Theory

2 Relevant Laws:

First:

- Matter, and energy can not* be created or destroyed.
- Transformations ARE ALLOWED!

Organisms are energy processing systems.
Energy from the Sun, or from Chemical Bonds is used to undertake cellular/organismal work

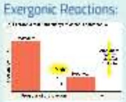
Work: Anything that requires atoms to be moved around through cellular actions (aka: "everything you do")

Kinetic & Potential Energy

Both are useful to organisms for different purposes.
Both contribute to phenomena at all levels of organization in the Universe.

Gibbs Free Energy:

Exergonic Reactions:



- Release energy (matter is converted from higher energy arrangements to lower energy arrangements)
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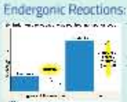

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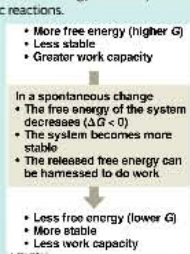
Biological Systems use Exergonic Reactions to provide the free energy necessary for endergonic reactions.



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Living systems are not the only systems in the universe that require energy conversion to function.

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Cellular Energy Theory:

ATP!

Adenosine Tri-Phosphate

- The short term energy storage/release molecule of choice in cells.

The Return of Kinetics

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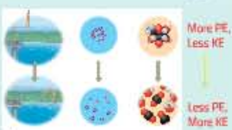

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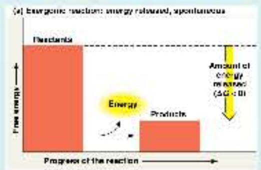

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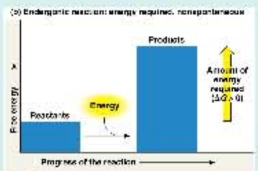

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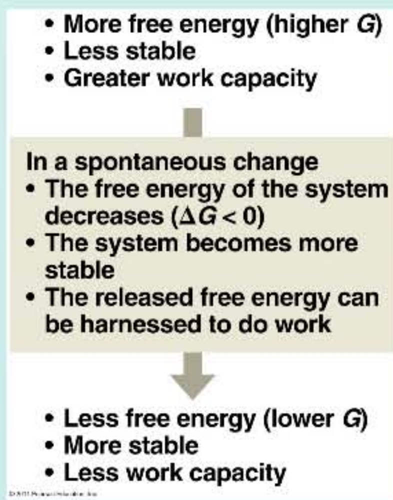

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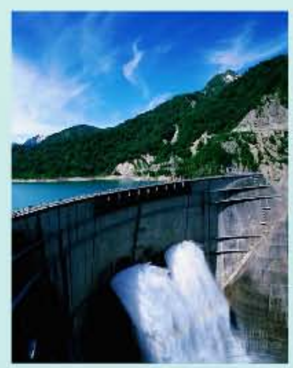

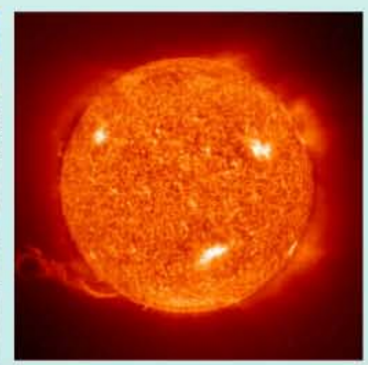

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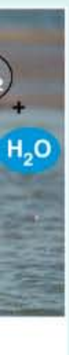

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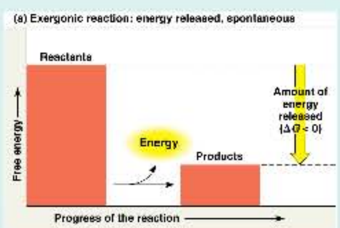

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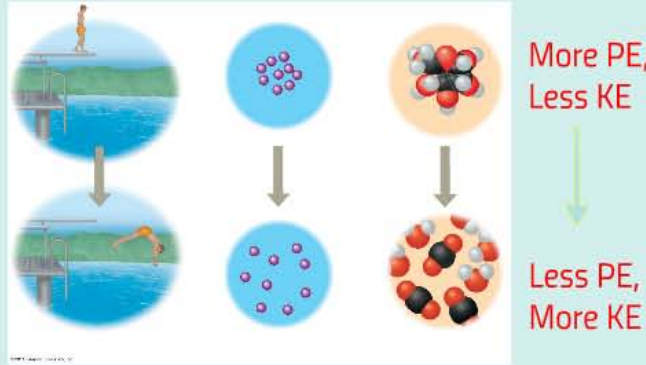

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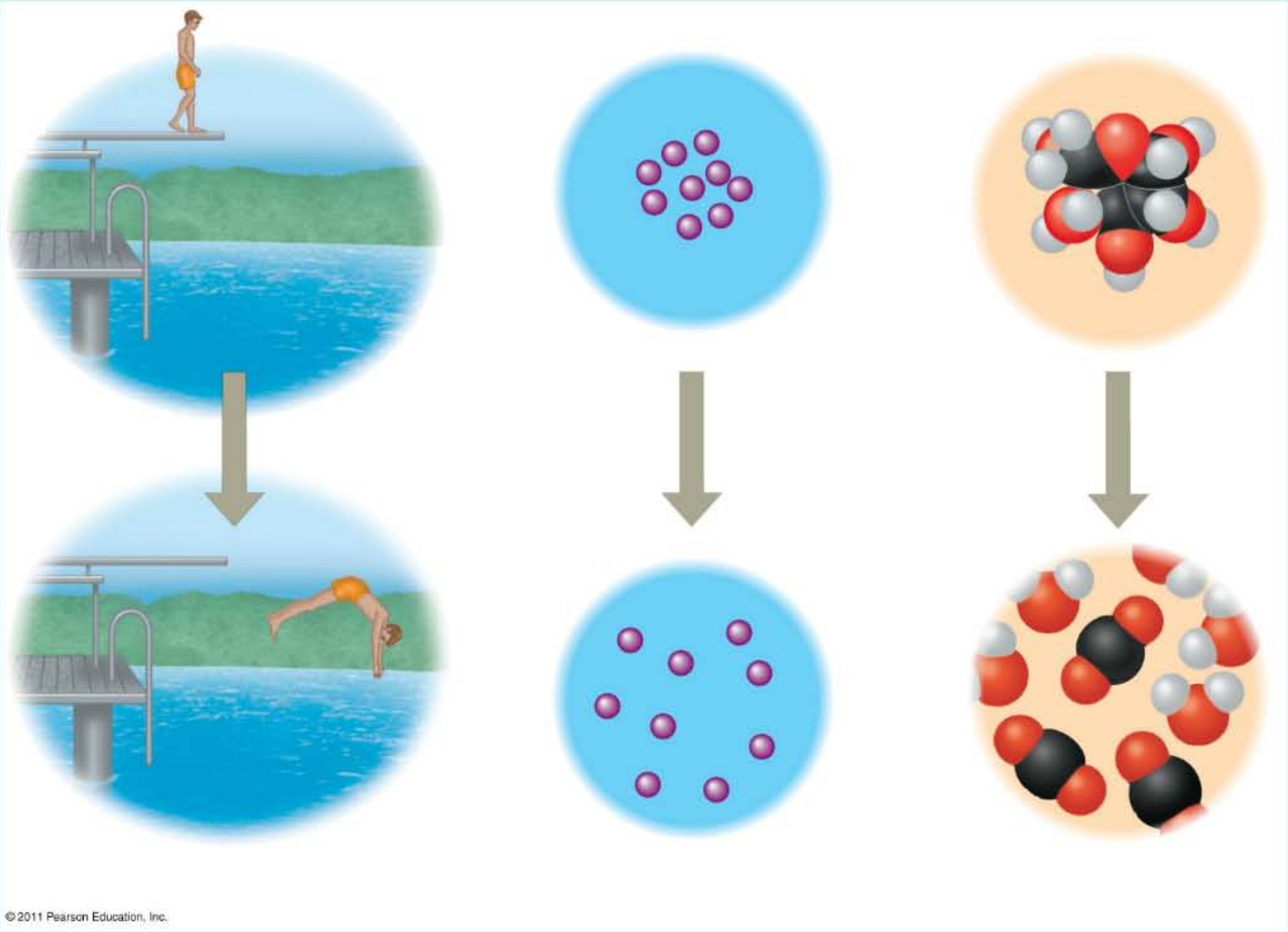

More PE,
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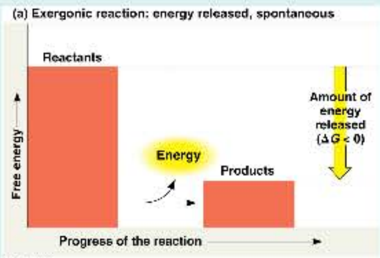

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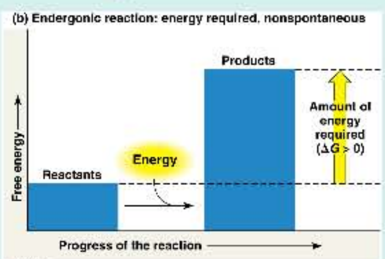

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Biological Systems use Exergonic Reactions to provide the free energy necessary for endergonic reactions.

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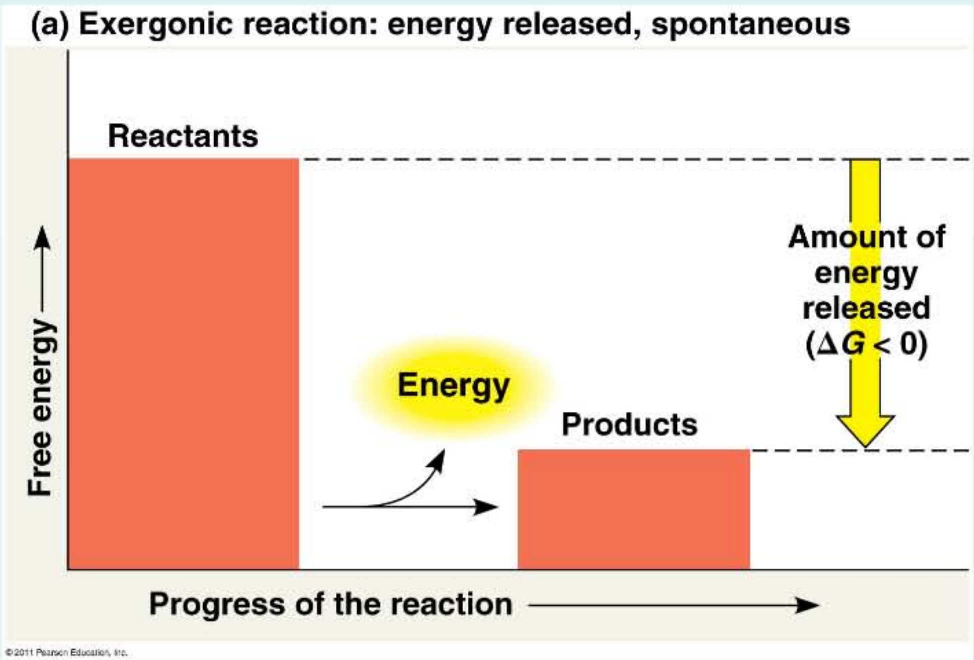

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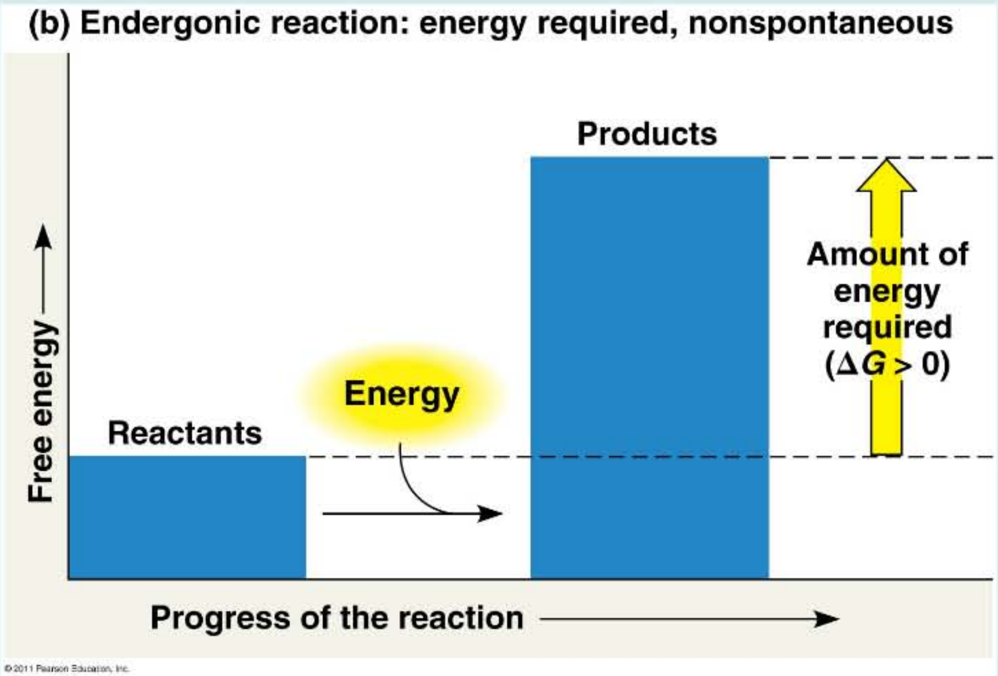

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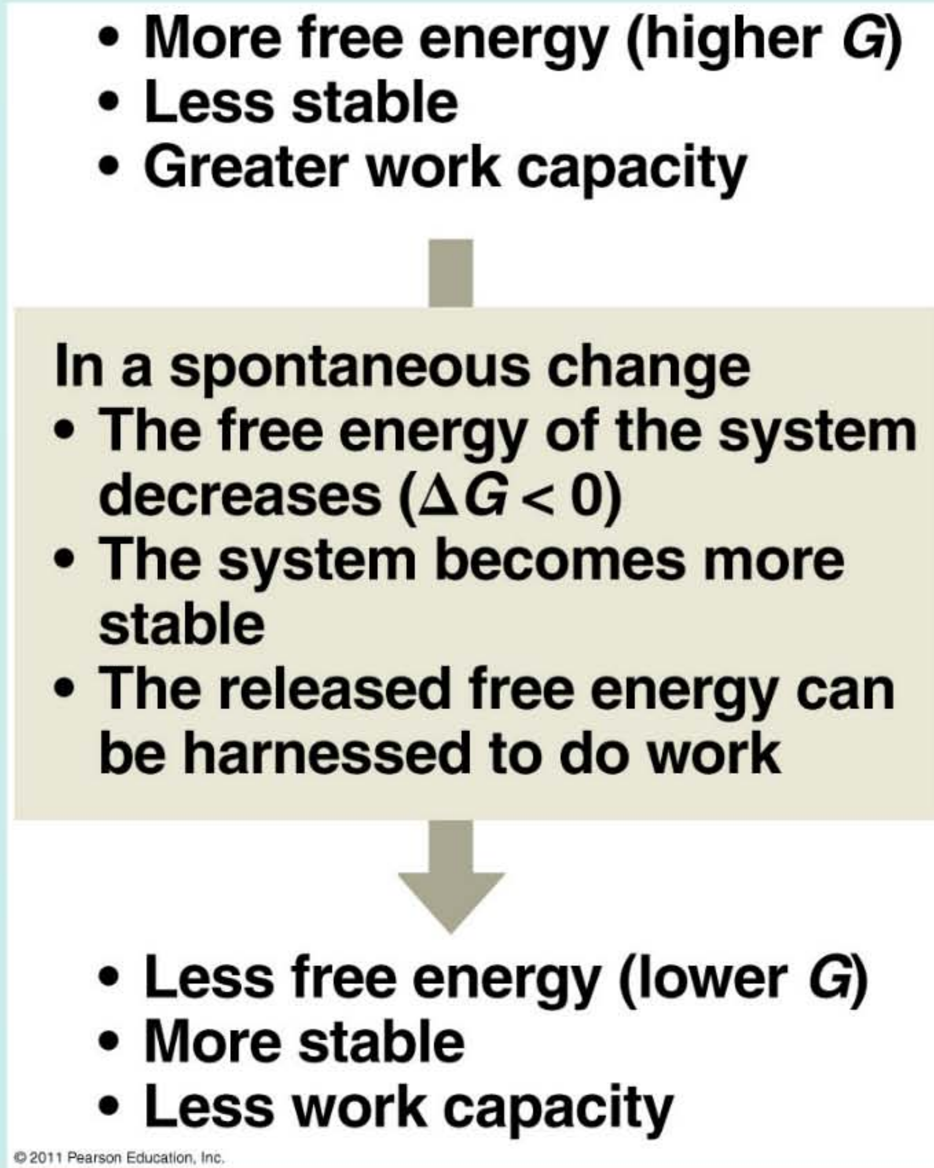

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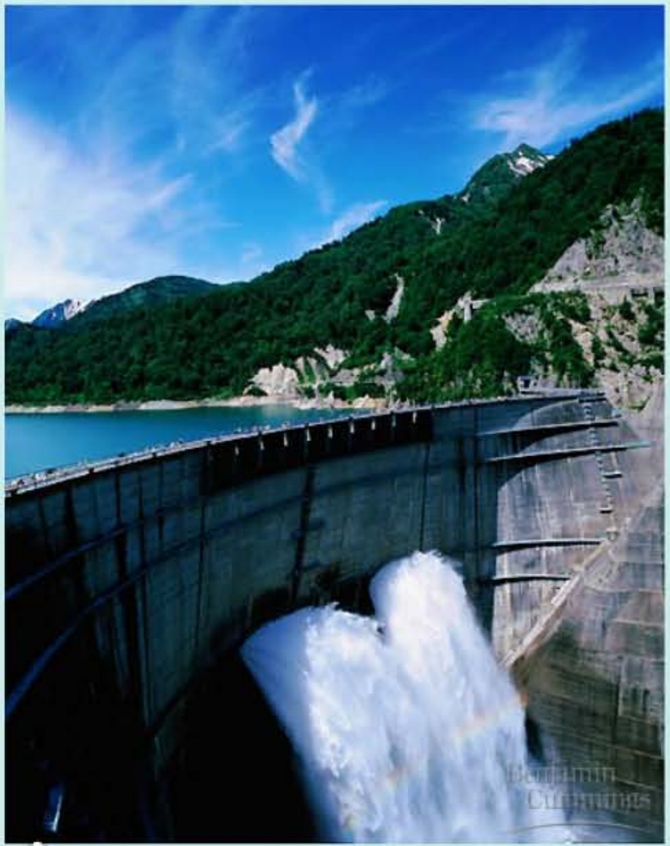

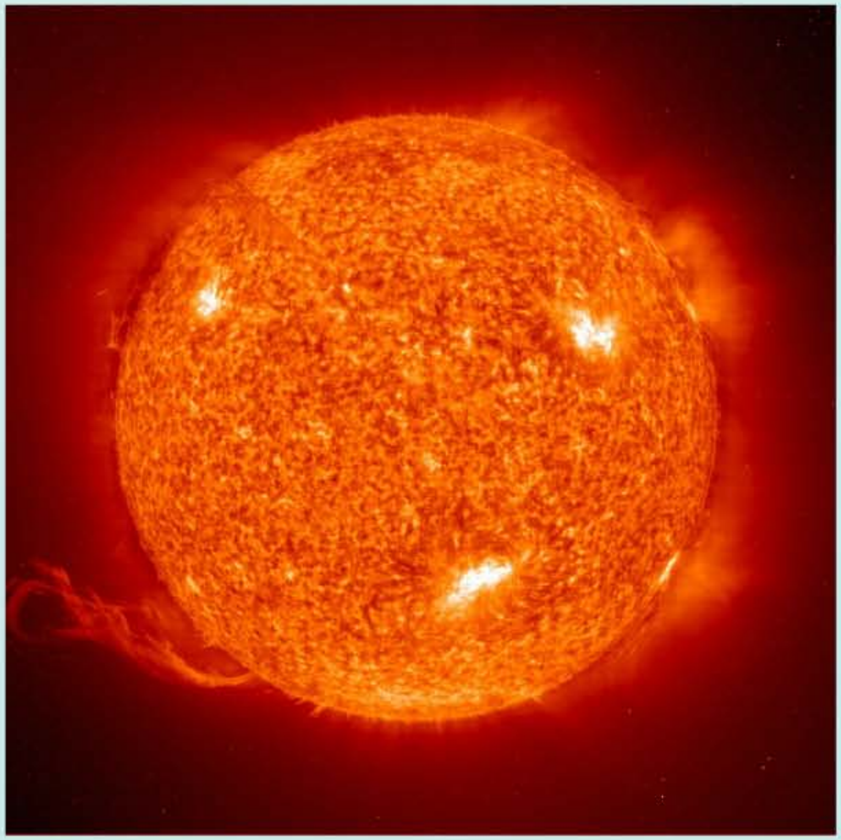

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Life is Highly Ordered


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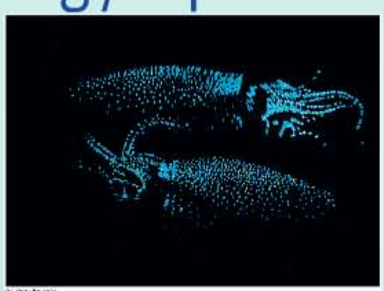

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Open & Closed Systems

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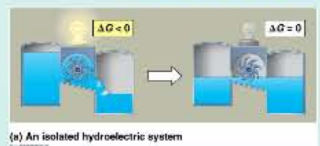

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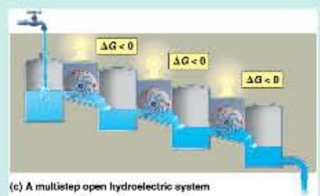

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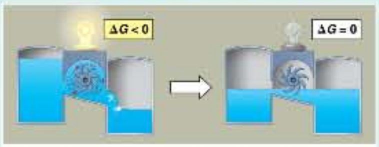

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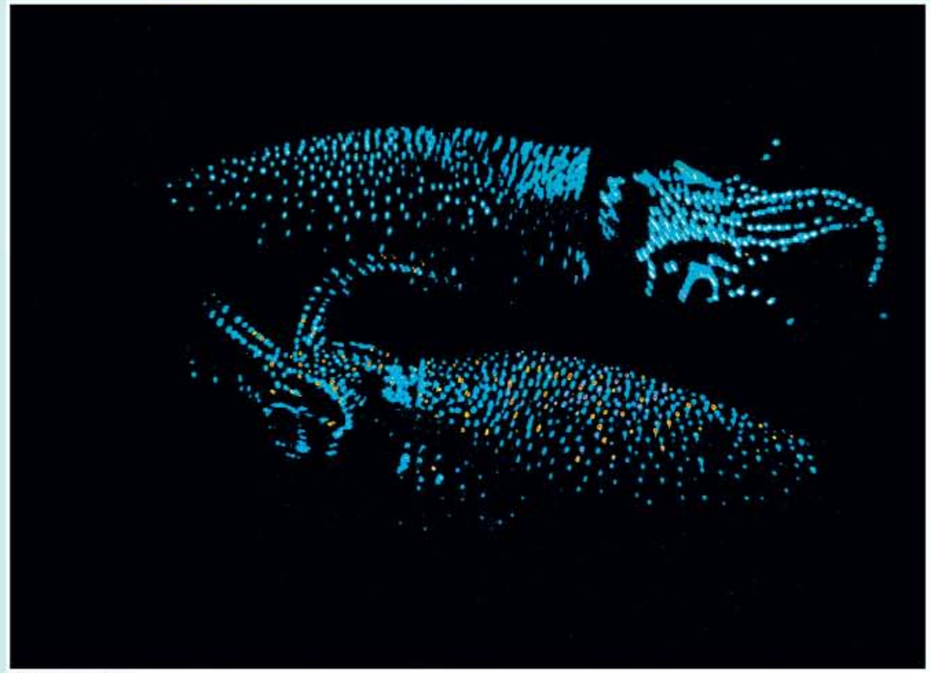

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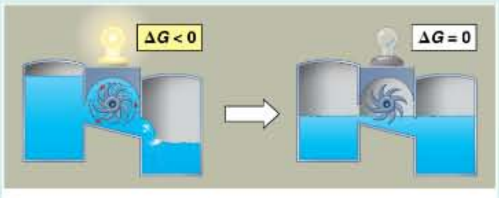

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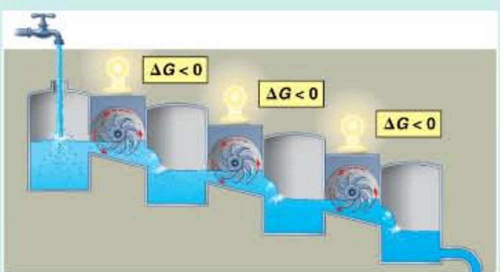

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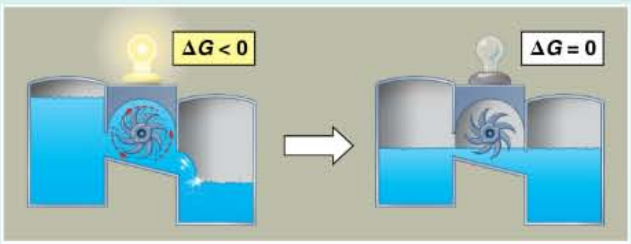

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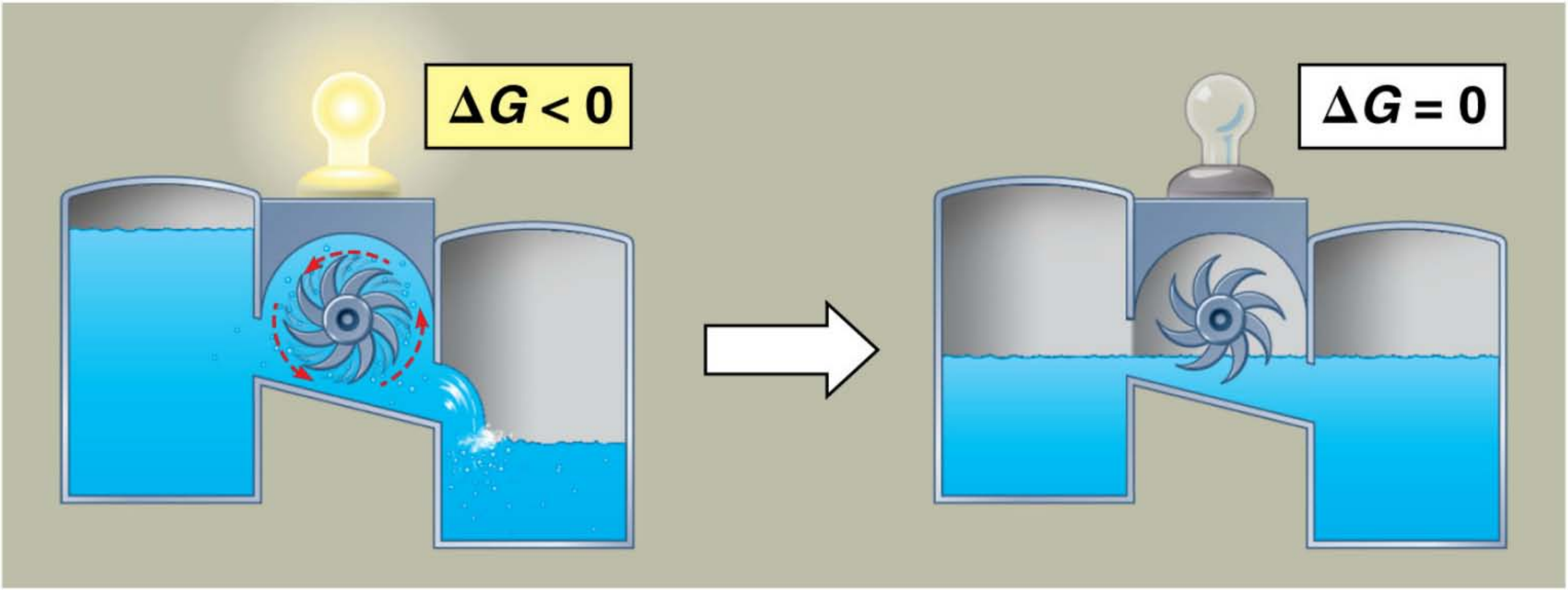

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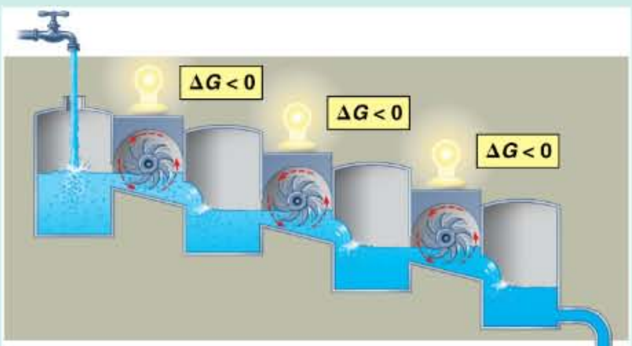

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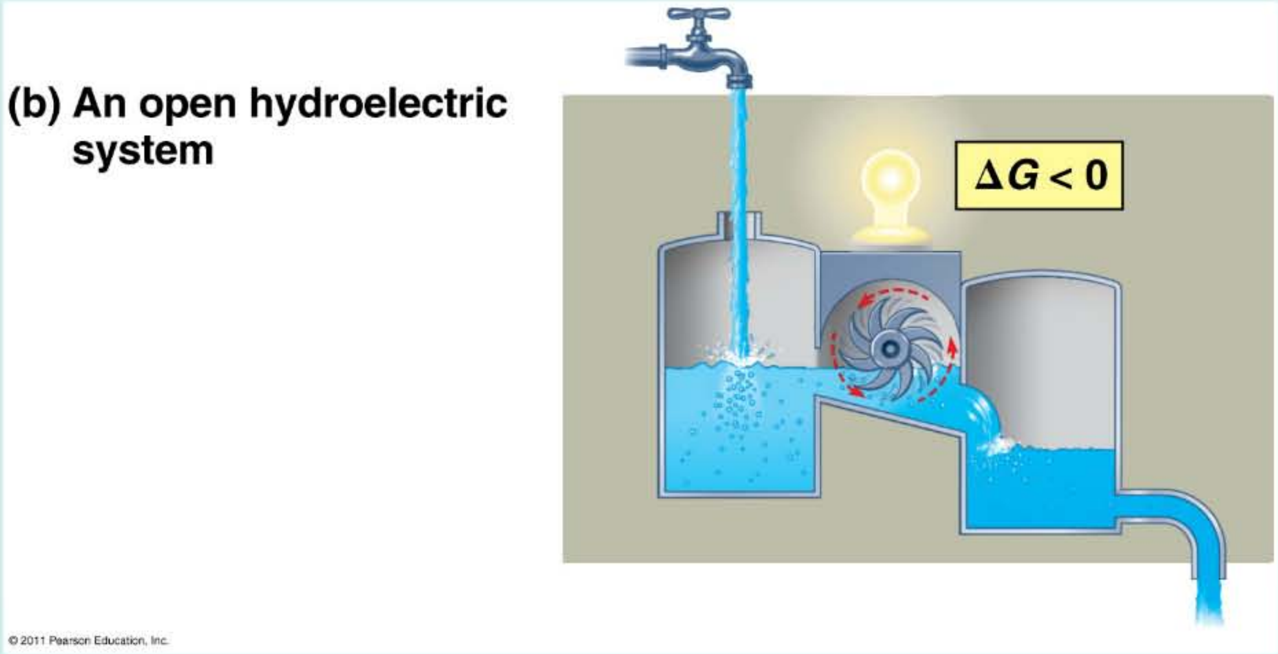

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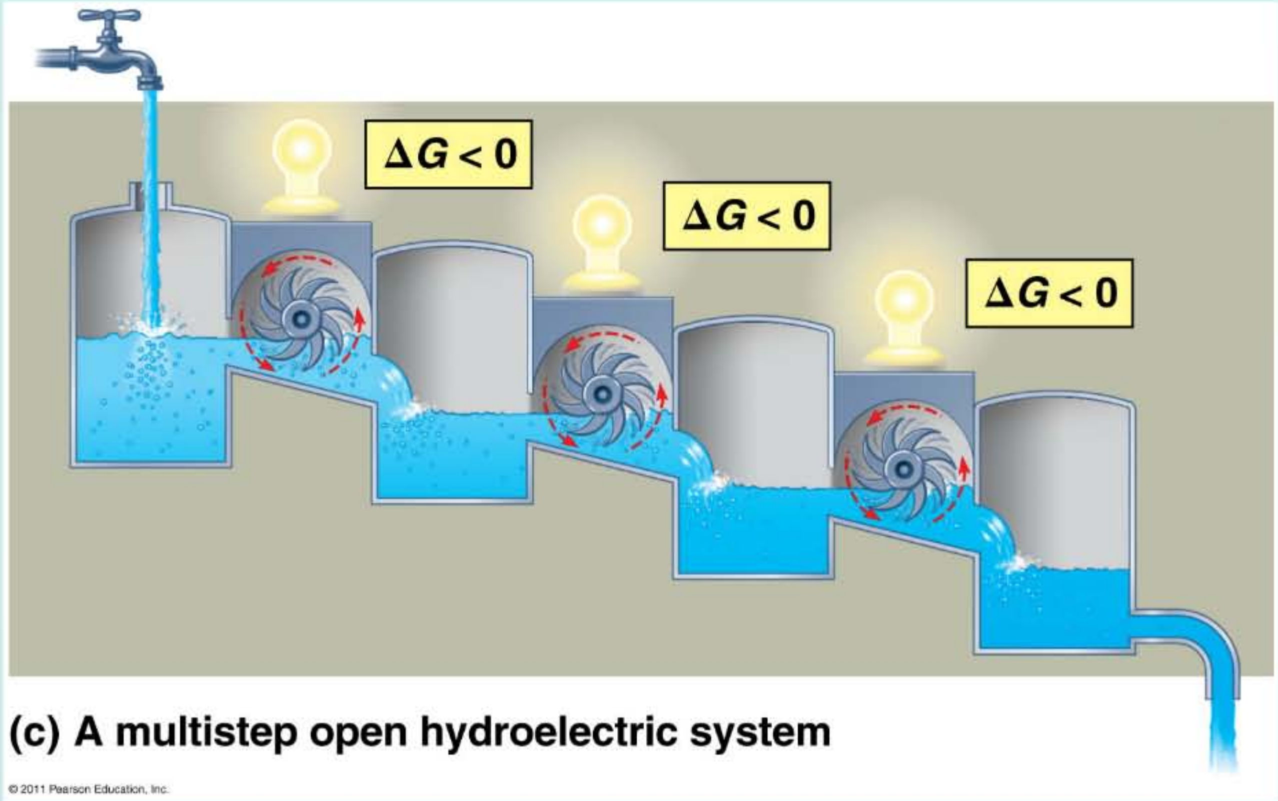

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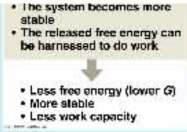

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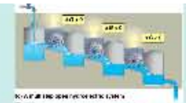

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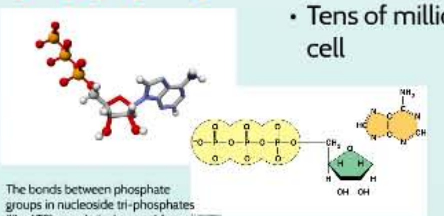
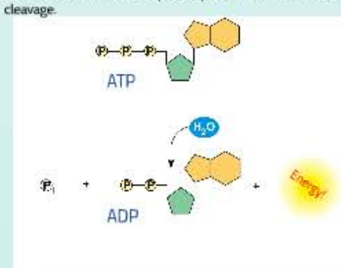
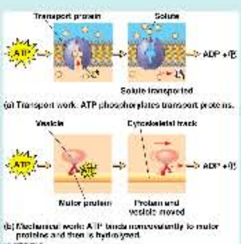


The bonds between phosphate groups in nucleoside tri-phosphates (like ATP) are relatively unstable.

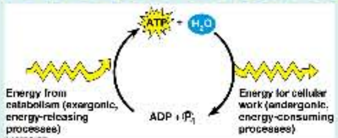
Much more free energy is released when the bonds between them are broken than is required by the cell to initiate their cleavage.





Much of the work done by cellular proteins is mediated by the addition and removal of phosphate groups from ATP by proteins to other proteins (kinases and phosphatases).

Metabolism



Refers to the sum total of all chemical reactions that take place in an organism.

Energy from catabolic reactions (ex: respiration) is used to power the synthesis of ATP from ADP and Phosphate groups.

ATP (and other NTP's) is used to power the anabolic Reactions that require chemical energy.

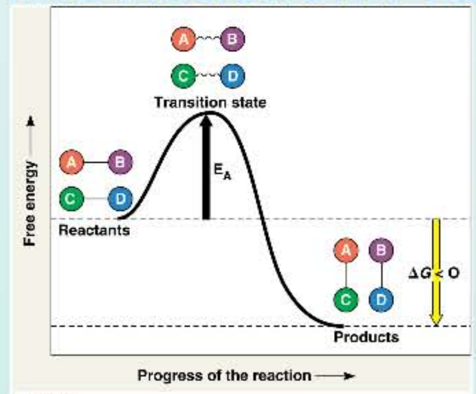
Reaction Coupling

Refers to linking an exergonic process with a cellular process.

If an endergonic process requires less free energy than an exergonic process produces, coupling those two reactions allows for maximum efficiency, and an overall negative delta G.

The Return of Kinetics

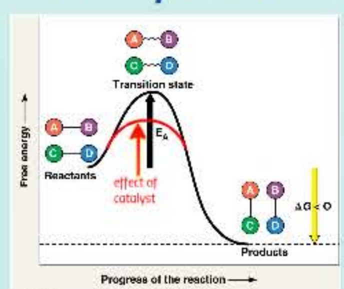
The Reaction Profile



All reactions require an input of energy (the "activation energy") to make the breaking of current chemical bonds energetically favorable (the "transition state").

The relationship between the energy of the products and the energy of the reactants is what determines if a reaction is exergonic or endergonic.

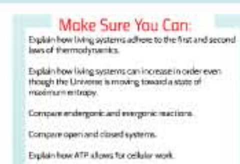
Catalysts!



Any substance that increases the rate of a chemical reaction while not participating in the reaction.

Lowers the activation energy of a reaction.

Reusable (since they don't participate).



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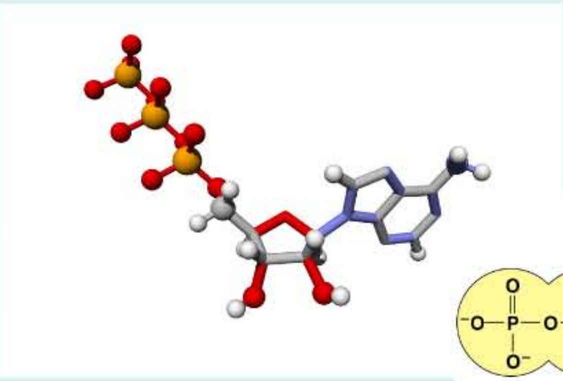

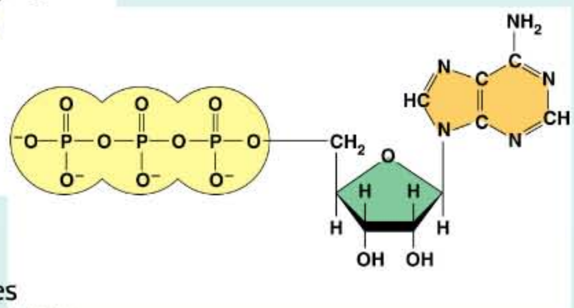

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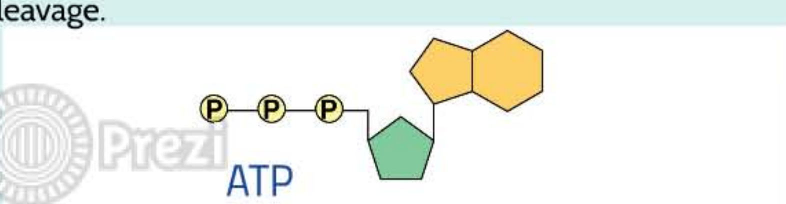
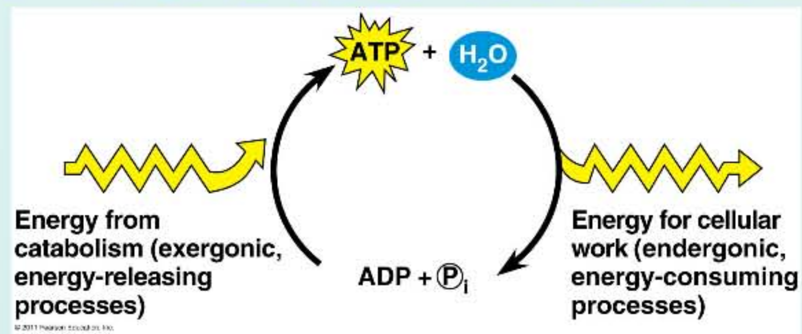


Metabolism



Refers to the sum total of all chemical reactions that take place in an organism.

Energy from catabolic reactions (ex: respiration) is used to power the synthesis of

ATP!

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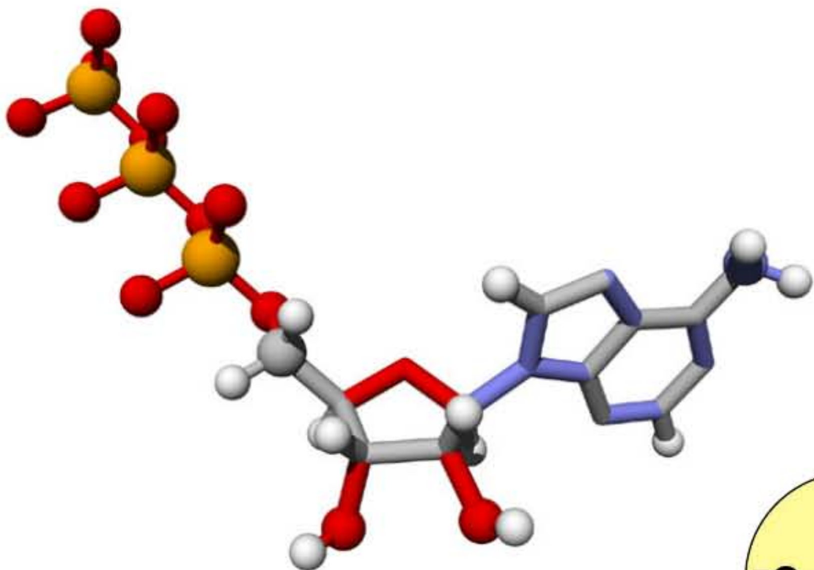
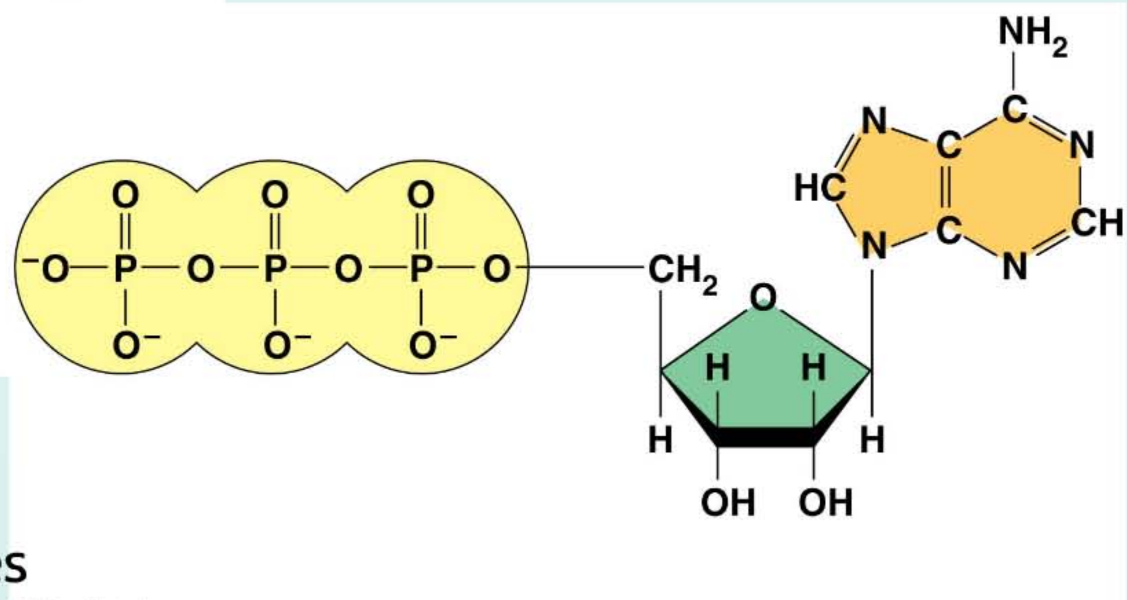
- Tens of millio
cell





The bonds between phosphate groups in nucleoside tri-phosphates (like ATP) are relatively unstable.

Much more free energy is released when the bonds between them are broken than is required by the cell to initiate their

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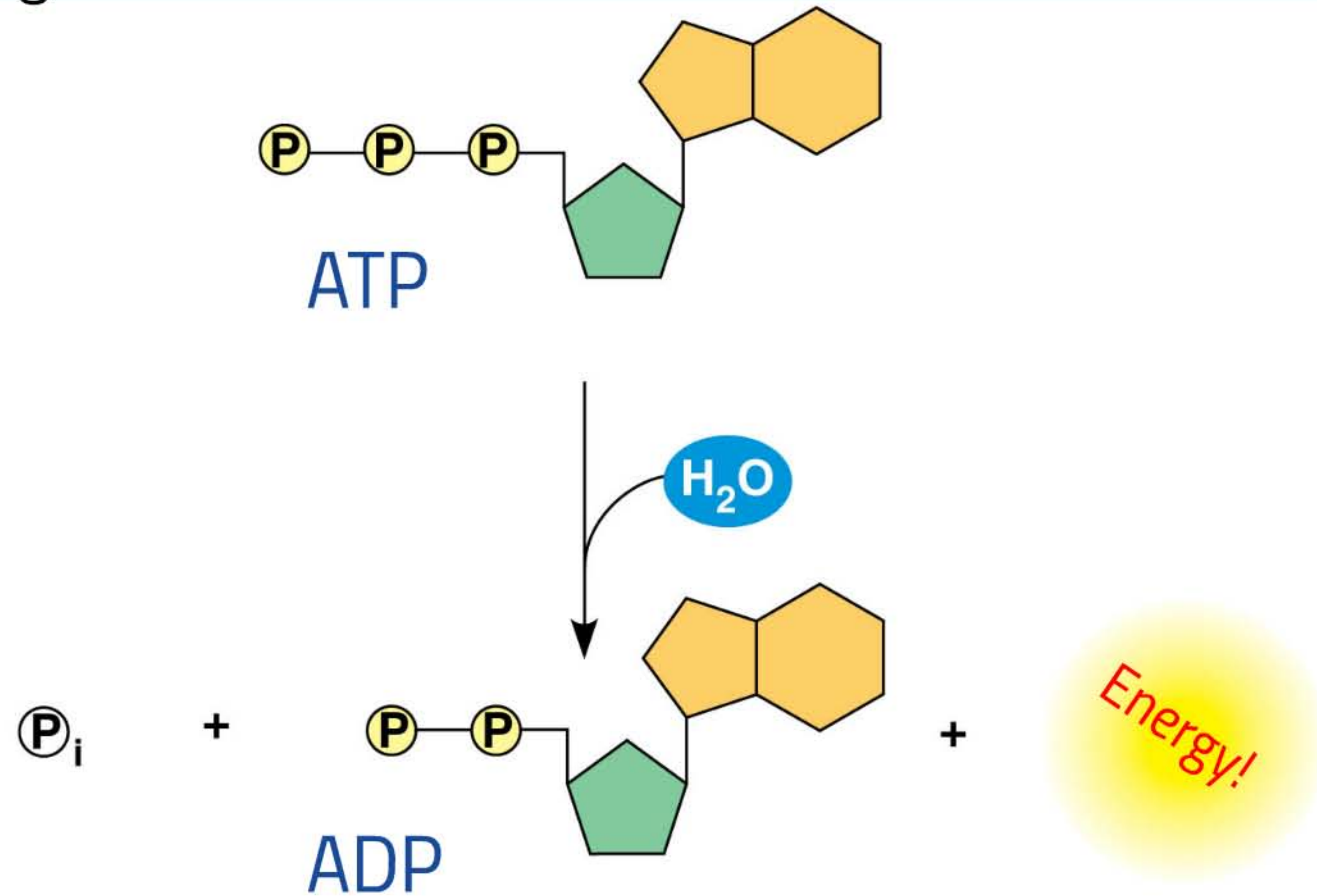
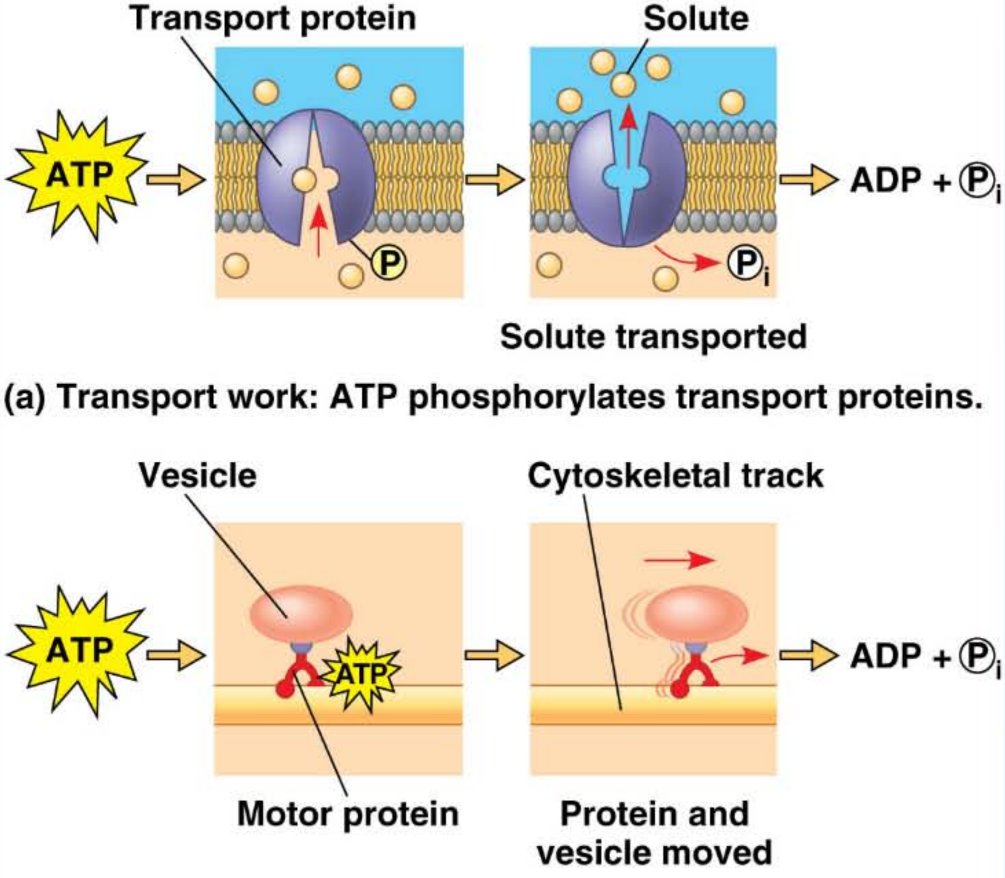
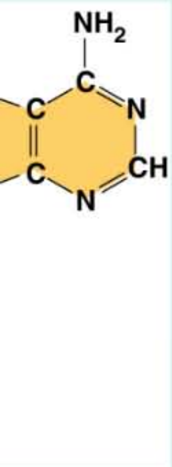




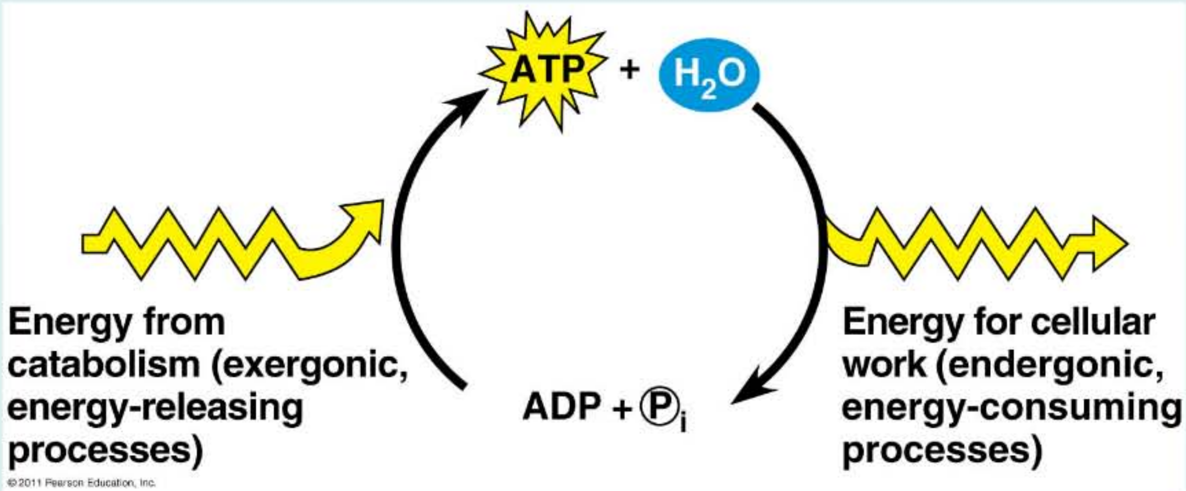
(a) Transport work: ATP phosphorylates transport proteins.

(b) Mechanical work: ATP binds noncovalently to motor proteins and then is hydrolyzed.

Much of the work done by cellular proteins is mediated by the addition and removal of phosphate groups from ATP by proteins to other proteins (kinases and phosphatases).



Metabolism



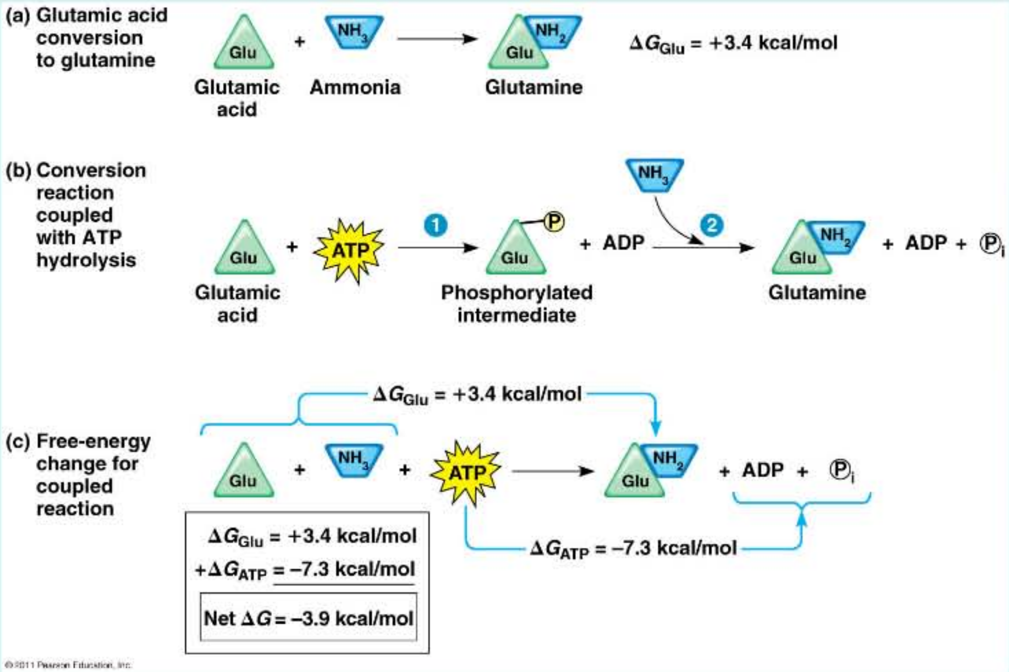
Refers to the sum total of all chemical reactions that take place in an organism.

Energy from catabolic reactions (ex: respiration) is used to power the synthesis of ATP from ADP and Phosphate groups.

ATP (and other NTP's) is used to power the anabolic Reactions that require chemical energy.

energy.

Reaction Coupling

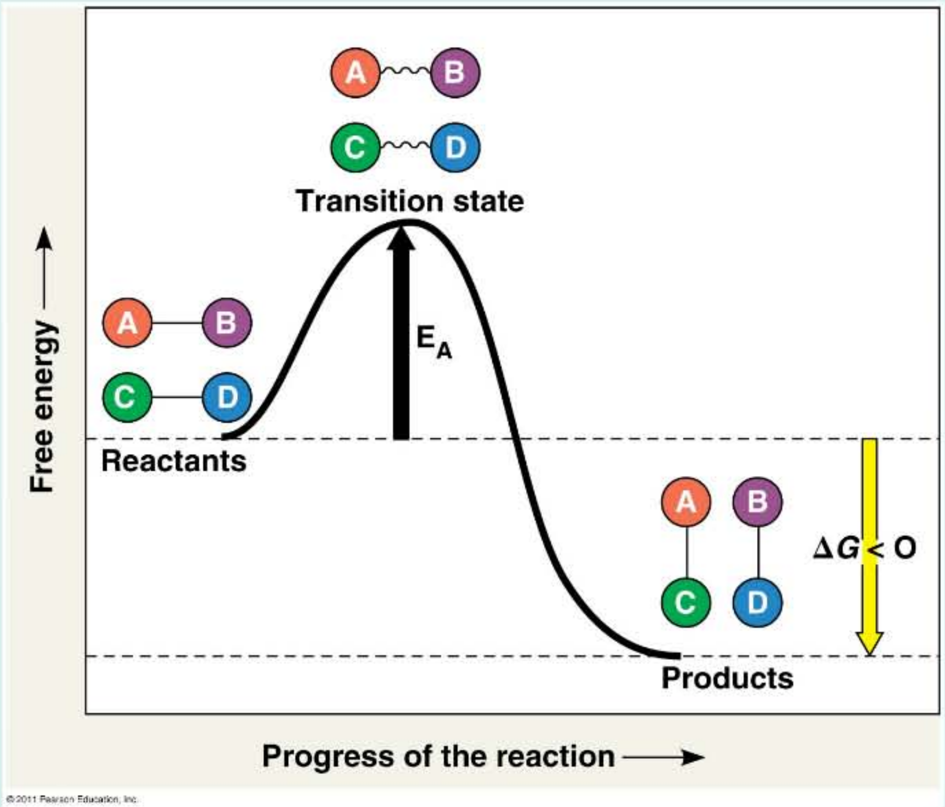


Refers to linking an exergonic process with a cellular process.

If an endergonic process requires less free energy than an exergonic process produces, coupling those two reactions allows for maximum efficiency, and an overall negative delta G.

The Return of Kinetics

The Reaction Profile

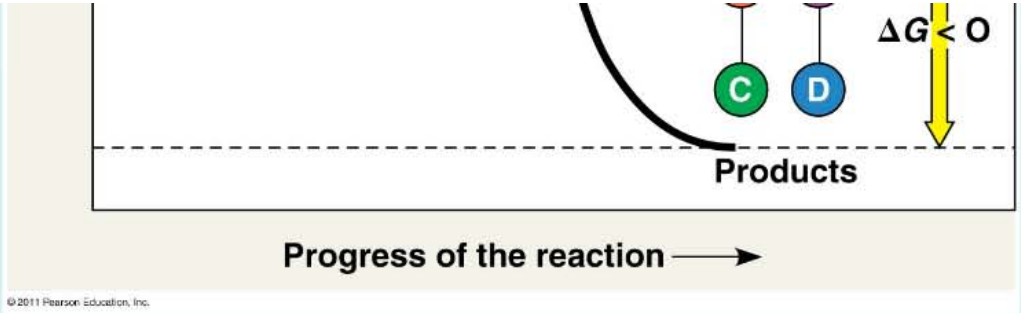


All reactions require an input of energy (the "activation energy") to make the breaking of current chemical bonds energetically favorable (the "transition state").

The relationship between the energy of the products and the energy of the reactants is what determines if a reaction is exergonic or endergonic.

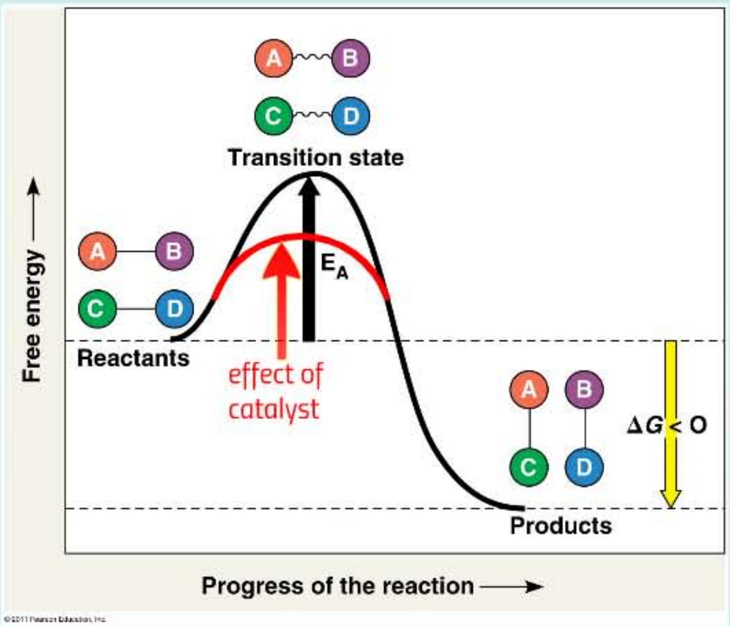
Catalysts!

Any substance that increases the rate of a chemical reaction while not



What determines if a reaction is exergonic or endergonic.

Catalysts!



Any substance that increases the rate of a chemical reaction while not participating in the reaction.

Lowers the activation energy of a reaction.

Reusable (since they don't participate).

Make Sure You Can:

Explain how living systems adhere to the first and second laws of thermodynamics.

Explain how living systems can increase in order even though the Universe is moving toward a state of maximum entropy.

Compare endergonic and exergonic reactions.

Compare open and closed systems.

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Explain how living systems adhere to the first and second laws of thermodynamics.

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Compare endergonic and exergonic reactions.

Compare open and closed systems.

Explain how ATP allows for cellular work.

Explain the effect of a catalyst on a reaction profile.

Cellular Energetics