

1. (45 pts) Your roommate, a Sanskrit major, finds the figure on the previous page (tear it out) under your bed and asks you to explain it.

a. What process does the dark circle of arrows in the center represent?

This is the Krebs or Citric Acid or Tricarboxylic Acid Cycle

b. Where does the pyruvate at the top come from? Start from the potato you had for dinner. No need for chemical structures. Discuss the major stages of the process so your roommate has a reasonable understanding of what is happening

Potato has starch which is a polymer of glucose

Starch is degraded in the mouth and small intestine into the individual molecules of glucose

Glucose is absorbed into the blood stream in the small intestine

Glucose then crosses the cell membrane into the cell

In the cell it is converted, through the reactions of glycolysis into pyruvate.

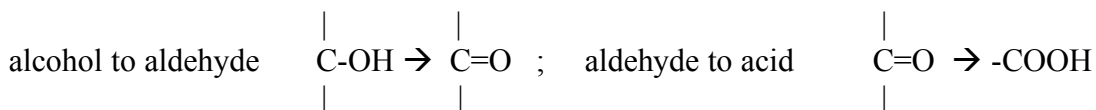
c. Billions and billions of molecules of pyruvate are produced yet in principle, the process in this figure(see part a) could function, although slowly, if there were only a single molecule of oxaloacetate (see 11 o'clock on the circle). Explain how this is possible.

The oxaloacetate (OAA) which has four carbons, is simply a carrier of the acetyl CoA through the process. The two are joined into a six carbon compound and in the course of the cycle, two CO₂ are broken off leaving a four carbon compound. This molecule is reorganized and becomes oxaloacetate again, which binds another acetyl CoA and the process begins again. Thus in principle, a single OAA could cycle around enough times to ferry as many acetyl CoA molecules through it as necessary. It would take time, but in fact there are very few OAA molecules compared to pyruvates (although far more than one.)

d. What is the most common type of reaction in this process.

oxidation

e. Give two different examples of such a reaction (not necessarily in this process), showing the molecular structure only of the parts of the molecule that are actually changed in the conversion of starting material to product.



f. What do the arrows that point away from the central circle in the figure represent

These are the reactions that take a given intermediate in the cycle and instead of having them converted to the next molecule, perform a different reaction on them to begin a pathway towards the production of molecules the cell needs to grow— amino acids, lipids etc.

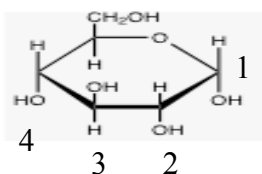
- g. A very sick young child is shown to be producing very large amounts of fatty acids and sterols but abnormally low levels of glutamine, proline, arginine, glutamate and purines. The “machinery” involved in the reactions represented by the arrows labeled 1,2,3 in the figure and also in the conversion of citrate to α -ketoglutarate are shown to be functioning normally. Propose an explanation.

It is likely that for some reason, the reactions that convert citrate to fatty acids and sterols are going at an abnormally high rate and a far greater than normal amount of the citrate is being converted to these products. As a result, there is not much citrate being converted to α -ketoglutarate and thus there is little α -ketoglutarate to be available for conversion to glutamate etc.

2. (15 pts) An enterprising young student notes that higher organisms do not produce ethanol and that higher organisms get more energy from sugar than organisms that do produce ethanol. He draws the conclusion that producing ethanol limits the amount of energy the cell can extract from sugar. He therefore decides to disable that reaction in yeast growing anaerobically. What do you think will happen to the yeast. Explain your answer.

Yeast would die. In the absence of air (anaerobic) , glycolysis involves a single oxidation reaction on an intermediate removing two protons and two electrons from it. Since there is no oxygen to absorb these protons and electrons there must be another reaction that reduces an intermediate by putting those two protons and electrons on it. One of the two steps in the conversion of pyruvate to ethanol is this reduction reaction. If it were disabled, the pathway would stop.

3. (10 pts)



- a. What is this molecule?

glucose

- b. Draw three isomers of this molecule.

switch any of the OH and H on the three carbons, 2, 3, 4 but not carbon 1 which can readily switch back by opening and reclosing the ring.

4. (15 pts) In the glycolytic pathway, both fructose-6-phosphate and glucose react with ATP, producing ADP. How then can it be that the pathway as a whole produces a net 2ATP per glucose. Explain fully.

There are two other reactions in the pathway that involve the conversion of ADP to ATP. Further, each of those reactions occurs twice for each glucose because they are performed on the three carbon molecules that result from the split of the fructose phosphate. the reactions involving conversion of ATP to ADP occur once per glucose because they are performed on the six carbon molecules before the split. Thus there are two ATP converted to ADP but four ADP converted to ATP.

5. (10 pts) Explain how a reaction that produces ATP can have a negative free energy.

Normally $\text{ADP} + \text{P}_i \rightarrow \text{ATP}$ has a free energy change of +7 kcal/mole—positive because the ATP is at a higher energy. However, if this reaction is coupled to a reaction that releases more than 7 kcal/mole, for example the conversion of PEP to pyruvate, then the two linked reactions would have an energy change that is the sum of the changes of those two reactions and will be negative.

6. (5 pts) $\text{CH}_3\overset{*}{\text{C}}\text{SCoA}$ What is the oxidation level of the central carbon atom (with asterisk) in this molecule. Explain your answer

Acid level. For these purposes, S can be considered equivalent to O. This the molecule is of the form $-\text{C}-\text{O}-$

