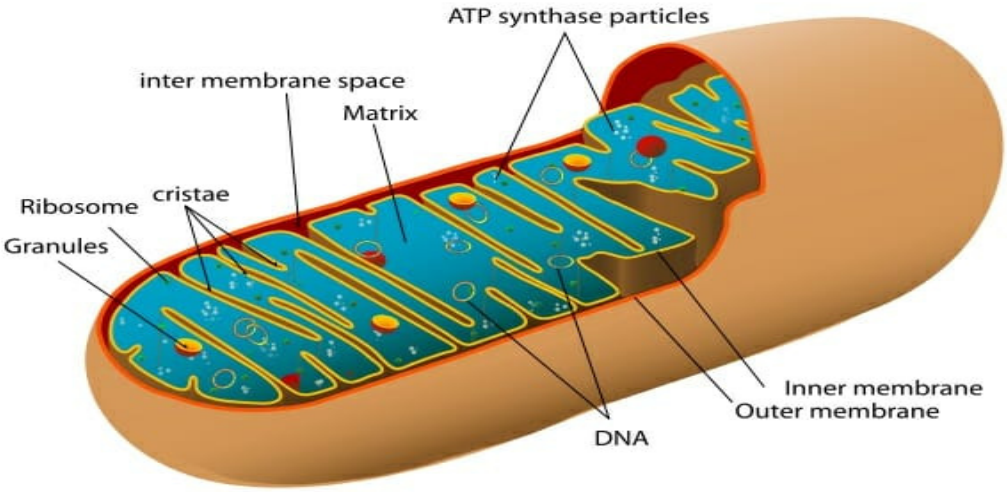
MITOCHONDRIA

The mitochondrion:

- Greek Mitos = „thread”, and chondrion = „granule”
- found in most eukaryotic cells
- energy factory of the cell"
- 0.5 to 1.0 micrometer (μm)
- Number: 1- several thousand /cell
- Surrounded by a double membrane:

1. Outer membrane
2. Intermembrane space.
3. Inner membrane (cristae).
4. Mitochondrial matrix.



1. Outer membrane:

• Similar to the eukaryotic plasma membrane (protein:phospholipid = 1:1)

• Contain porin proteins → make the membrane permeable to 10.000 Dalton.

2. Inner membrane:

• Protein:phospholipid = 80:20

• Rich in cardiolipin (phospholipid) → makes the inner membrane impermeable

• Molecules require special transport proteins to enter or exit the matrix

• forms cristae

• Cristae – expand the surface area of the inner mitochondrial membrane – Contain proteins:

• Specific transport proteins

• Proteins of the electron transport chain

• ATP-synthase

3. Intermembrane space:

• Between the outer membrane and the inner membrane

• The concentrations of molecules in the intermembrane space is the same as in the cytosol.

4. Matrix:

• Gel-like

• Contains: – hundreds of enzymes – special mitochondrial ribosomes, tRNAs and mRNAs – several copies of the mitochondrial DNA genome.

5. GENETIC APPARATUS OF MITOCHONDRIA:

Mitochondrial DNA:

• 2-10 mtDNA copies/mitochondrion

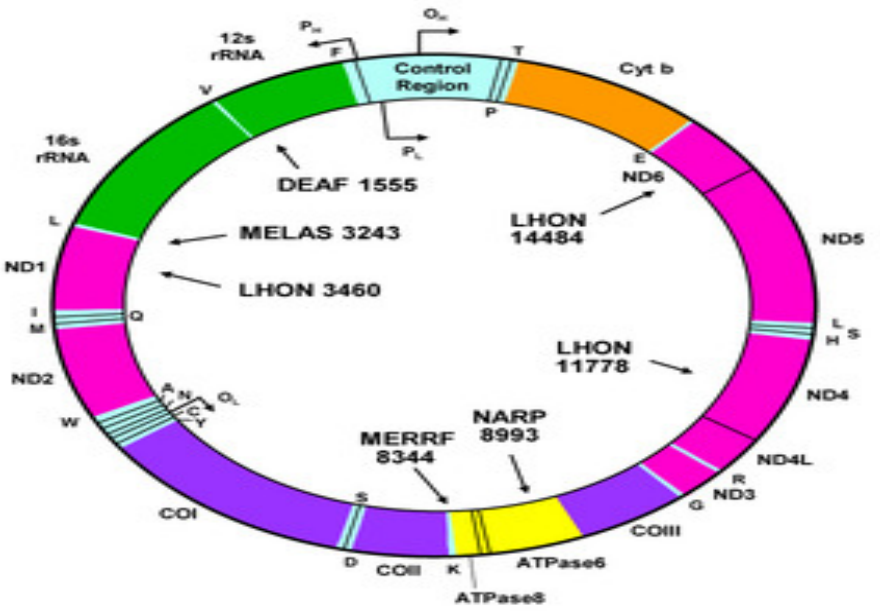
• Double stranded, circular, short (~16,600 base pairs)

• Codes for only 37 genes (13 for proteins, 22 for tRNA and 2 for rRNA)

• Other genes are in the eukaryotic nucleus → posttranslational transport

• The two strands are different by their nucleotide content (one strand is guanine-rich, other strand is cytosine-rich)

• Both of the strands contain gene.



Mutation of mtDNA:

• Free radicals

• No histon proteins

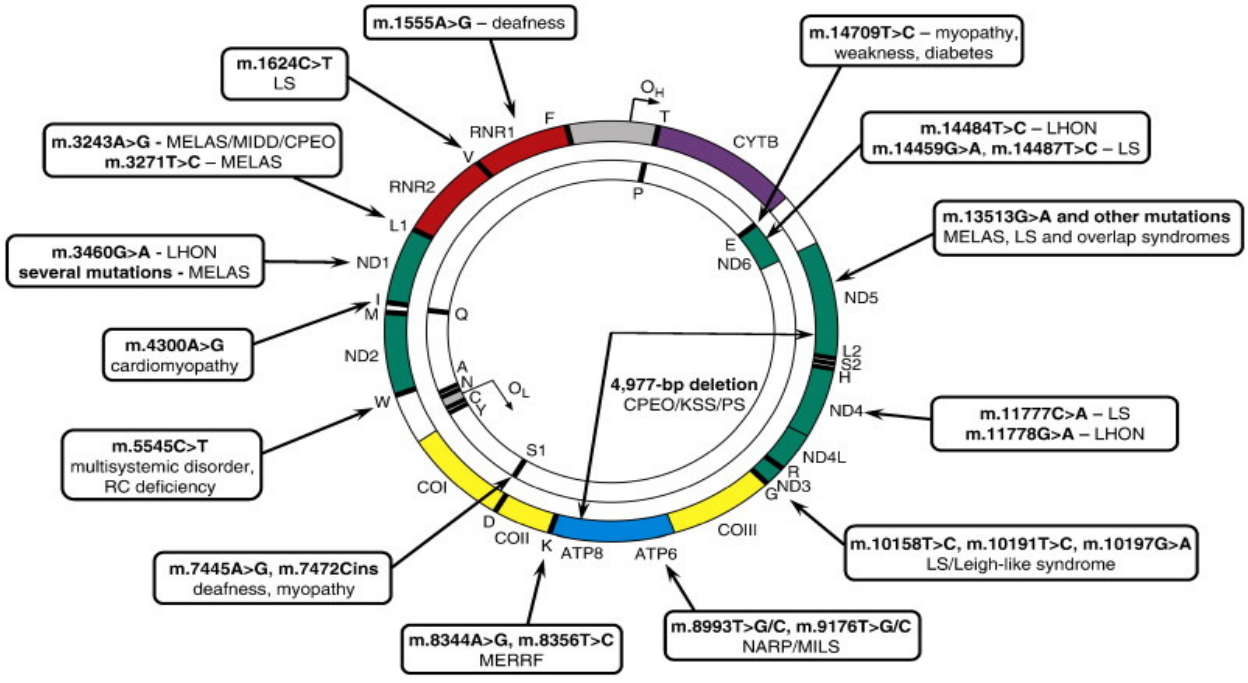
• Proofreading and repair are weak → damage of the DNA, proteins and of the inner membrane.

• Non- mendelian inheritance

• Maternal inheritance (from mother to child)

• Homoplasmy-copies of mtDNA are all identical in a cell (normal or mutated)

• Heteroplasmy- copies of mtDNA are different in a cell (normal and mutated) -ratio of mutated mtDNA reaches a treshold → disease.



Mitochondrial diseases:

• Sensory organs, muscle, heart, nervous system, pancreas, are affected → these cells use more energy than other cells

• Neurological disorders

• Diabethes mellitus

• Blindness

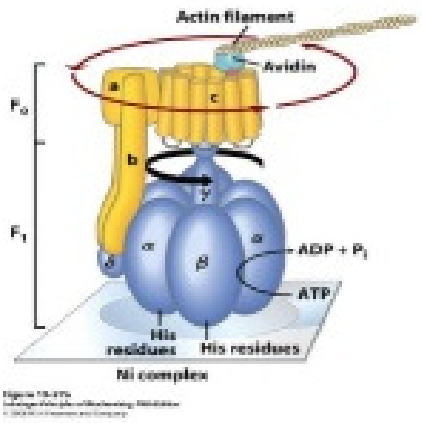
• Myopathy (muscular weakness)

6. Mechanisms:

The synthesis of ATP

• From glucose and fatty acids

• 3 main processes: 1. Glycolysis 2. Citric acid cycle 3. Terminal oxidation NAD+ (Nicotinamide adenine dinucleotide)



• Coenzyme

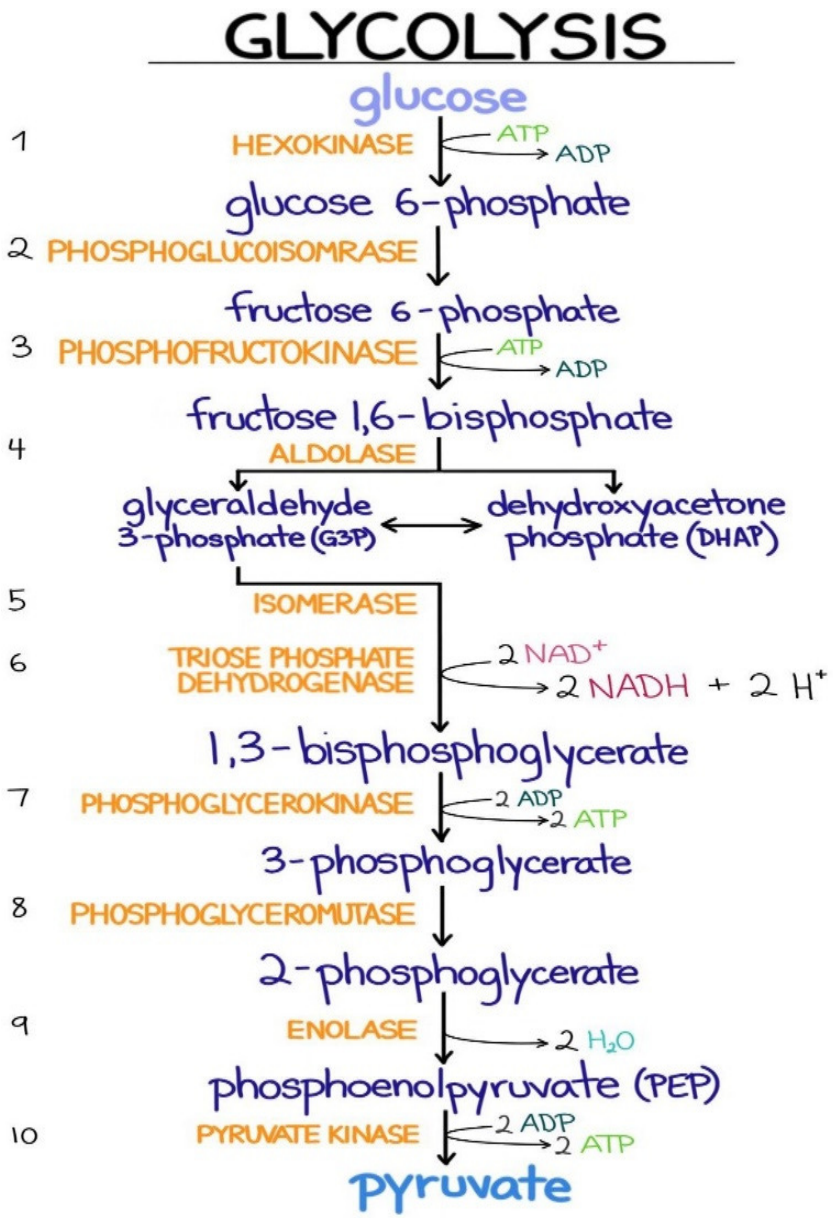
• transports electrons from one reaction to another NADH (Nicotinamide adenine dinucleotide)

• NAD+ → accepts electrons from other molecules and becomes reduced → NADH

• NADH → donate electrons and becomes oxidized to its original form → NAD+.

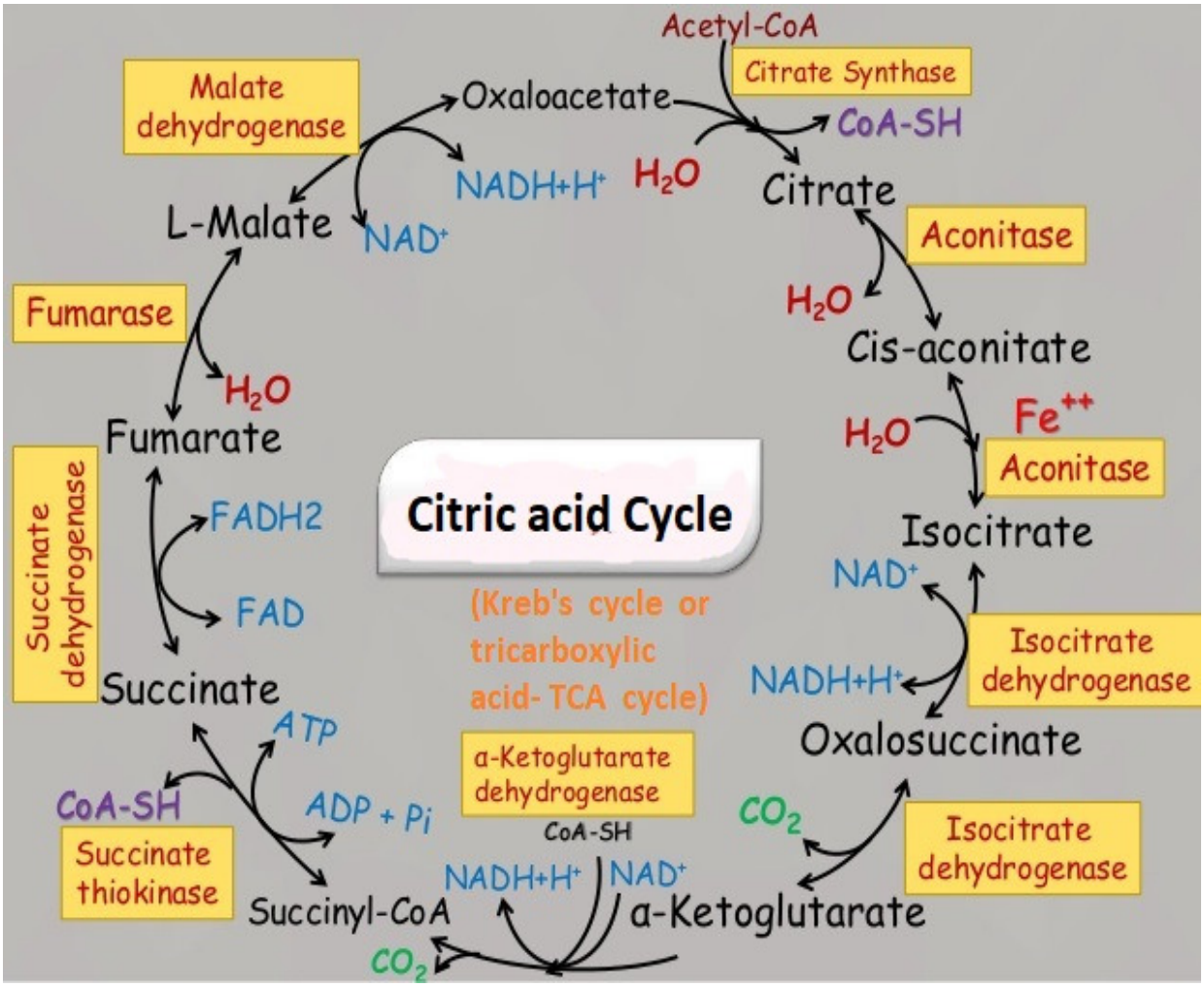
I. Glycolysis:

- converts glucose (C6) into pyruvate (C3)
- In the cytosol
- Oxygen is never involved in the reaction
- Ten reactions → ten intermediate compounds
- Formation of 2 ATPs (4- 2) and 2 NADHs, 2 pyruvates



II. Citric acid cycle:

- In the matrix of the mitochondrion
- Pyruvate (C3) loses 1 carbon atom → acetic acid (C2)
- Acetic acid + Coenzyme A (CoA) → Acetyl CoA
- Oxaloacetate (C4) + acetyl group (C2) = citrate (C6)
- Formation of: – 2 CO2 – 3 NADH – 1 FADH2 – 1 GTP.



III. Terminal oxidation / Oxidative phosphorylation:

• In the inner mitochondrial membrane by protein complexes

• 3 events:

a) **Oxidation of coenzymes** → transport of the electrons the final electron acceptor is molecular oxygen → is reduced to water (harmful intermediates are generated =ROS) ***.

*** [• During reduction of oxygen → harmful, instable intermediates are produced (superoxide or peroxide anions)

• These are called reactive oxygen species (ROS): – are very harmful to cells – oxidize proteins, destroy the membrane and cause mutations in DNA – Cause diseases and is proposed as one cause of aging]

b) **Movement of protons:**

• Are pumped into the intermembrane space → electrochemical proton gradient (proton-motive force)

• Protons have to flow back into the matrix trough ATP synthase.

c) ATP synthesis by ATP synthase:

• Enzyme complex

•F_o: proton channel

• F_1: catalytic activity

• Protons flow through the complex (chemiosmosis) → this kinetic energy rotates the F1 subunit → synthesis of ATP from ADP + Pi.

7. ATP production from bioorganic molecules:

- 1 g fatty acid: 9Kcal/37kJ
- 1 g carbohydrate: 4Kcal/17kJ
- 1 g protein: 4Kcal/17kJ.

Aerobic organisms:

- requires oxygen to grow
- use oxygen to make energy (cellular respiration)
- Produce more energy than anaerobes ↔ high levels of oxidative stress.

Facultative anaerobic organisms:

- make ATP by aerobic respiration if oxygen is present
- Switch to fermentation if oxygen is not present.

8. Functions:

- Regulation of the membrane potential
- Apoptosis (programmed cell death)
- Signaling (regulation of gene expression)
- Regulation of cellular metabolism
- Steroid synthesis