THE METABOLISM

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EXPLANATION

- Capture energy from the sun to build organic molecules (anabolism), and then break down organic molecules to obtain energy (catabolism).
- Plants, algae, and some bacteria harvest the energy of sunlight through photosynthesis, converting radiant energy into chemical energy. These organisms, along with a few others that use chemical energy in a similar way, are called autotrophs ("self-feeders"). All other organisms live on the energy autotrophs produce and are called heterotrophs ("fed by others"). At least 95% of the kinds of organisms on earth—all animals and fungi, and most protists and bacteria— are heterotrophs.

CELLULAR RESPIRATION

- The energy-depleted electron (associated with a proton as a hydrogen atom) is donated to some other molecule. When oxygen gas (O2) accepts the hydrogen atom, water forms, and the process is called aerobic respiration.
- When an inorganic molecule other than oxygen accepts the hydrogen, the process is called anaerobic respiration.
- When an organic molecule accepts the hydrogen atom, the process is called fermentation.

GLUCOSE CATABOLISM

1. **Substrate-level phosphorylation**.

- In the first, called substrate- level phosphorylation, ATP is formed by transferring a phosphate group directly to ADP from a phosphate-bearing intermediate. During glycolysis, discussed below, the chemical bonds of glucose are shifted around in reactions that provide the energy required to form ATP.

2. Aerobic respiration.

- In the second, called aerobic respiration, ATP forms as electrons are harvested, transferred along the electron transport chain, and eventually donated to oxygen gas. Eukaryotes produce the majority of their ATP from glucose in this way.

GLYCOLYSIS

- **Stage One**: Glycolysis. The first stage of extracting energy from glucose is a 10-reaction biochemical pathway called glycolysis that produces ATP by substrate-level phosphorylation.
- Two ATP molecules are used up early in the pathway, and four ATP molecules are formed by substrate-level phosphorylation. This yields a net of two ATP molecules for each molecule of glucose catabolized.
- In addition, four electrons are harvested as NADH that can be used to form ATP by aerobic respiration.

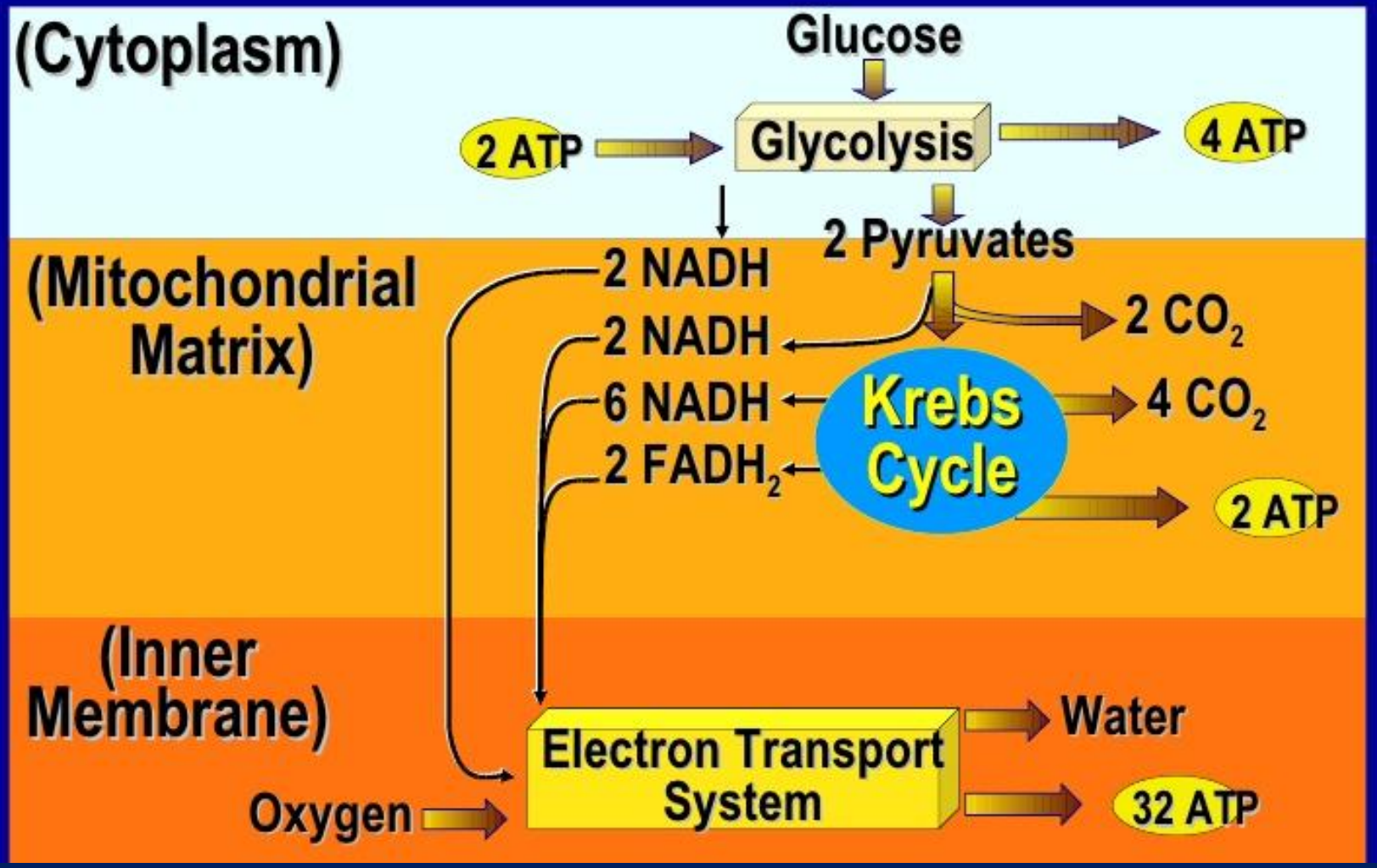
AEROBIC RESPIRATION

- **Stage Two**: Pyruvate Oxidation. In the second stage, pyruvate, the end product from glycolysis, is converted into carbon dioxide and a two-carbon molecule called acetyl-CoA. For each molecule of pyruvate converted, one molecule of NAD+ is reduced to NADH.

- **Stage Three**: The Krebs Cycle. The third stage introduces this acetyl-CoA into a cycle of nine reactions called the Krebs cycle, named after the British biochemist, Sir Hans Krebs, who discovered it. (The Krebs cycle is also called the citric acid cycle, for the citric acid, or citrate, formed in its first step, and less commonly, the tricarboxylic acid cycle, because citrate has three carboxyl groups.) In the Krebs cycle, two more ATP molecules are extracted by substrate-level phosphorylation, and a large number of electrons are removed by the reduction of NAD+ to NADH.

- **Stage Four**: Electron Transport Chain. In the fourth stage, the energetic electrons carried by NADH are employed to drive the synthesis of a large amount of ATP by the electron transport chain.

Energy Harvested from Glucose



ANAEROBIC RESPIRATION

- In the presence of oxygen, cells can respire aerobically, using oxygen to accept the electrons harvested from food molecules. In the absence of oxygen to accept the electrons, some organisms can still respire anaerobically, using inorganic molecules to accept the electrons. For example, many bacteria use sulfur, nitrate, or other inorganic compounds as the electron acceptor in place of oxygen.