TIME Instructional Resources

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NSF - #0736947

TIME – Cellular Respiration

Chemical potential energy

The two general rules for chemical potential energy of carbon compouncs are:

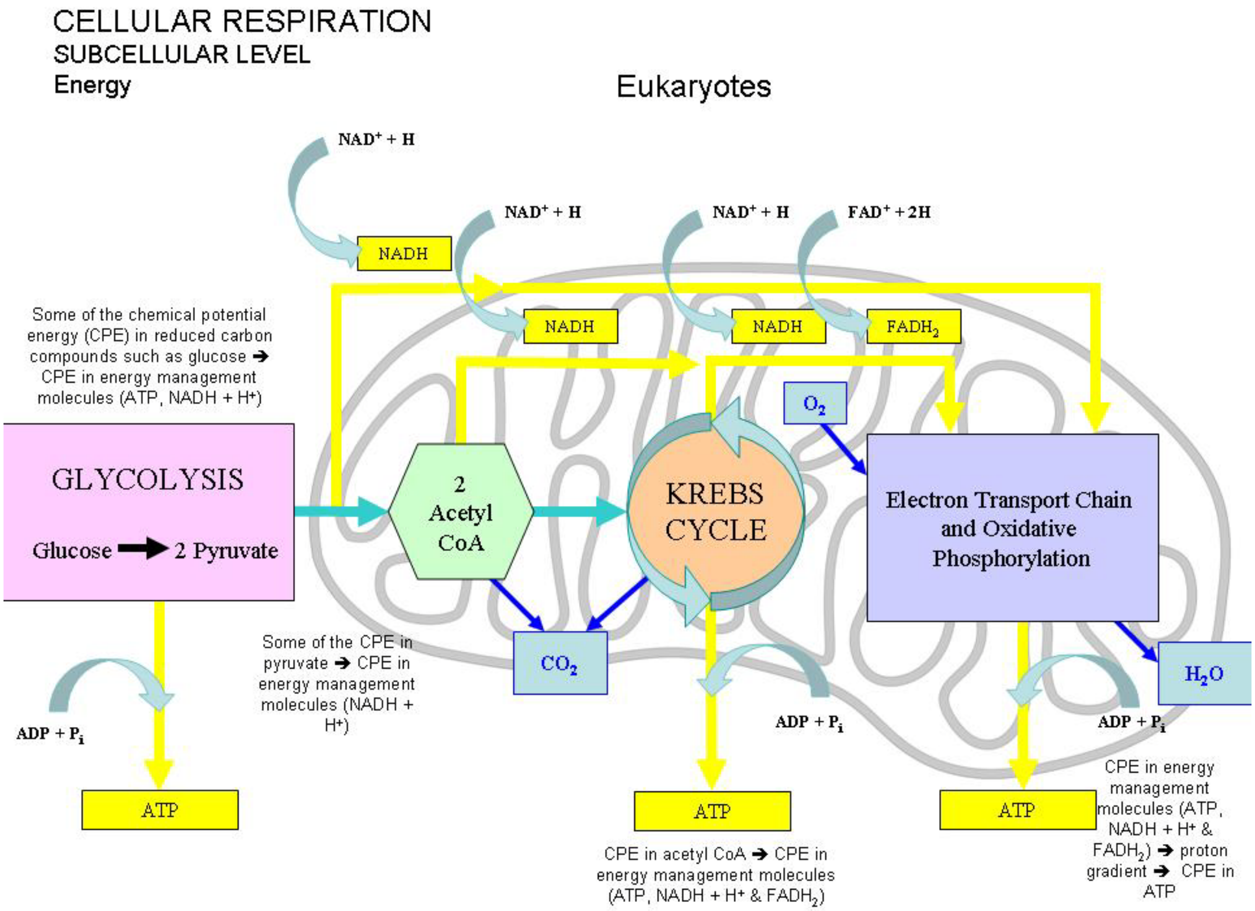
1) molecules with C-C and C-H bonds have more chemical potential energy than those with C-O bonds;
2) reduced forms of a molecule have more chemical potential energy than oxidized forms.

Indicate whether each of the following statements is true or false.

A. NADH has less chemical potential energy than NAD+.
B. NADH has higher bond energies than NAD+.
C. Fats with lots of C-H bonds have higher bond energy than sugars $(CH_2O)_n$.
D. Carbon dioxide has very little bond energy.
E. Because each carbon atom in glucose is bonded to at least one atom of hydrogen, it has more chemical potential energy than carbon dioxide (CO_2).
F. Methane (CH_4) has less chemical potential energy than glyceraldehyde ($C_3H_6O_3$).
G. "More chemical potential energy" means that bond energies of that molecule can do more cellular work than molecules of "less chemical potential energy."

ANSWERS:

A. False
B. True
C. True
D. True
E. False
F. False
G. True



TIME – Cellular Respiration

Energy management molecules

NADH and $FADH_2$ are the energy management molecules of the processes of cellular respiration. Indicate whether the following statements are true or false.

Hint: The two general rules about respiration and energy are:

1) molecules with C-C and C-H bonds have more chemical potential energy than those with C-O bonds;
2) reduced forms of a molecule have more chemical potential energy than oxidized forms.

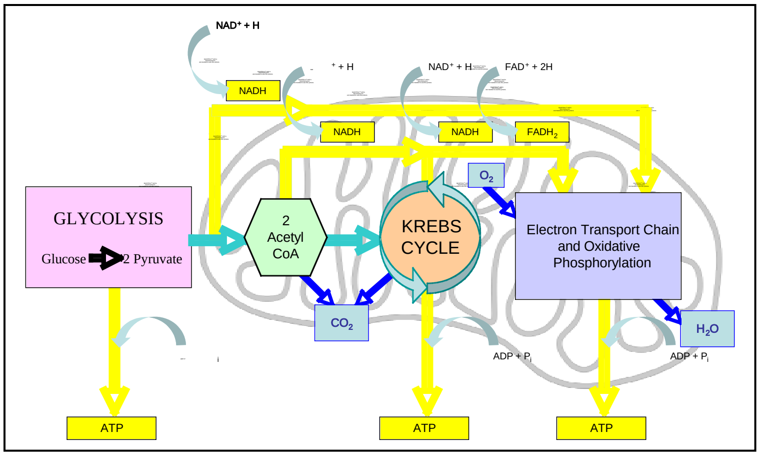
A. NADH and $FADH_2$ transfer the bond energy of sugar to the bond energy of ATP.
B. NADH and $FADH_2$ "shuttle" chemical potential energy from the Krebs cycle to the electron transport chain.
C. NADH and $FADH_2$ are highly oxidized molecules.
D. NADH and $FADH_2$ are the reduced forms of NAD+ and FAD.
E. NADH and $FADH_2$ are transformed into energy.

ANSWERS:

A. True
B. True
C. False
D. True
E. False

TIME – Cellular Respiration

Following energy and matter



Different molecules carry different potential energy. Indicate whether each of the following statements is true or false.

Hints:

1) molecules with C-C and C-H bonds have more chemical potential energy than those with C-O bonds;
2) reduced forms of a molecule have more chemical potential energy than oxidized forms.
3) the potential chemical energy of a compound is a measure of its ability to do work.

A. Organic molecules have more chemical potential energy than carbon dioxide.
B. Organic molecules and carbon dioxide have the same chemical potential energy.
C. Carbon dioxide plus water have the same chemical potential energy as organic molecules because they contain the same elements.
D. During cellular respiration, some of the atoms in the organic molecules are converted to energy.
E. The carbon dioxide produced by cellular respiration is released by the organisms causing it to lose weight.
F. Organic compounds such as sugars and fats are stores of chemical potential energy that can be moved throughout an organism.
G. During cellular respiration, when organisms burn (oxidize) organic molecules, some of the chemical potential energy in organic molecules is transferred to ATP.
H. During cellular respiration, organic compounds are transformed into the energy needed to do cellular work.
I. Chemical potential energy in ATP is transformed into mechanical energy when it is used to move something in the cell.
J. The chemical potential energy in ATP is used to do cell work.
K. ATP is made by cells when they need to do work.
L. ATP is transported throughout and organism to where it is needed to do work.

ANSWERS:

A. True
B. False
C. False
D. False
E. True
F. True
G. True
H. False
I. True
J. True
K. True
L. False

TIME – Cellular Respiration

Matching bond energy

Cellular respiration consists of processes and reactions that transfer chemical potential energy (bond energy) from molecules with C-C and C-H to ATP. Match the level of bond energy to the molecules of cellular respiration.

Hint: The two general rules about respiration and energy are:

1) molecules with C-C and C-H bonds have more chemical potential energy than those with C-O bonds;
2) reduced forms of a molecule have more chemical potential energy than oxidized forms.

A. High
B. Low
C. Intermediate

1. Fats
2. Carbon dioxide
3. NAD+
4. Glucose
5. Acetyl CoA
6. ADP
7. NADH
8. FAD2
9. ATP
10. Pyruvate

ANSWERS:

1. C
2. A
3. A
4. B
5. A
6. C
7. A
8. B
9. B
10. A

Cellular Respiration

Matching redox state

Cellular respiration consists of several processes and many reactions. Some of these involve changes of redox state of various molecules. Match the redox state to the molecules of cellular respiration.

Hint; reduced forms of a molecule have more chemical potential energy than oxidized forms.

A reduced
B fully oxidized
C partially oxidized

C acetyl CoA
A glucose
B carbon dioxide
A NADH
B FAD
C pyruvate
A FAD2
A fats
B NAD+

Cellular Respiration

Oxidation and Reduction

Oxidation involves the loss of electrons by an atom. This can be complete transfer of an electron to another substance or the movement of an electron farther away from the atom.

Reduction involves the gain of electrons by an atom. This can be the complete transfer of an electron to that atom from another substance or the movement of an electron closer to the atom.

Determine whether each of the following statements is true or false.

False The overall equation for cellular respiration is $C_6H_{12}O_6 + 6\ O_2 \text{-->}\ 6\ CO_2 + 6\ H_2O$. During this reaction carbon is reduced.

False The overall equation for cellular respiration is $C_6H_{12}O_6 + 6\ O_2 \text{-->}\ 6\ CO_2 + 6\ H_2O$. During this reaction oxygen is reduced.

True In general, when an atom bonds to more oxygens, it is oxidized.

True Substance A may be reduced by substance B and then be oxidized by substance C.

False The equation for the transformation of NAD^+ to NADH is $NAD^+ + H^+ + 2e^- \text{-->}$ NADH. During the reaction NAD^+ is oxidized.

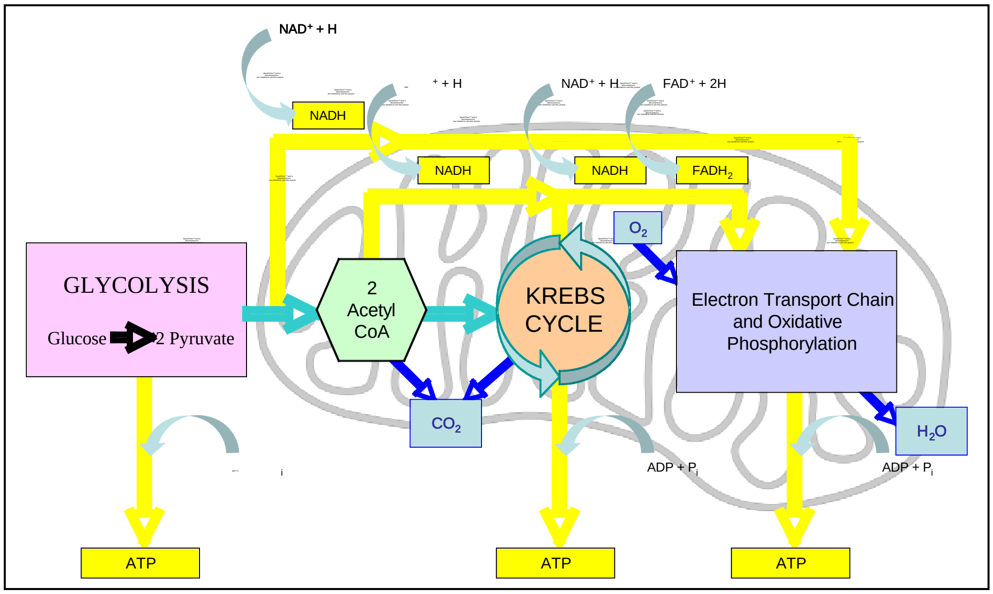
True When the charge on an atom increases (becomes more positive) it is oxidized.

False NAD^+ is the reduced form of NADH.

Cellular Respiration

Four sets of reactions

Cellular respiration is a complex set of reactions that can be subdivided into 4 major processes each in a different place and accomplishing something different. These are: glycolysis, acetyl coA production, the Krebs cycle and the electron transport chain (ETC) combined with oxidative phosphorylation (OP). The diagram also shows the production of energy management molecules (NADH, FADH2 and ATP during these processes.



Indicate whether each of the following is true or false.

False The large arrows pointing to ATP indicate that the same amount of ATP is produced by each process.

True The arrows at the top of the diagram indicate the path of the products of glucose oxidation.

False Each of the four processes produces some ATP.

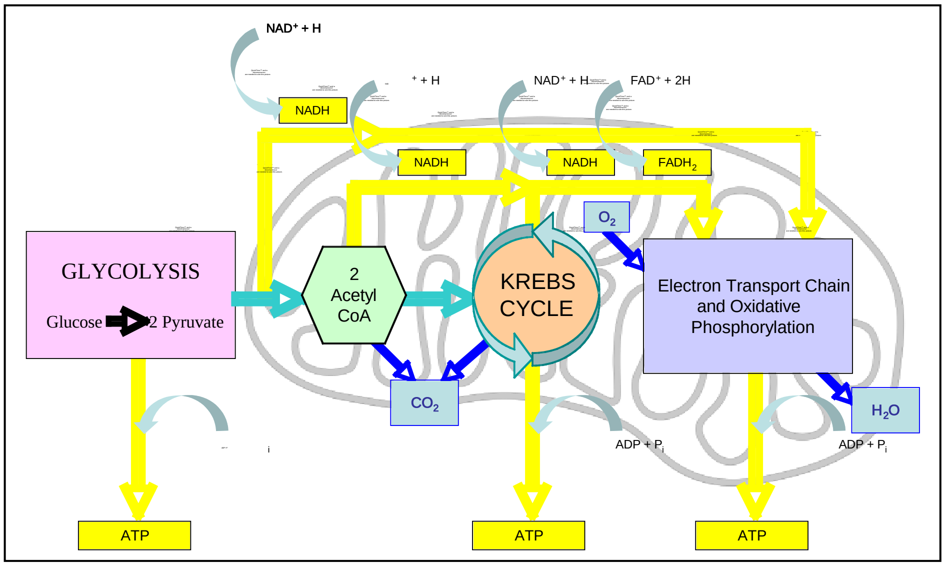
True NADH and FADH2 are not used directly to fuel cellular work, but are used to drive ATP synthesis.

False Each of the four processes produces NADH which is eventually used in ATP production.

False All of the products of the processes of cellular respiration are carbohydrates.

Cellular Respiration

Summary of biological oxidation of glucose



In cellular respiration, glucose (and other substances) are completely oxidized and its (their) bond energies captured for cellular work. Indicate whether each of the following statements is true or false about this process.

Hint: The two general rules about respiration and energy are:

1) molecules with C-C and C-H bonds have more chemical potential energy than those with C-O bonds;
2) reduced forms of a molecule have more chemical potential energy than oxidized forms.

concept = bond energy

True C-H and C-C bond have higher potential chemical energy than do C-O bonds.

False CO_2, one of the products of cellular respiration, has more bond energy than glucose and other inputs.

True Water, one of the outputs of cellular respiration, has less bond energy than glucose and other inputs.

False C-O bonds have higher potential energy than C-C bonds.

concept = redox

True Oxidation of glucose is a step-wise process in which its chemical potential energy is captured for biological use.

True Oxidation of glucose in cellular respiration is a step-wise combustion.

False Reduced molecules have less chemical potential energy than oxidized molecules.

False In the redox reactions of the electron transport chain, the beginning reactants have less chemical potential energy than the end products.

concept = Matter

False The products of fully oxidized glucose are carbon dioxide, water and energy, which is used up.

False The products of fully oxidized glucose are carbon dioxide, water and ATP.

True All of the carbons of glucose are converted to carbon dioxide in cellular respiration.

False The water product of cellular respiration comes directly from the carbon skeleton.

True The water product of cellular respiration comes directly from the reduction of oxygen.

concept = ATP

True The energy to make most of ATP in cellular respiration is from a proton gradient.

True The bond energy of glucose is captured in the bond energy of ATP in cellular respiration.

False In oxidative phosphorylation, oxygen provides the chemical potential energy to convert ADP and Pi to ATP.

False Some of the bond energy of glucose is transferred to ATP, the rest to carbon dioxide.

concept = EMM

True The reduction of NAD+ and FAD in the Krebs cycle provides a means to transfer chemical potential energy to ETC/OP.

False NADH and $FADH_2$ transfer protons to ETC/OP.

True ATP, NADH and $FADH_2$ are considered energy management molecules because the can transfer chemical potential energy.

False The energy management molecules, NADH, $FADH_2$ and ATP can be converted to energy.

Cellular Respiration

Why Living Things Need Energy

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

All living things need energy. Inquiring minds want to know: why and when?

concept = One
false Only cells that are moving molecules or doing mechanical work need energy.
false Non-dividing cells do not need energy.
true Cells need energy to drive reactions that do no occur spontaneously.

concept = Two
true A cell needs energy to move a secretory vesicle from the Golgi apparatus to the plasma membrane.
true A paramecium needs energy to make its cilia beat.
true A dividing cell needs energy to move the chromosomes into the new daughter cells.
false An amoeba changes shape by letting its cytoplasm diffuse, therefore this does not require energy.

concept = Three
false Bacteria in a rich broth require energy to take up glucose.
true Nerve cells need energy to maintain K+ and Na+ gradients across their membranes.
true A cell needs energy to build a protein out of individual amino acids.
false A cell needs energy to break down a protein into individual amino acids.

concept = Four
false Living things can't perform reactions that require energy ($+\Delta G$), so they perform alternative reactions that yield the same results.
false Living things require energy to produce order, but not to maintain it.

true	Living things are ordered, organized systems. They require energy to fight entropy's push towards disorder.