range of enzymatic and microbial conversions. Under aerobic conditions, pyruvate is converted to CO_2 and NADH through the TCA cycle.

The overall reaction in glycolysis is

$$\text{glucose} + 2\,\text{ADP} + 2\,\text{NAD}^+ + 2\,\text{Pi} \longrightarrow 2\,\text{pyruvate} + 2\,\text{ATP} + 2(\text{NADH} + \text{H}^+) \qquad (5.4)$$

The net ATP yield in glycolysis is 2 mol ATP/glucose under anaerobic conditions.

Pyruvate produced in the EMP pathway transfers its reducing power to NAD^+ via the Krebs cycle. Glycolysis takes place in cytoplasm, whereas the site for the Krebs cycle is the matrix of mitochondria in eucaryotes. In procaryotes, these reactions are associated with membrane-bound enzymes. Entry into the Krebs cycle is provided by the acylation of coenyzme-A by pyruvate.

$$\text{pyruvate} + \text{NAD}^+ + \text{CoA-SH} \xrightarrow{\text{pyruvate dehydrogenase}} \text{acetyl CoA} + \text{CO}_2 + \text{NADH} + \text{H}^+ \qquad (5.5)$$

Acetyl CoA is transferred through mitochondrial membrane at the expense of the conversion of the two NADHs produced in glycolysis to 2 FADH. Acetyl CoA is a key intermediate in the metabolism of amino acids and fatty acids.

The reactions involved in the TCA cycle are presented in Fig. 5.5. Condensation of acetyl CoA with oxaloacetic acid results in citric acid, which is further converted to isocitric acid and then to α-ketoglutaric acid (α-KGA) with a release of CO_2. α-KGA is decarboxylated and oxidized to succinic acid (SA), which is further oxidized to fumaric acid (FA). Hydration of fumaric acid to malic acid (MA) and oxidation of malic acid to oxaloacetic acid (OAA) are the two last steps of the TCA cycle. For each pyruvate molecule entering the cycle, three CO_2, four $NADH + H^+$, and one $FADH_2$ are produced. The succinate and α-ketoglutarate produced during the TCA cycle are used as precursors for the synthesis of certain amino acids. The reducing power ($NADH + H^+$ and $FADH_2$) produced is used either for biosynthetic pathways or for ATP generation through the electron transport chain.

The overall reaction of the TCA cycle is

$$\text{acetyl-CoA} + 3\,\text{NAD}^+ + \text{FAD} + \text{GDP} + \text{Pi} + 2\text{H}_2\text{O} \longrightarrow \text{CoA} + 3(\text{NADH} + \text{H}^+) + \text{FADH}_2 + \text{GTP} + 2\,\text{CO}_2 \qquad (5.6)$$

Note from Fig. 5.5 that GTP can be converted easily into ATP; some descriptions of the TCA cycle show directly the conversion of ADP plus phosphorus into ATP, as succinyl CoA is converted to succinate.

The major roles of the TCA cycle are (1) to provide electrons (NADH) for the electron transport chain and biosynthesis, (2) to supply C skeletons for amino acid synthesis, and (3) to generate energy.

Many of the intermediates in the TCA cycle are used extensively in biosynthesis. Removal of these intermediates "short-circuits" the TCA cycle. To maintain a functioning TCA cycle, the cell can fix CO_2 (heterotrophic CO_2 fixation). In some microbes, phosphoenolpyruvate (PEP) can be combined with CO_2 to yield oxalacetate. Three enzymes that can catalyze such a conversion have been found (PEP carboxylase, PEP carboxykinase, and PEP carboxytransphosphorylase). Pyruvate can be combined with CO_2 to yield