

Metabolism

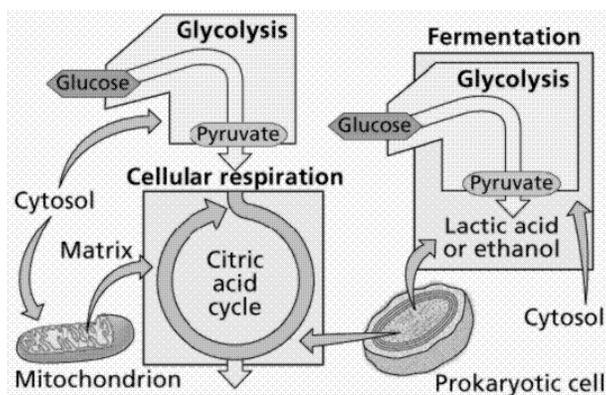
5.7.00:

- Enzymatic Reactions
- General Concepts of Metabolism
- Central Metabolism (Glycolysis, TCA, oxidative Phosphorylation)

12.7.00:

- Photosynthesis
- Metabolism of selected compounds
- Principles of Metabolic Engineering

Metabolism is Organized in Compartments



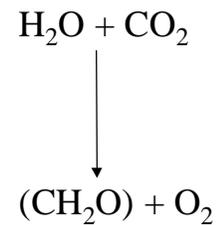
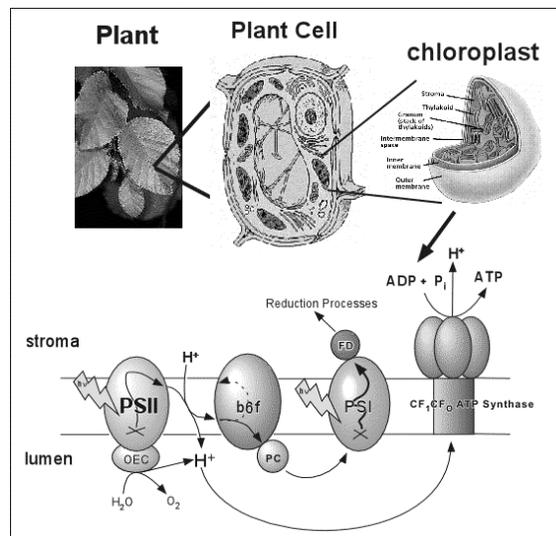
Photosynthesis I

“Nature has put itself the problem if how to catch in flight light streaming to the earth and to store the most elusive of all powers in rigid form”

Julius Robert Mayer, 1842

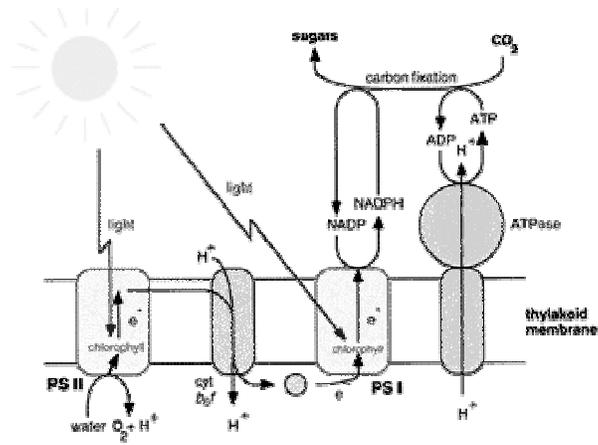
10^{17} kcal of free energy is stored annually by photosynthesis on earth. This corresponds to the assimilation of more than 10^{10} tons of carbon into carbohydrate and other forms of organic material.

Photosynthesis II

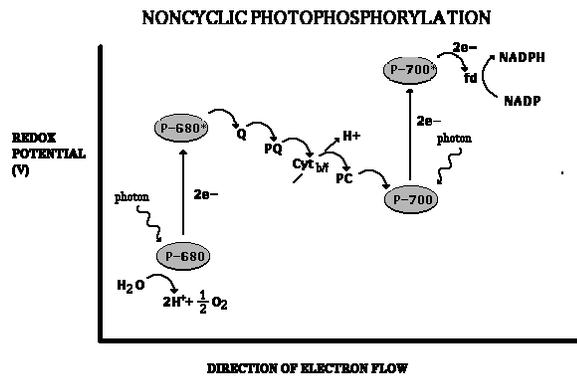


(CH_2O) represents carbohydrate (e.g. sucrose and starch)

Photosynthesis III

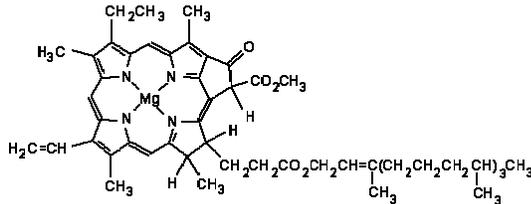


Photosynthesis IV



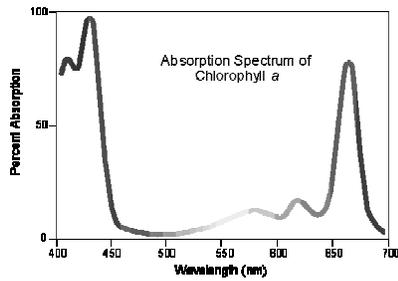
Light is used to create a reducing potential

Chlorophyll

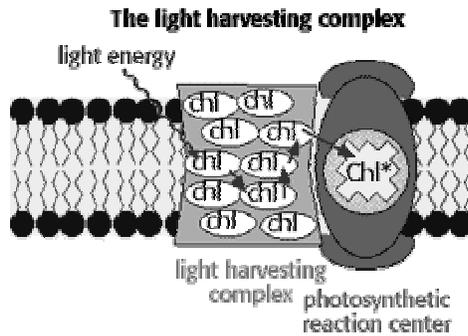


Structure of chlorophyll a

One of the highest absorption coefficient of organic compounds

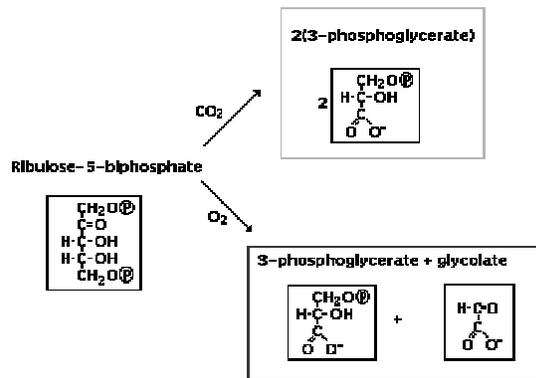


Light-harvesting complexes



- Increases the yield of excited electrons
- The energy is finally transferred to the photosynthetic reaction center

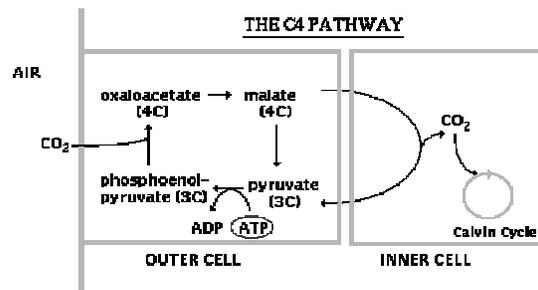
Rubisco



Ribulose-1,5-bisphosphate carboxylase

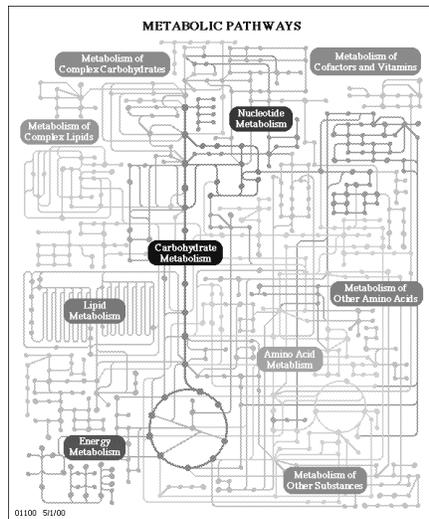
- Rubisco is the most abundant enzyme
- Even though it evolved early, it is far from being perfect
- Plants in warm climate have to cope with increasing mal-functioning

C4 plants



- Provides a high local concentration of CO₂

Metabolism: Overview



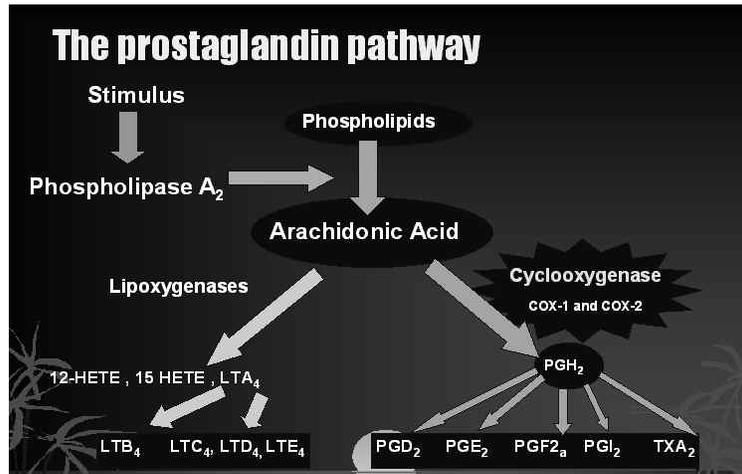
- several hundreds to thousands of different reactions in each cell
- building blocks are used and reused to assemble larger molecules

Synthesis of Prostaglandins I

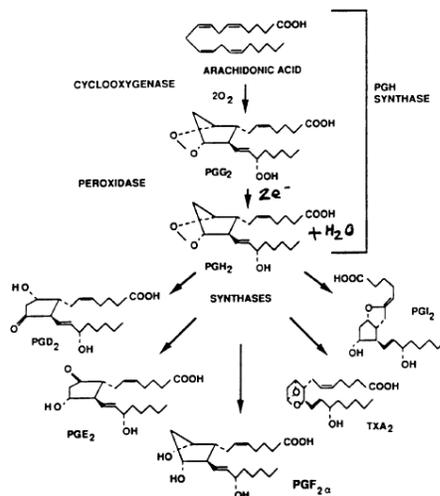
Prostaglandins - the action

E1, E2, F1 α , F2 α	Increase vascular permeability Cause inflammation - Wheal and flare Contract smooth muscle - uterus / git / bronchi Increase hyperalgesia in sensory afferent nerve fibres Reduce gastric acidity
D2	Increase hyperalgesia in sensory afferent nerve fibres Inhibit platelet adhesion
Thromboxane	Increase vascular permeability Aggregate platelets
Prostacycline	Decrease vascular tone Reduce platelet adhesion

Synthesis of Prostaglandins II



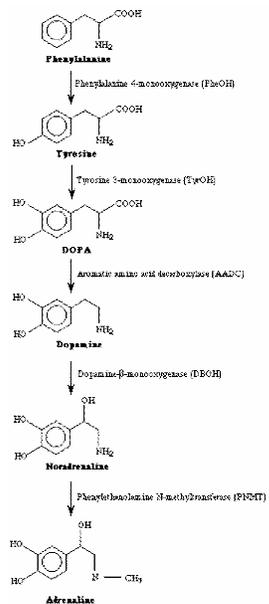
Synthesis of Prostaglandins III



Prostaglandin synthase is a multifunctional enzyme

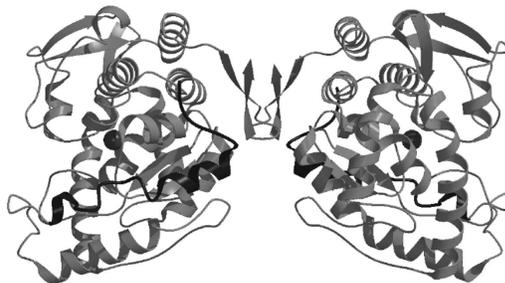
Its inhibitors are widely used:
e.g. Ibuprofen, Aspirin

Phenylalanine is linked to hormones



- missing phenylalanine hydroxylase causes also missing information processing

Phenylalanine hydroxylase

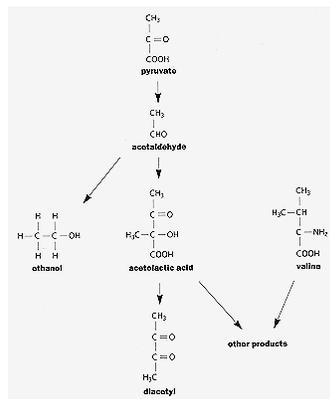


- Deficiency of this enzyme causes phenylketonuria
- 1 out of 20000 newborn
- Usually severe mental retardation

Metabolic Engineering I

- Trying to influence the biochemical network by inhibiting or activating certain steps in metabolism
- Long list of failures
- Very short list of successes
- Techniques involve drugs and most of the time genetic engineering techniques

Metabolic Engineering II



• Diacetyl is one of the more important carriers of flavor in milk products and beer

• Some success in engineering *Lactococcus lactis*

• Unfortunately, there is a discussion of increasing cancer risk with increasing concentration of diacetyl

MCA - Metabolic Control Analysis

$$C_i^A = \frac{\partial A}{\partial v_i} \cdot \frac{v_i}{A} = \frac{\partial \ln A}{\partial \ln v_i}$$

- Sensitivity Analysis

- Valid only, if the rest of the system remains unchanged

One of the major breakthroughs of this technique was the discovery that control is almost always spread over the complete pathway.