Carbohydrate Metabolism

How are carbohydrates metabolized within a cell?

Gylcolisis vs Kreb's Cycle (Oxidation / Phosphorylation)

Gycolysis occurs in the cytoplasm //// Kreb's Cycle occurs in the mitochondria
Gycolysis does not require oxygen //// Kreb's Cycle requires oxygen.
Gycolysis produces only 2ATP + 2 NADH //// Kreb's cycle produces 38 ATP (10 NADH + 2 FADH = 34ATP)
Gycolysis produces 2 CO_2 //// Kreb's Cycle produces 4 CO_2 + 6H_2O (metabolic water).
1 NADH = 3ATP / 1 FADH = 2APT
Glucose = 686 kcal/moles /// ATP = 7.3 kcal/mole ---- 40% efficiency / 60% lost as heat

Gycolisis: (with and without O_2)

with oxygen: glucose 6C ------> 2 pyruvate (3C) ----------> 2 CO_2 + 2 acetyl-CoA (2C)

without oxygen: glucose 6C ------> 2 pyruvate (3C) ----------> 2 lactic acid (3C) ----------> 2 lactate (3C)

Note: lactate is able to cross the plasma membrane, enters the blood, liver takes up lactate, liver combine two lactate molecules to produce a glucose molecule / glucose molecule can either be incorporated into glycogen in the liver or glucose can leave liver, go into the blood and be picked up by a tissues in your body.

What happens when carbohydrates either are not available or are very limited? What type of signals alerts the body to this crisis? How does the body try to compensate for this condition? Where do the alternative acetyl-CoA molecules come from? Why can't the acetyl-CoA molecules enter the Kreb's cycle? What happens to the excess acetyl-CoA molecules?

1. Cells switch from carbohydrate metabolism to triglyceride metabolism (triglyceride = glycerol (3C) + fatty acids). Enzymes cleave off two carbon segments off the fatty acid molecule to make acetyl-CoA molecules. These molecules may enter the mitochondria and may enter the Kreb's Cycle if oxaloacetic acid (the entry point into the Kreb's Cycle). The glycerol molecule goes to the liver where it is converted into a glucose molecule.

2. Low blood glucose signals pancreas (alpha cells) to release glucagon into the blood. Normally, glucagon would mobilize glucose from glycogen but reserves are already depleted. However, glucagon also can alter metabolism of adipocytes to break down triglycerides into gycerol and fatty acids). Nerve fibers embedded into adipose tissue may also release catecholamines which also breakdown triglycerides.

3. The body will try to compensate by producing acetyl-CoA molecules from fatty acids.

4. When carbohydrates are very low or not present in the body then the body will try to make glucose (gluconeogenisis) from glycerol or amino acids. Another source of glucose is to convert oxaloacetic acid into glucose but this "shuts down" the Kreb's Cycle. (Note: oxaloacetic acid is the entry point into the Kreb's Cycle) Remember, some cells can only make ATP from glucose molecules (e.g. brain cells and RBCs).

5. As acetyl-CoA molecules accumulate they start to aggregate into acetoacetic acid, Beta-hydroxybutyric acid & acetone (i.e. the ketone bodies). These are all strong metabolic acids and are also known as ketones (ketosis). This is an extremely dangerous condition. The breath will smell "sweet" and as these ketones continue to build up in the body, the individual will become confused, followed by coma and death without corrective action.