1. ATP is a ribose bonded to three phosphate group. Each phosphate group has a negative charge. Phosphate groups have repulsion against each other. Therefore, it is unstable, and energy is high. Therefore, high energy is stored in phosphoanhydride bonds in ATP.

   There are two phosphoanhydride bonds in ATP and each bond contains energy. The more phosphoanhydride bond is hydrolyzed, the more energy ATP can produce. Also, the hydrolysis of the different phosphoanhydride bond can produce different amount of free energy. ADP to AMP releases more energy than ATP to ADP. The free energy it produces depends on substrates and products' structures and stabilization. The larger the substrates and products' stability difference, the more energy it can produce. Breaking different phosphoanhydride bonds from ATP will result in products with different stability. For example, ADP has no resonance form, while AMP has resonance form, thus AMP is more stable. Since the products' stability is different, different amounts of energy can be produced. Also, the polar phosphate is pH dependent since polar phosphate is ionizable, so ionization can change phosphate group's stability. The concentration of magnesium ion in the cellular environment can also change the stability, thus deciding the amount of energy produced. The change in free energy can be used to activate molecules for reactions that are highly unfavorable or found in anabolic pathways.

   The advantage of hydrolyzing different bonds in the molecule is that it can provide different amounts of energy to facilitate different reactions, which can reduce energy loss. The disadvantage is that ester bond hydrolysis provides the least amount of energy, thus is not very helpful in cellular processes. Also, due to instability, the phosphoanhydride bond can break down even when no energy is actually needed. Then, these energies will be lost as heat. If different bonds can be hydrolyzed in the molecule, there is a larger possibility of unnecessary energy release. Therefore, it will induce more energy loss.

2. There are four steps involved in producing ATP molecules, including glycolysis, PDC, citric acid cycle and oxidative phosphorylation.

   Glycolysis is the first step of glucose breakdown under aerobic conditions. It requires 2 ATPs to break down glucose into 2 pyruvate, 4 ATPs and 2 molecules of NADH. Since 4 ATPs are generated and 2 ATPs are used, the net gain of ATP is two. Then, PDC reaction happens and oxidizes pyruvate to Acetyl CoA with Coenzyme A. There are 2 pyruvates produced from last step, so 2 coenzyme A will be produced from PDC. Also, 2 NADH is produced during this process. After that, the 2 molecules of Acetyl CoA enter into citric acid cycle. Two citric acid cycles happen. Each citric acid cycle will produce 1 ATP molecule, 3 NADH and 1 FADH2. By doubling the number, 2 ATPs, 6 NADH and 2 FADH2 is produced from the citric acid cycle step. The oxidative phosphorylation can be divided into two parts, electron transport chain and chemiosmosis. During ATP synthesis, 4 H^+ ions are required to make ATP in the matrix. In electron transport chain, one NADH can pump 10 H^+ ions and one FADH2 can pump 6 H^+ ions by donating electrons to generate free energy. Therefore, one NADH can create 2.5 ATP and one FADH2 can create 1.5 ATP

during the chemiosmosis process. However, the NADH generated from glycolysis would only produce 1.5 ATP due to NADH transport over the mitochondrial membrane.

There are totally 10 NADH and 2 FADH2 generated during the whole process. 8 NADH produce 2.5 ATP, 2 NADH produce 1.5 ATP and two FADH2 produce 1.5ATP. Therefore, there are 26 ATP generated during oxidative phosphorylation. By adding the 4 ATP generated from glycolysis and citric acid cycle, 30 ATP is generated from the breakdown of glucose under aerobic conditions. The discrepancy of 30 generated here and 36 that many people believe is due to the differences of the number of ATP produced by NADH and FADH2. They assume that one NADH produces 3 ATP, and one FADH2 produces 2 ATP. By replacing the number of 2.5 and 1.5 with 3 and 2, the number of ATP generated will be 36.

3. (a)

Electron-transport chain includes four complexes. Complex I accepts electron from NADH. Complex II accepts electron from FADH2. Complex III accepts electron from complex I and complex II through CoA. Complex IV accepts electron from complex III. Since mitochondria is purified, there is no NADH and FADH2 to donate electrons to the electron transport chain. Rotenone and amytal are used to inhibit complex I. A complex II inhibiter is used to inhibit complex II. Antimycin A is used to inhibit complex III. Cyanide, azide, and CO is used to inhibit complex IV. Mitochondrial O2 experiment is used to measure the effect to help us deduce the location of electrons donated. Since oxygen reacts with electrons to produce water and increase electron transfer potential, an increase in oxygen consumed means that more electrons are donated and passed out from the last carrier, generating free energy.

- We firstly want to check whether the complex X donates its electron to complex IV. We can inhibit complex III and see if O2 is consumed. If O2 is consumed, complex X donates electrons to complex IV. Vice Versa.
- Then we want to check complex III. We can inhibit complex I and complex II. If there is an increase in oxygen consumed, complex X donates electrons to complex III. Vice Versa.
- After that, we want to check complex II. We can inhibit complex I. If there is an increase in oxygen consumed, complex X donates electrons to complex II. Vice Versa.
- Lastly, we want to check complex I. We can inhibit complex II. If there is an increase in oxygen consumed, complex X donates electrons to complex I.

(b)

If complex X has a lower redox potential, complex X has a stronger tendency to donate electrons, thus complex X can donate electrons more quickly to the electron-transport chain. Oxygen is consumed and free energy is generated more efficiently. Redox potential is the tendency to take oxidation-reduction reactions. If complex X has a higher redox potential, complex X has a stronger tendency to accept electrons.

4. Citric acid cycle is an amphibolic pathway that links anabolic and catabolic pathways. Amphibolic intermediates are Intermediates that can be found in both catabolic and anabolic reactions. In the first reaction of the citric acid cycle, oxaloacetate (4 carbons) reacts with acetyl-CoA (2 carbons) to form citrate (6 carbons), so this reaction is anabolic. In the last reaction of the cycle, L-malate is broken down to oxaloacetate and hydrogen ion, which is a catabolic reaction. Therefore, oxaloacetate is an amphibolic intermediate. Acetyl is catabolized by pyruvate, so it is involved in catabolic reaction. Acetyl-CoA and oxaloacetate can together form citrate, so it is involved in anabolic reaction. Therefore, Acetyl-CoA is an amphibolic intermediate.

   Acetyl CoA is more important. Oxaloacetate can be reproduced in the citric acid cycle, while acetyl CoA cannot. Therefore, the number of molecules of Acetyl CoA decides the number of cycles that can undergo, which determines the amount of energy produced.

5. Reciprocal regulation is important because glycolysis and gluconeogenesis has counteractive activity. If they are both active, their effects will be offset, which is not desired. When glucose concentration in blood is high, glucose will become fructose 6-phosphate. High levels of fructose 6-phosphate stimulate phosphoprotein phosphatase, activating PFK2. PFK2 phosphorylates Fructose 1,6-bisphosphate into Fructose 2,6-bisphosphate, which stimulates PFK1 and inhibits FBP1. PFK1 activates glycolysis and FBP activates gluconeogenesis. Therefore, fructose 2,6-bisphosphate activates glycolysis and inhibits gluconeogenesis. Glycolysis breaks down glucose to pyruvates, lowering the glucose concentration in blood. When glucose concentration in blood is low, glucagon stimulates PKA, which activates FBPase2. FBPase2 dephosphorylates Fructose 2,6-bisphosphate to Fructose 6-phosphate. In this case, PFK-1 is inhibited and FBP1 is activated. Therefore, gluconeogenesis is activated, and glycolysis is inhibited. Since more glucose is generated, the glucose concentration in blood will increase. These pathways can also be regulated with energy change.

6. Lipids mainly have three types of roles in cell, structural support for cells and organelles, storage of carbons for energy in the form of triacyclglycerols and information transduction and structural support through liver. Although most kinds of fat can be synthesized by human body, Omega must be obtained from our diet. It is an essential fat, which is an important part of cell membranes and affect the function of cell receptors. Protein's function is super varied, and it is essential for structure, function and regulation of human body. For example, antibodies can bind to viruses to protect body, enzymes catalyze chemical reactions in cells, proteins can transport molecules throughout the body and build up muscle fibres. Carbohydrates are the main source of energy. Glucose, as carbohydrate, is the only form that can be used by cells. Other forms of carbohydrates can also be easily converted to glucose. Therefore, glucose can provide energy fast. In this case, taking many carbohydrates in diet can make brain and muscle work more efficiently. However, lipids and proteins can also be converted to glucose and provide energy, though more slowly. Therefore, I would drop carbohydrates.

7. I would prefer to have the non-functional mutation in glycogen myophosphorylase because the effect of the mutation is acceptable. Glycogen myophosphorylase assists glycogen breakdown in muscle cells into glucose-1-phosphate. The mutation of this enzyme will result in McArdle disease, preventing glycogen breakdown in muscle cells, so glucose concentration will drop, and less pyruvate will be produced. As a result, citric acid cycle and oxaloacetate will be reduced. Therefore, ATP cannot be generated immediately and can only be generated from other pathways, such as fat mobilization and liver gluconeogenesis. It will cause fatigue, muscle we`akness and rhabdomyolysis. Also, people with glycogen myophosphorylase mutated will experience second wind phenomena when exercising, since energy is produced slowly. It might also cause some other complications. For example, fat mobilization will use many ketone bodies, which causes ketoacidosis. Since glycogen cannot be broken down, leading to hyperglycemia. People with glycogen myophosphorylase might also experience cardiovascular disease ad higher level nitrogen load. I could live with the condition by taking complex carbohydrates to keep blood glucose stable and doing warm up slowly when exercising to provide body with time to produce energy needed.

8. Polypeptides are linked through non-covalent interactions. The extreme high temperature and low pH value can influence these interactions, thus changing protein structures. If the temperature is high, and the pH value is low, the bonds that link polypeptides will break from weaker bonds to stronger bonds. Since proteins form muscle cells, the polypeptide structure change will cause muscle cells to work improperly and finally dead.

9. My advice is that the contestant can compete in the show but better not to. The potential contestant has Type 1 diabetes, which means that his body cannot produce insulin. Insulin promotes glycolysis. When the blood sugar is high, insulin stimulates the liver to store glucose as glycogen. Without insulin, the contestant will not be able to start glycolysis process, thus cannot lowering the blood sugar level. However, they had access to a blood glucose monitor and insulin injections, so their blood glucose level can be monitored, and blood glucose level can be kept at a normal level by inducing insulin. On the other hand, participating in this competition might still induce some problems. The lifestyle in the competent has a tremendous change compared with his normal lifestyle with more physically demanding challenges, and different sets of food eaten. It is hard to decide the appropriate amount of insulin induced. Excess induction of insulin might lead to hypoglycemia. If no laboratory equipment is provided, we can predict the contestant's blood sugar based on the symptoms. If the person's glucose level is too high, he will experience extreme thirst and an increase in urine production. If the person's glucose level is too low, he will experience dizziness and tiredness due to a lack of energy supply.