Aerobic & Anaerobic respiration

In Anaerobic process, the pyruvate is converted to lactate in a process called lactic acid fermentation:

pyruvate + NAD^{+} + H $\rightarrow$ lactate + NADH

This process occurs in the bacteria & also occurs in animals under hypoxic conditions, e.g., in overworked muscles that are starved of oxygen, or in infarcted heart muscle cells.

In aerobic organisms, a complex mechanism has been developed to use the oxygen in air as the final electron acceptor.

pyruvate is converted to acetyl-CoA and CO_2 within mitochondria in a process called pyruvate decarboxylation

Comparison Chart

	Aerobic Respiration	Anaerobic Respiration
Cells involved	Most organisms and body cells need oxygen to produce energy and to survive.	Anaerobic metabolism may occur in muscle cells and red blood cells, as well as some types of bacteria and yeast
Lactic Acid Production	None	Yes
Energy Produced/Glucose Molecule	High (38 ATP molecules)	Low (only 2 ATP molecules)
Products	ATP, water, and carbon dioxide	ATP, Lactic Acid
Reactants	Oxygen + Glucose (sugar)	Glucose
Reaction Site in the Cell	Cytoplasm, mitochondria	Cytoplasm
Stages Involved	1.Glycolysis 2.Krebs cycle 3. Electron Transport Chain	1. Glycolysis 2. Fermentation
Combustion	complete	incomplete

Citric acid cycle

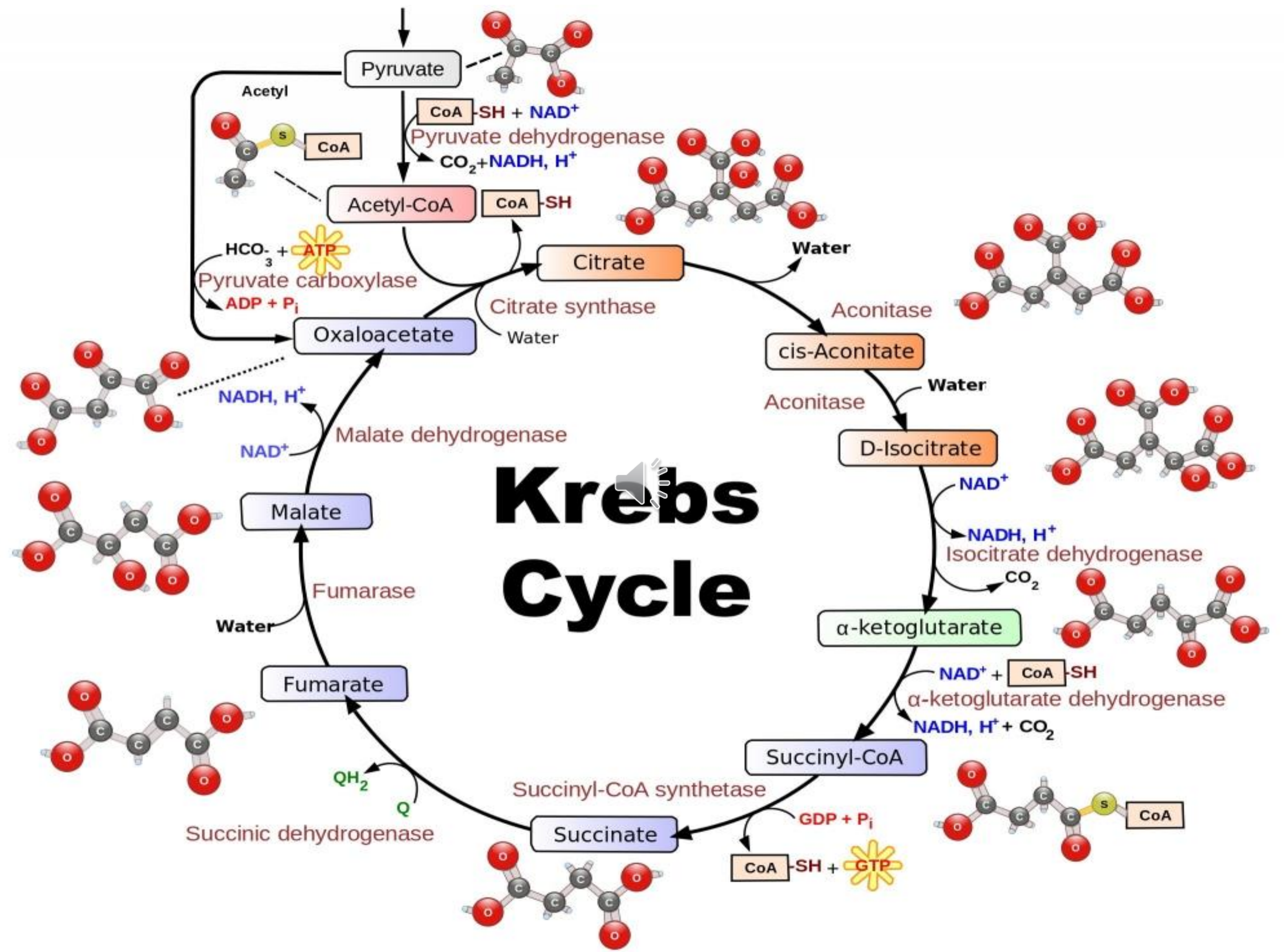
also known as the tricarboxylic acid cycle (TCA cycle), the Krebs cycle.

The name of this metabolic pathway is derived from citric acid (a type of tricarboxylic acid) that is first consumed and then regenerated by this sequence of reactions to complete the cycle.

TCA cycle is a series of chemical reactions occurs in the mitochondria used by all aerobic organisms to:

1- generate energy through the oxidization of acetate derived from catabolism of carbohydrates, fats and proteins into carbon dioxide.

2- provides precursors like certain amino acids as well as the reducing agent NADH that is used in numerous biochemical reactions (i.e. gluconeogenesis).


Krebs
Cycle
Pyruvate
Acetyl
CoA
CoA-SH + NAD+
Pyruvate dehydrogenase
CO2+NADH, H+
Acetyl-CoA
CoA-SH
HCO3- + ATP
Pyruvate carboxylase
ADP + Pi
Citrate
Citrate synthase
Water
Water
Aconitase
cis-Aconitate
Water
Aconitase
D-Isocitrate
NAD+
NADH, H+
Isocitrate dehydrogenase
CO2
α-ketoglutarate
NAD+ + CoA-SH
α-ketoglutarate dehydrogenase
NADH, H+ + CO2
Succinyl-CoA
Succinyl-CoA synthetase
GDP + Pi
CoA-SH + GTP
Succinate
Succinic dehydrogenase
QH2
Q
Fumarate
Fumarase
Water
Malate
Malate dehydrogenase
NAD+
NADH, H+
Oxaloacetate

Citric acid cycle Overview

1- Acetyl-CoA produced from catabolism of CHO, fats & proteins, along with two equivalents of water (H_2O) are consumed by the citric acid cycle producing two equivale. of carbon dioxide (CO_2) and one equivalent of HS-CoA

2- one complete turn of the cycle converts three equivalents of nicotinamide adenine dinucleotide (NAD+) into three equivalents of reduced NAD+ (NADH), one equivalent of ubiquinone (Q) into one equivalent of reduced ubiquinone (QH_2), and one equivalent each of guanosine diphosphate (GDP) and inorganic phosphate (Pi) into one equivalent of guanosine triphosphate (GTP). The NADH and QH_2 generated by the citric acid cycle are in turn used by the oxidative phosphorylation pathway to generate energy-rich adenosine triphosphate (ATP).

Products of the first turn of the cycle are: one GTP (or ATP), three NADH, one QH2, two CO2

Oxidative phosphorylation

Is a metabolic pathway that uses energy released by the oxidation of nutrients to produce adenosine triphosphate (ATP). It is a highly efficient way of releasing energy, compared to alternative fermentation processes such as anaerobic glycolysis. During oxidative phosphorylation, electrons are transferred from electron donors to electron acceptors such as oxygen, in redox reactions.

Although oxidative phosphorylation is a vital part of metabolism, it produces reactive oxygen species such as superoxide (O_2^-) and hydrogen peroxide (H_2O_2), which lead to propagation of free radicals, damaging cells and contributing to disease.

Electron Transport Chain

Energy-rich molecules, such as glucose, are metabolized by a series of oxidation reactions ultimately yielding CO_2 and water. The metabolic intermediates of these reactions donate electrons to specific coenzymes—nicotinamide adenine dinucleotide (NAD^+) and flavin adenine dinucleotide (FAD)—to form the energy-rich reduced coenzymes, NADH and $FADH_2$. These reduced coenzymes can, in turn, each donate a pair of electrons to a specialized set of electron carriers, collectively called the electron transport chain, as electrons are passed down the electron transport chain, they lose much of their free energy. Part of this energy can be captured and stored by the production of ATP from ADP and inorganic phosphate (P_i). This process is called oxidative phosphorylation. The remainder of the free energy not trapped as ATP is used to drive further reactions such as Ca^{2+} transport into mitochondria, and to generate heat.

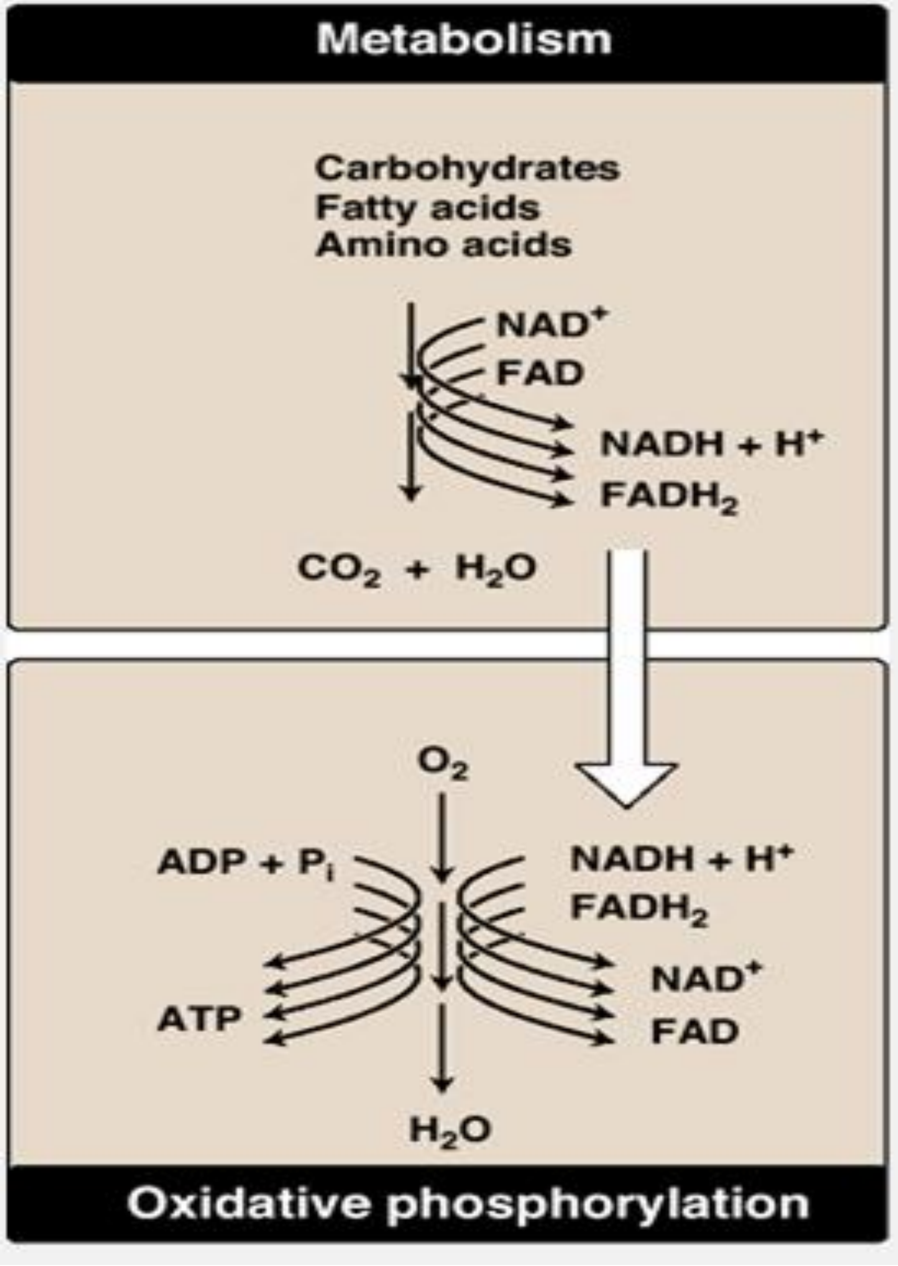
Mitochondrion

The electron transport chain is present in the inner mitochondrial membrane and is the final common pathway by which electrons derived from different fuels of the body flow to oxygen.

Electron transport and ATP synthesis by oxidative phosphorylation proceed continuously in all tissues that contain mitochondria.

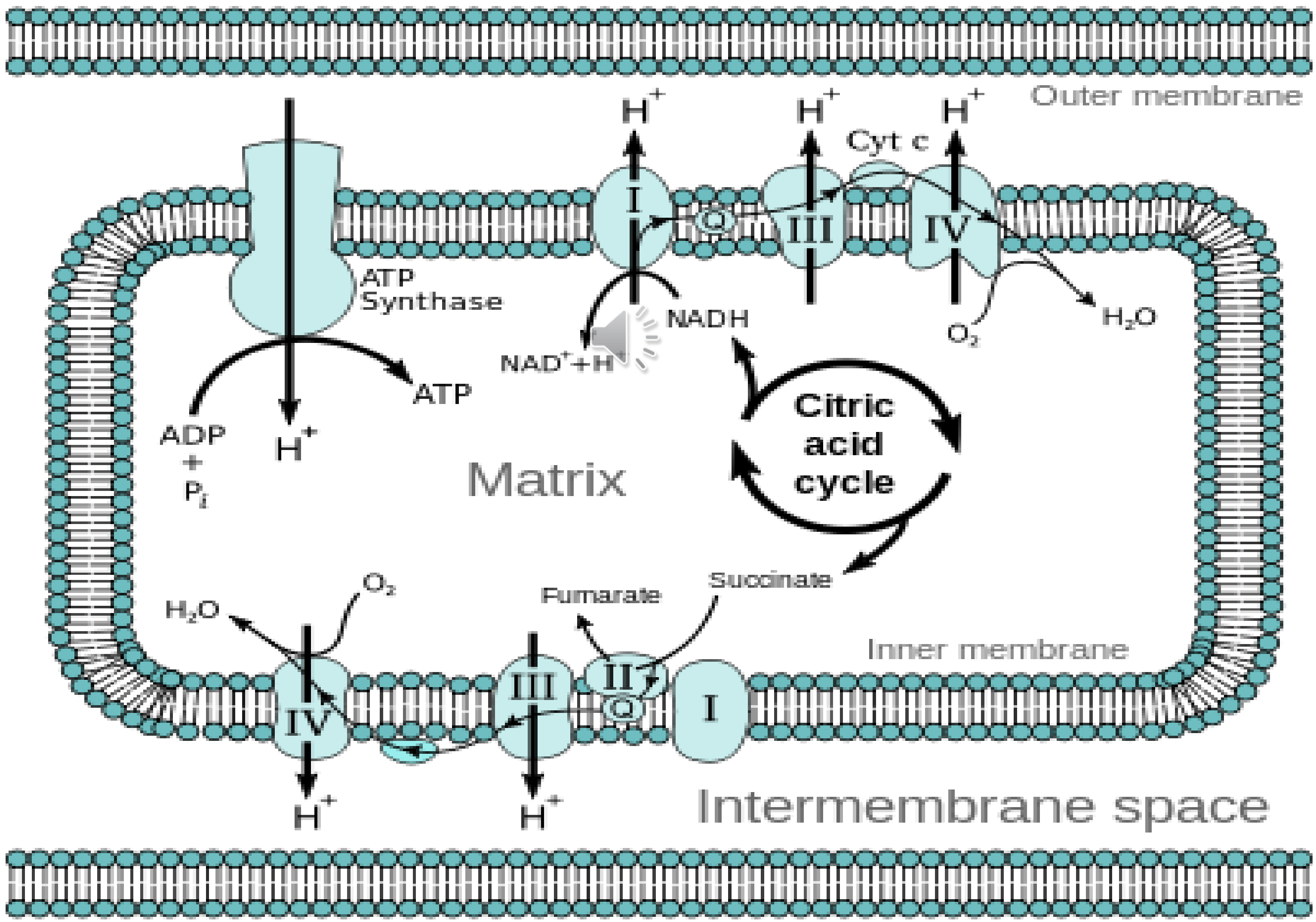
Structure of the mitochondrion:

The components of the electron transport chain are located in the inner membrane. Although the outer membrane contains special pores, making it freely permeable to most ions and small molecules, the inner mitochondrial membrane is a specialized structure that is impermeable to most small ions, including H^+, Na^+, and K^+, and small molecules such as ATP, ADP, pyruvate important to mitochondrial function.



The metabolic breakdown of energy yielding molecules.

Oxidative phosphorylation



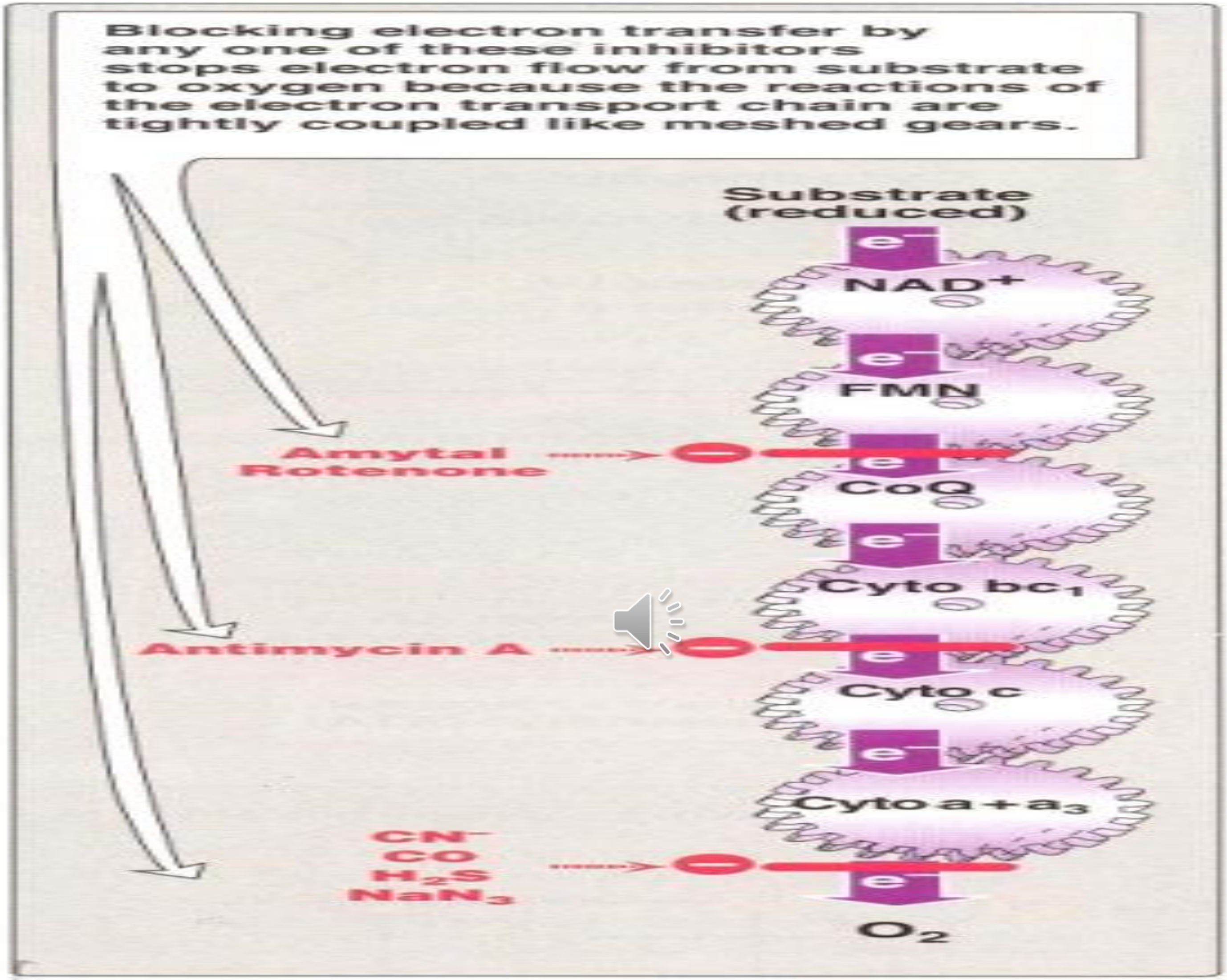


Figure 6.10
Site-specific inhibitors of electron transport shown using a mechanical model for the coupling of oxidation-reduction reactions. [Note: Figure illustrates normal direction of electron flow.] CN^- = cyanide; CO = carbon monoxide; H_2S = hydrogen sulfide; NaN_3 = sodium azide; FMN = flavin mononucleotide; FAD = flavin adenine dinucleotide; CoQ = coenzyme Q; Cyto = cytochrome.