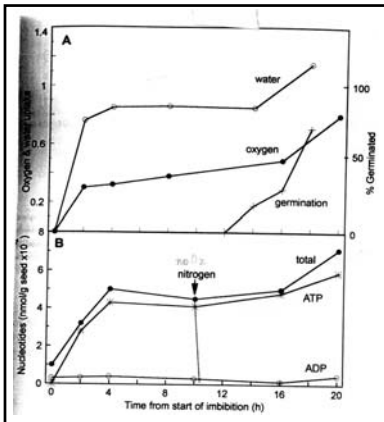
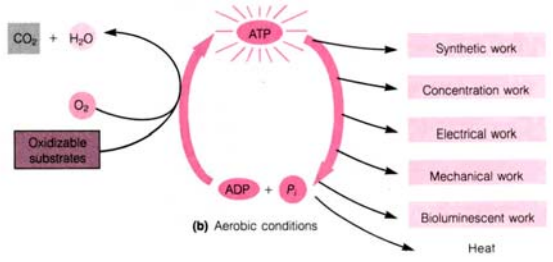


Experiment:
Time-course of water and oxygen uptake, and seed germination

Interpret results

Pradet et al 1968; 1981)

Aerobic organisms obtain energy from oxidation of food molecules



Becker et al. Third Ed. World of the Cell

Germination: Oxygen Needs_ Outline

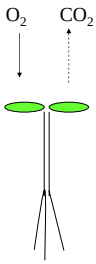
1. Increase in oxygen uptake is needed to generate energy for

- synthesis of enzymes to degrade stored foods
- synthesis of materials for new cells, e.g. RNA, membranes.

2. Principles of C oxidation and energy yield. Organisms obtain energy from oxidation-reduction reactions.

- a. Oxidation of fatty acids and glucose yield energy in reducing equivalent as NADH.
- b. Energy in NADH can then be trapped as ATP.

3. How do embryos get energy and building materials from seed reserves?



Mobilization of seed reserves

I. Degradation of polymers

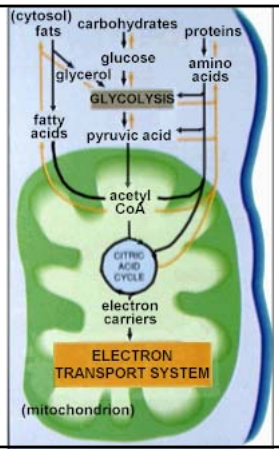
2. Transport of a soluble form to growing root and shoot apices via phloem

Main seed reserves: Carbohydrates, Lipids, proteins

a. Starch -- amylase --> glucose
sucrose is transport form

b. Lipids--lipase --> glycerol and fatty acid ---> acetyl CoA

c. Proteins --peptidase -> amino acids
Amino acids are transported to growing cells



Catabolism:

Breaking down food molecules to obtain energy & metabolites.

How are food molecules broken down?

1. **Polymer breakdown**
2. **Glycolysis**
3. **Kreb cycle (TCA): complete oxidation of C to CO_2 and generation of NADH**
4. **Reducing power NADH via Electron transport + phosphorylation to ATP**

Role of O2: electron acceptor

Principles of C oxidation and energy yield

1. Stored foods supply reduced C.

Reduced C is oxidized with release of 2H trapped as NADH

Lipid **alcohol** **aldehyde** **acid**

CH_3 ---> CH_2OH ---> CHO ---> $COOH$ ---> CO_2

+ 2H +2H +2H +2H

Most **reduced** form of C

Most **oxidized** form of C

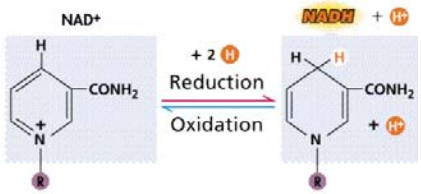
2. Energy in the reduced compounds can be trapped in ATP.

$4H + O_2$ ---> $2H_2O$ + n ATP

Two Basic Forms of energy: a. Reducing energy

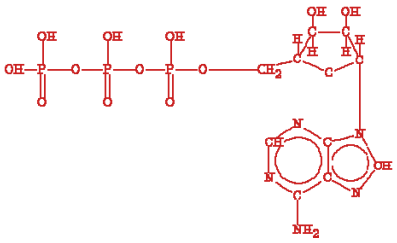
NADH and NADPH are universal carriers of electrons.

Reducing energy



2 electron carrier

Basic forms of energy: b. ATP: chemical bond energy



$2NADH + 2H^+ + O_2 \rightarrow 2H_2O + n\ ATP$

Energy in NADH is trapped as ATP.

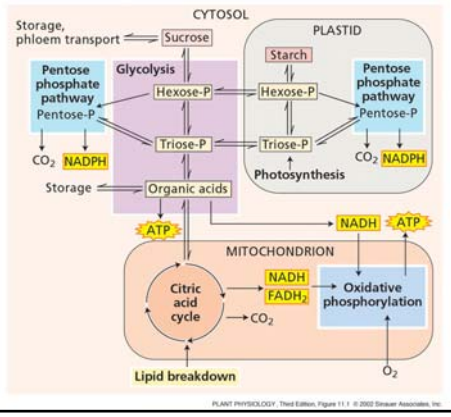
Energy from oxidation of 1 mole of Glucose?

- Complete combustion of glucose :

$Glucose + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + Energy$

- The free energy released, $\Delta G^{\circ\prime} = -686$ kcal/mole
- Since hydrolysis of ATP gives $\Delta G^{\circ\prime} \sim -10$ kcal/mole, 1 mole Glucose contains energy for 70-85 moles of ATP.
- In respiration, 1 glucose yields 36 ATP.

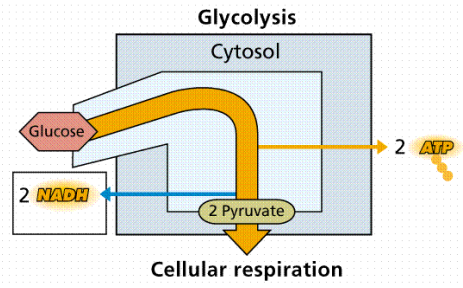
Overview of organic molecule breakdown & synthesis

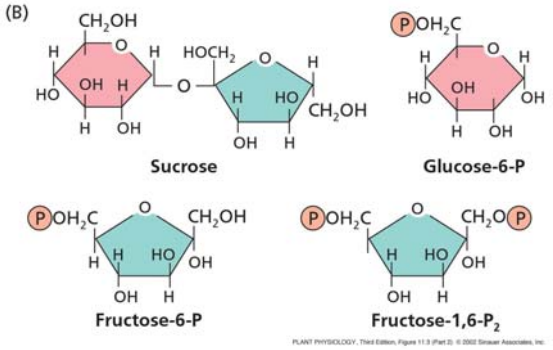


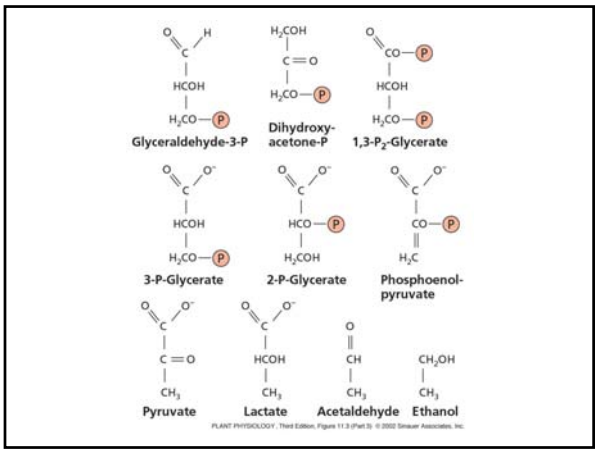
11-1

2. Glycolysis (simplified): Glucose ---> 2 PVA

6 C ----> 2 (3 C)

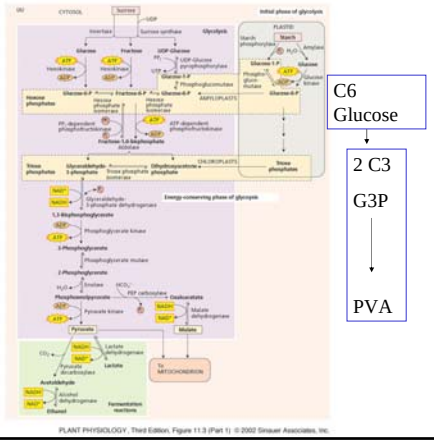




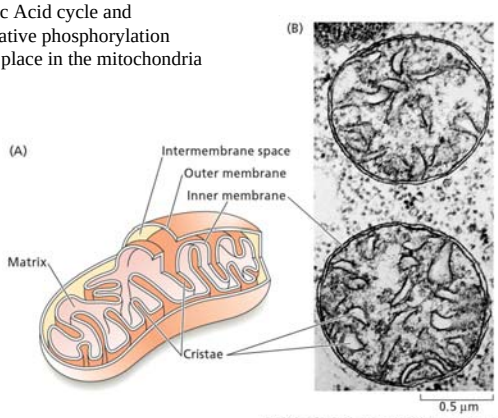


11-3. Taiz Glycolysis in the cytoplasm

(10 steps)

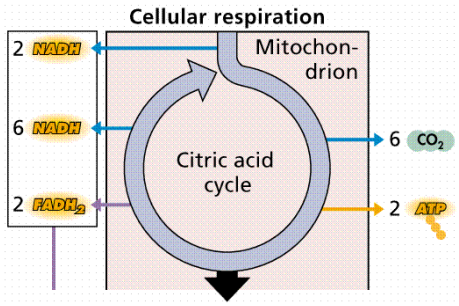


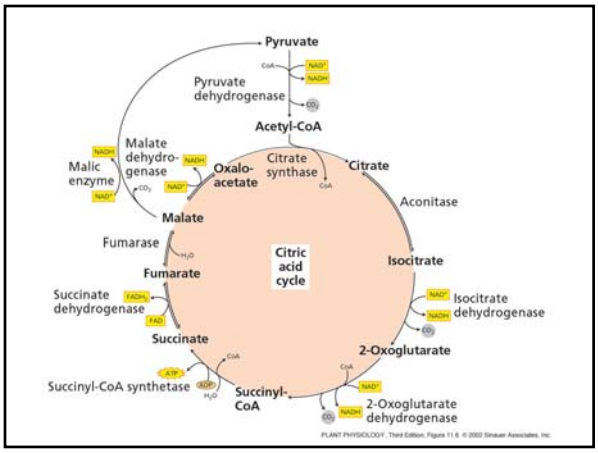
Citric Acid cycle and oxidative phosphorylation take place in the mitochondria



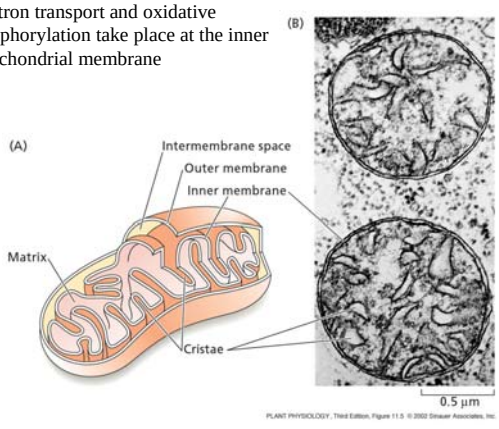
3. Kreb Cycle or **TCA cycle (simplified).**

Oxidation of 2 PVA --> 6 CO_2 + 8NADH + 2$FADH_2$



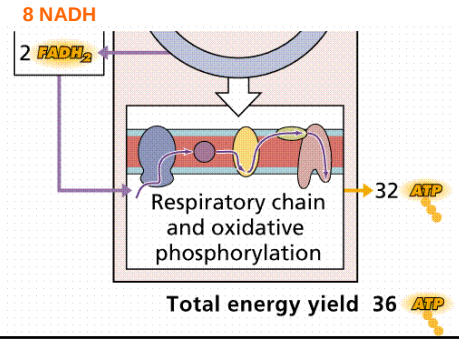


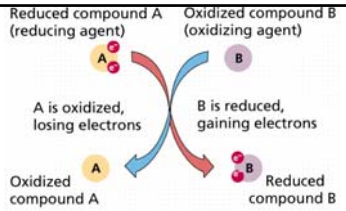
Electron transport and oxidative phosphorylation take place at the inner mitochondrial membrane



4. (Simplified reaction of electron transport & ATP formation)

NADH + H^+ + 1/2 O_2 --> NAD+ + H_2O + 3ATP

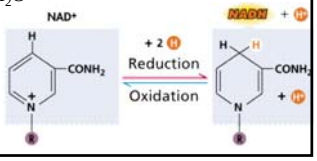


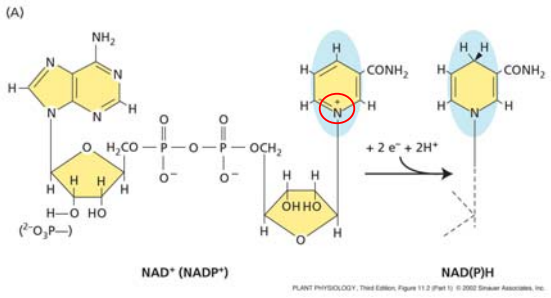


Electrons from NADH are accepted by oxygen

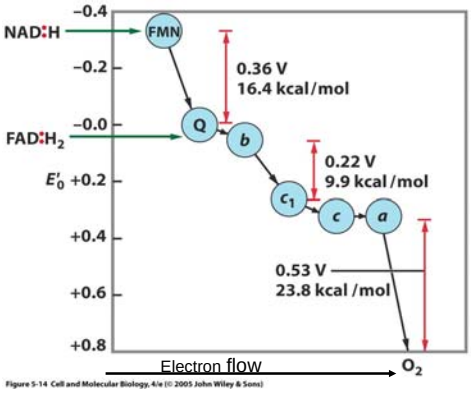
e donor: NADH + H^+ --> NAD^+ + 2e- + $2H^+$

e acceptor: 1/2O_2 + 2e- + $2H^+$ --> H_2O

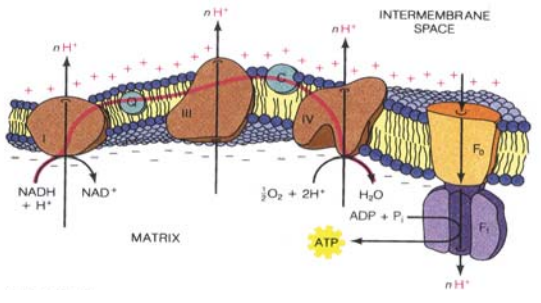




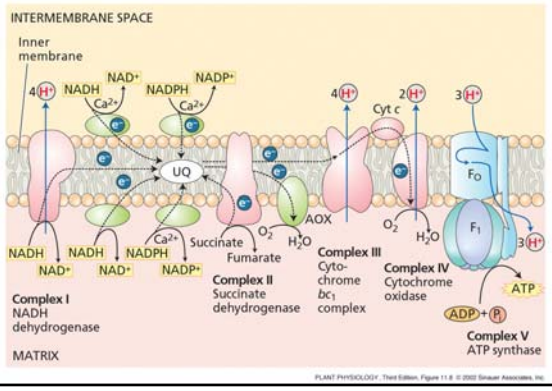
Electron Transport



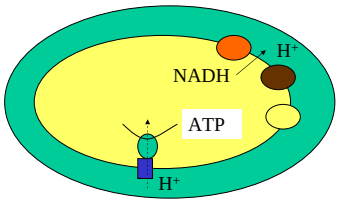
Energy from electrons flow through respiratory complexes I, III, and IV is used to pump H^+ across the membrane from inside to outside.



Taiz, ch 11. Electron transport and phosphorylation



Conversion of one energy form to another

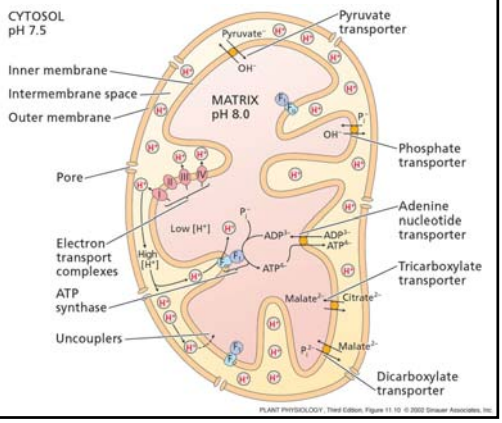


NADH oxidation ---> H^+ gradient ----> ATP

Reducing energy --> proton electrochemical ---> chemical

11-8

pmf



Summary

1. Stored food (carbohydrate, lipid, and proteins) are broken down to their monomers. E.g. glucose

2. Glucose --> 3C --> CO_2 + NADH.
   NADH + O_2 --> H^+ gradient (pmf) --> ATP

3. **ATP** energy is used for active transport.

ATP and reducing power (NADPH) is used for biosynthesis of new macromolecules

•4. **C metabolites** of stored food (e.g. glucose, C_3, amino acids) provide C skeleton for biosynthesis of macromolecules, e.g. new enzymes, RNA, cell wall, etc.

Mobilization of seed reserves

I. Degradation of polymers

2. Transport of a soluble form to growing root and shoot apices via phloem

3. Conversion to new molecules in cells & to ATP

Main seed reserves: Carbohydrates, Lipids, proteins

a. Starch -- amylase --> glucose
Glu + Fructose → sucrose
sucrose is transport form

b. Lipids--lipase --> glycerol and fatty acid ---> acetyl CoA

c. Proteins --peptidase -> amino acids
Amino acids are transported to growing cells

d. Phytin : bind minerals

Know these molecular Structures

Starch

Cellulose

Sucrose

Glucose

Glyceraldehyde 3-P (G3P)

Pyruvate (PVA)

Oxidation-reduction

NAD(P)+/NAD(P)H

Lipid

Fat is triglyceride. Glycerol

Fatty acid

Acetyl-CoA

Protein is a polymer of 20+ amino acids in a specific order.

Amino acid –general structure