Metabolic Pathways

Stage 1

Confine substrate (glucose) inside the cell and form phosphorylated six-carbon units (fructose 1,6-diphosphate)

Step 1: Hexokinase transfers a phosphate group to glucose from ATP, forming glucose 6-phosphate.

Steps 2 & 3: The glucose molecule is rearranged to form fructose 6-phosphate, and a second phosphate group is added to give fructose 1,6-diphosphate. Phosphofructokinase (an allosteric enzyme) carries out this third step.

Stage 2

A six-carbon unit is split into two three-carbon units, and two ATP molecules are produced. Two NAD molecules are reduced.

Step 4: The six-carbon sugar fructose is split into two different three-carbon sugar-phosphates by aldolase.

Step 5: Dihydroxyacetone phosphate is rearranged to form a second molecule of glyceraldehyde 3-phosphate.

Step 6: Another phosphate group is added, and two hydrogen atoms, with their electrons, are transferred to NAD.

Step 7: Phosphoglycerate kinase catalyzes the transfer of a phosphate group to ADP, forming ATP.

Stage 3

Pyruvic acid is formed, and two more ATP molecules are produced.

Steps 8 & 9: The remaining phosphate group is moved from the end to the middle carbon atom by phosphoglycerate mutase, and a molecule of water is removed by enolase.

Step 10: The phosphate group is transferred to ADP by pyruvate kinase, forming another ATP molecule.

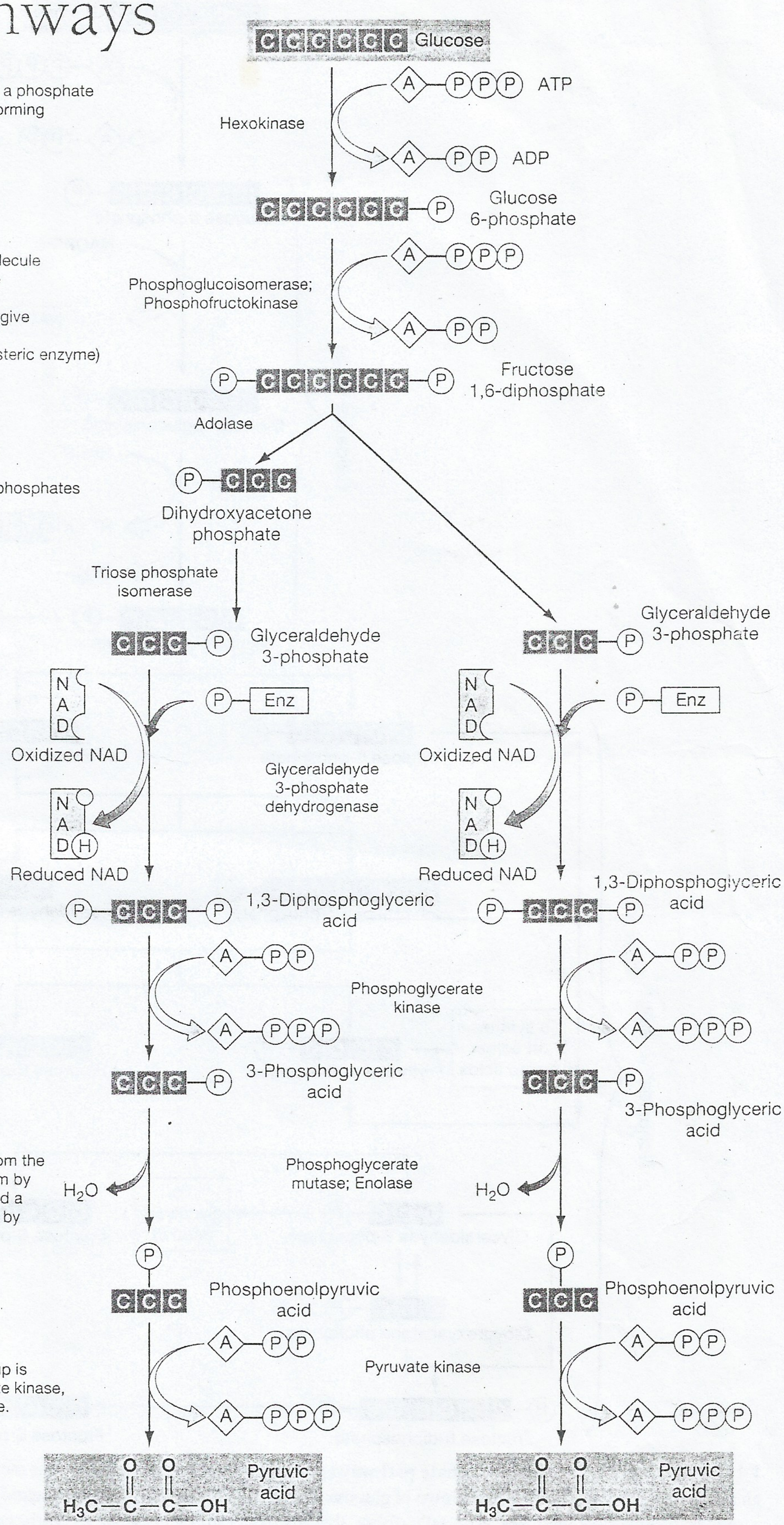

FIGURE E.1 Glycolysis (Embden-Meyerhof pathway). Each of the 10 steps of glycolysis is catalyzed by a specific enzyme, which is indicated in a purple oval. (Refer to Chapter 5 for an explanation; Figure 5.11 shows a simplified version of the process. ◀ p. 116)

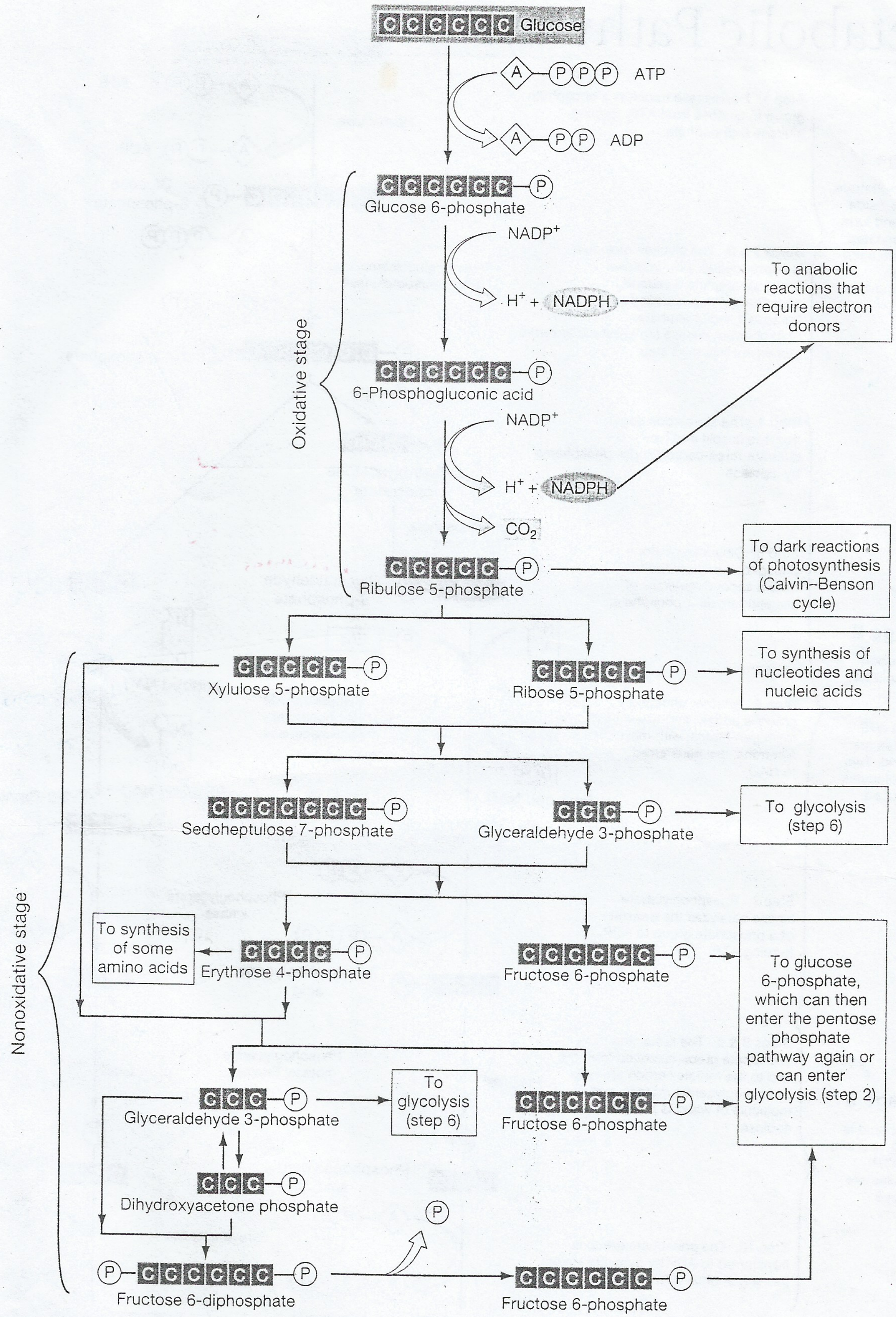

FIGURE E.2 Pentose phosphate pathway (phosphogluconate pathway). This metabolic pathway occurs with glycolysis. It provides an alternative pathway for the breakdown of glucose as well as pentoses (five-carbon sugars). This pathway plays three important roles: (1) It provides intermediate pentoses, especially ribose, that the bacterial cell must use to synthesize nucleic acids. (2) This pathway's intermediates can be used to synthesize some amino acids. (3) The pentose phosphate pathway reduced NADP to NADPH. This coenzyme, like NADH, is an electron carrier and thus is a source of reducing power. The fates of several intermediates are indicated. For clarity, the specific enzymes catalyzing these reactions and the structural formulas of substrates have been omitted. (Refer to Chapter 5 for an explanation of this pathway. ◀ p. 117)

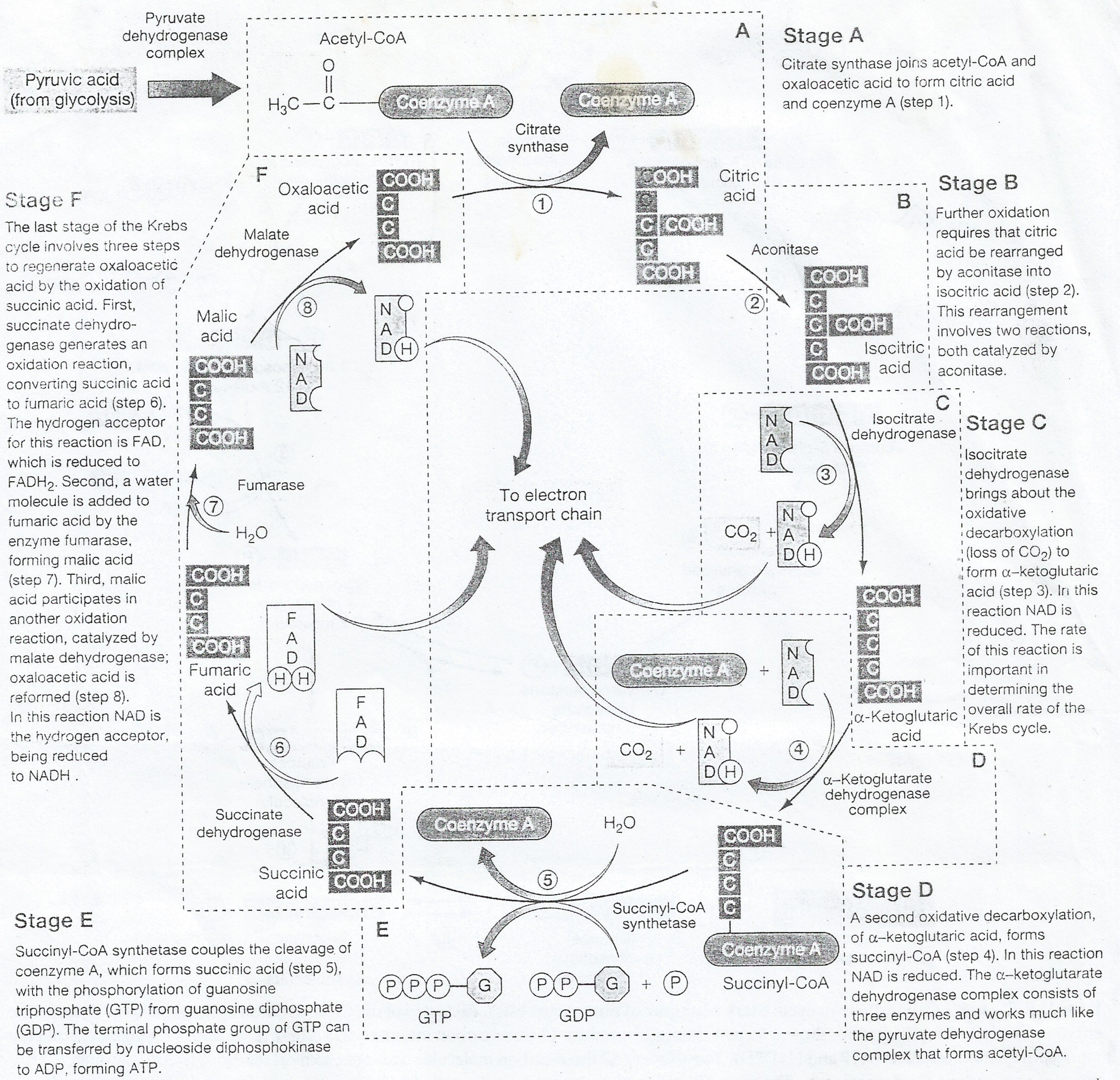

FIGURE E.3 Krebs cycle (also called the citric acid cycle and the tricarboxylic acid cycle). The reaction that converts pyruvic acid to acetyl-CoA precedes the Krebs cycle (see Figure 5.16). This reaction is catalyzed by a pyruvate dehydrogenase complex, which contains three enzymes. Each of the eight steps of the Krebs cycle is also catalyzed by a specific enzyme, as indicated in a purple oval. (Refer to Chapter 5 for an explanation; Figure 5.17 shows a simplified version of the process. ◄ p. 121)

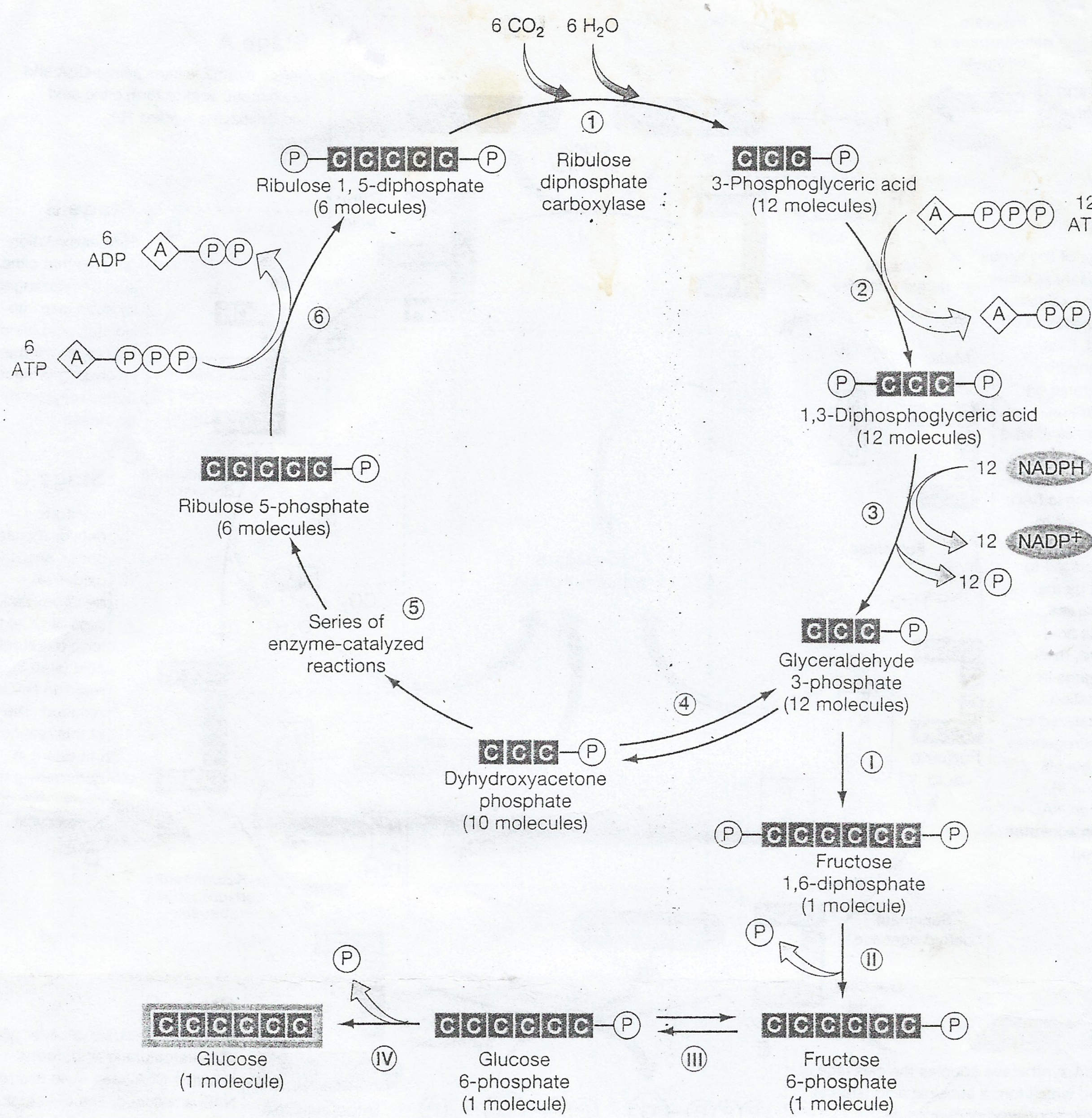

FIGURE E.4 **Calvin-Benson cycle (dark reactions of photosynthesis).** Each step of the Calvin-Benson cycle is catalyzed by a specific enzyme, which for simplicity is not shown. Steps 1 through 3 produce 12 three-carbon intermediates. These three steps are dependent on photophosphorylation products (ATP and NADPH). Two of every 12 three-carbon molecules undergo chemical reactions (steps I through IV) to produce a six-carbon glucose molecule. The other 10 three-carbon molecules are recycled (steps 4 through 6), forming 6 five-carbon molecules. These are phosphorylated by ATP to ribulose-1,5-diphosphate. Each of these five-carbon molecules then combines with a CO_2 molecule, starting the process once again. The enzyme catalyzing this step is *ribulose diphosphate carboxylase*, the most prevalent enzyme in the biological world. (Refer to Chapter 5 for an explanation of the process. ◀ pp. 127–128)