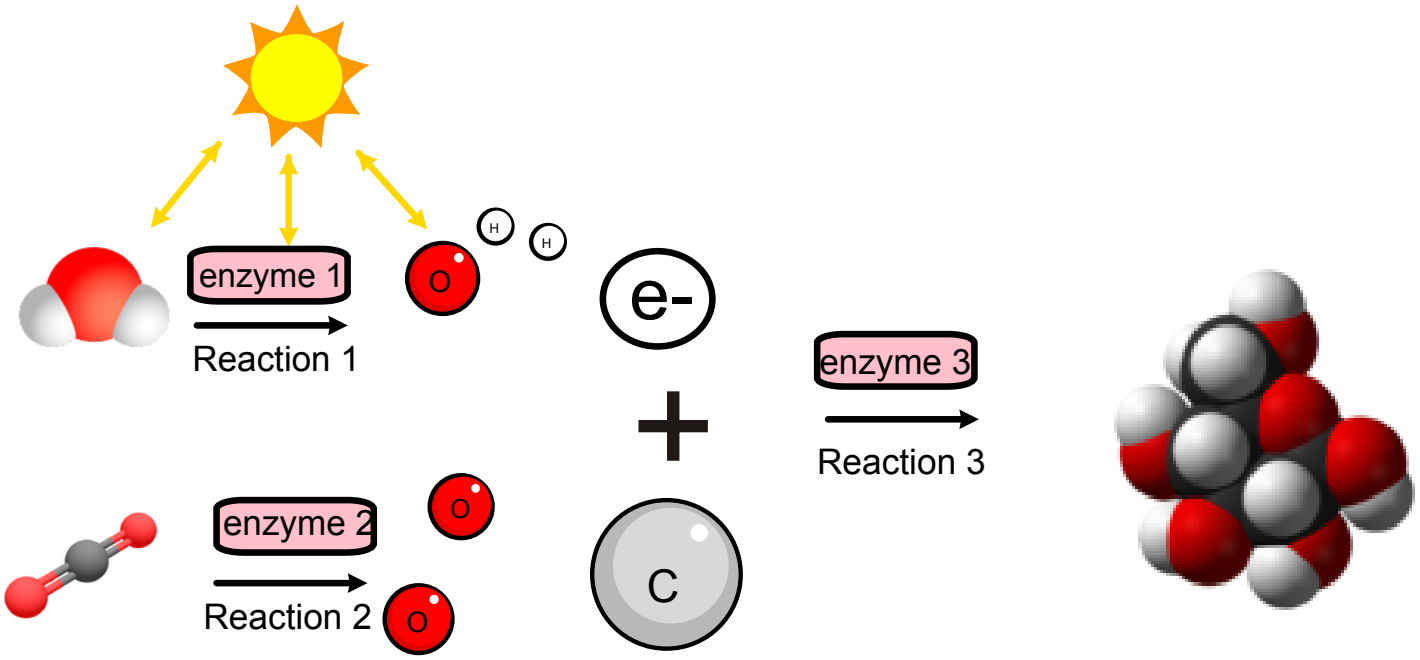
Enzymes in a Chloroplast

Work with a group to formulate a plan that would allow a system to monitor the amount of glucose present and adjust production accordingly. Draw a diagram and share with the class.



Enzymes in a Chloroplast

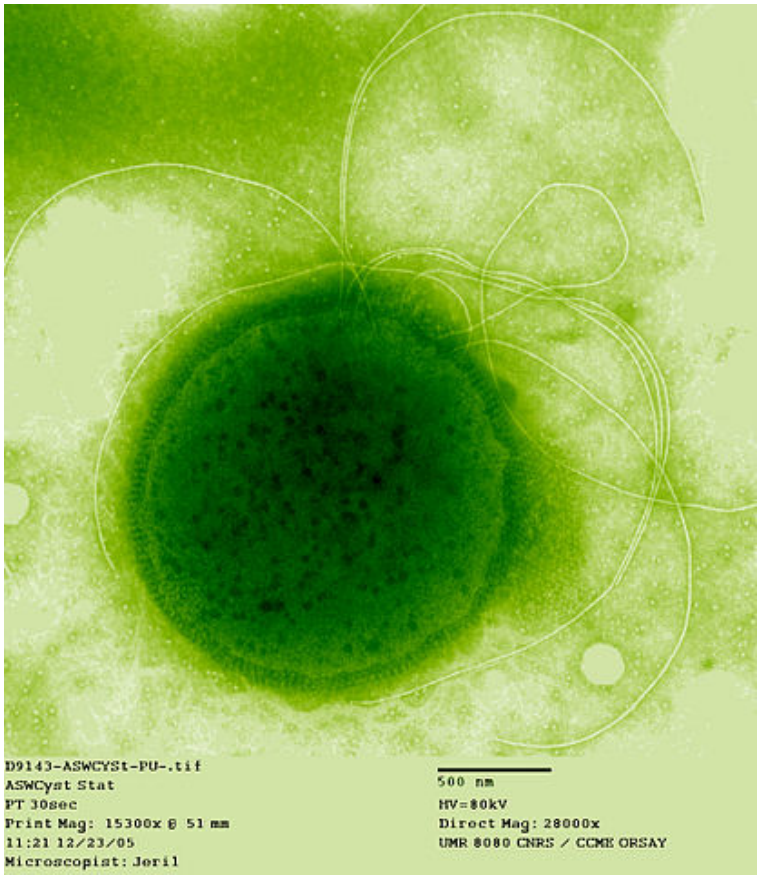
Though this is still simplified (we will see this expanded further soon), it is enough to pose a question: What would be a good way for a biological system to regulate sugar production?



Evolution and Metabolism

As early prokaryotic life forms began to evolve, those capable of more efficient metabolism were favored in natural selection.

Some prokaryotes developed the ability to convert UV radiation into chemical energy. These had a distinct advantage because they were able to utilize the most abundant energy source available on earth: **sunlight**



Evolution and Metabolism

Today, because of the effectiveness of biological sunlight utilization, almost all living things (99.99999%) rely on the energy from sunlight in some way.