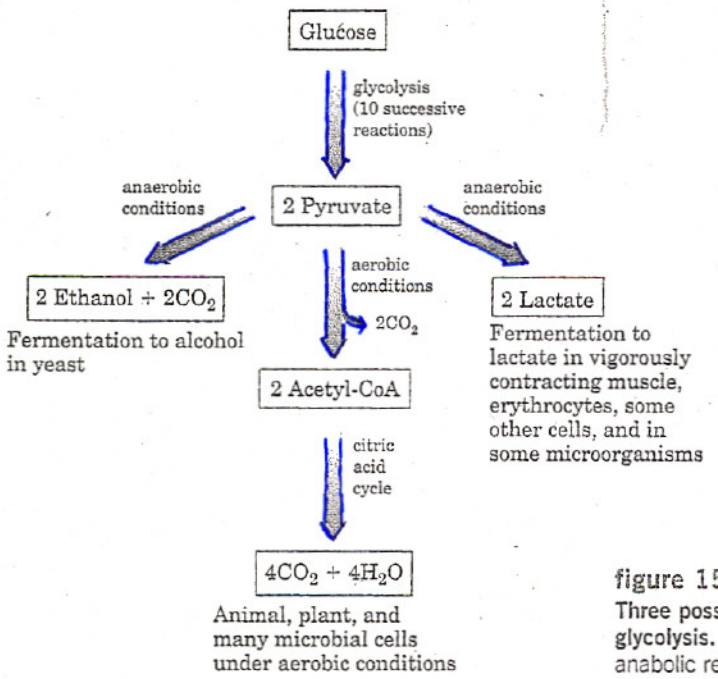


figure 15–3

Three possible catabolic fates of the pyruvate formed in glycolysis. Pyruvate also serves as a precursor in many anabolic reactions, not shown here.

FERMENTATION (S)

1. **Fermentation to alcohol (alcoholic fermentation), in yeast and some microorganisms**

pyruvate decarboxylase

$$\text{Pyruvate} + H^+ \longrightarrow \text{Acetaldehyde} + CO_2$$

alcohol dehydrogenase

$$\text{Acetaldehyde} + NADH + H^+ \longleftrightarrow \text{Ethanol} + NAD^+$$

Overall Reaction:

$$\text{Glucose} + 2\,Pi + 2\,ADP + 2\,H^+ \longrightarrow 2\,\text{Ethanol} + 2\,CO_2 + 2\,ATP + 2\,H_2O$$

2. **Fermentation to lactate, in muscle cells and some micro-organisms**

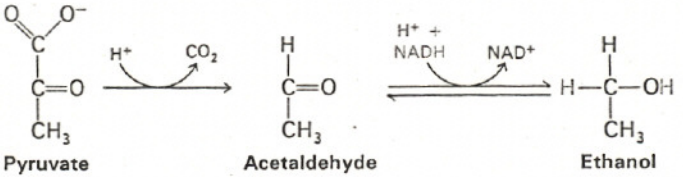
lactate dehydrogenase

$$\text{Pyruvate} + NADH + H^+ \longleftrightarrow \text{Lactate} + NAD^+$$

Overall Reaction:

$$\text{Glucose} + 2\,Pi + 2\,ADP \longrightarrow 2\,\text{Lactate} + 2\,ATP + 2\,H_2O$$

Fermentation to alcohol:



Fermentation to lactate:

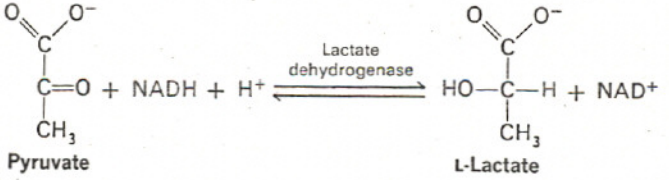


Figure 19-4, page 490; Figure 19-5, page 491

Stryer: Biochemistry, Fourth Edition

Set I

T-56

PHOSPHOFRUCTOKINASE

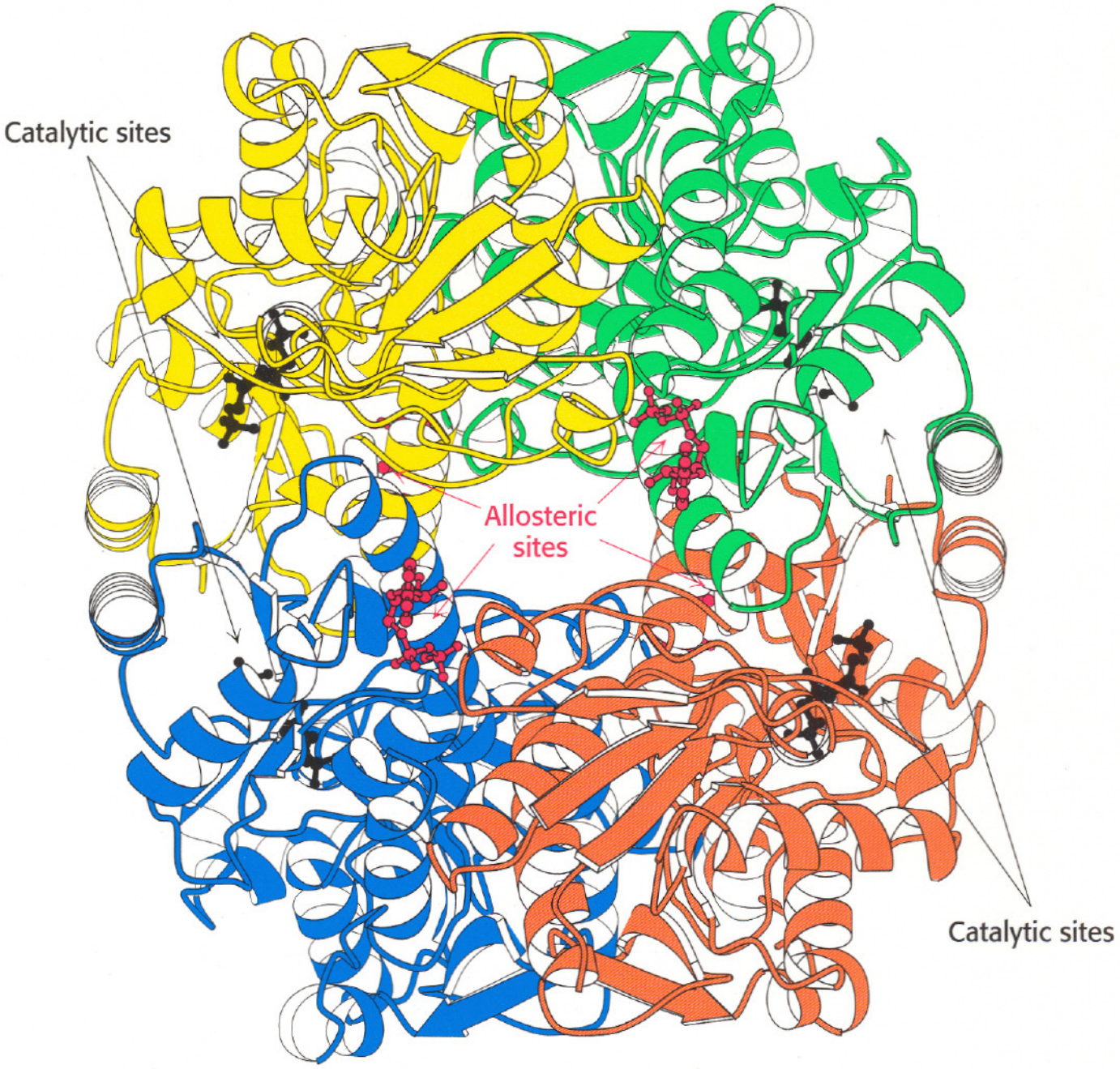
Phosphofructokinase is the most important control element in the mammalian glycolytic pathway

Solved X- Ray Structure

- **Homotetramer (340 kDa)**
- **Has two conformation states, R and T, that are in equilibrium**

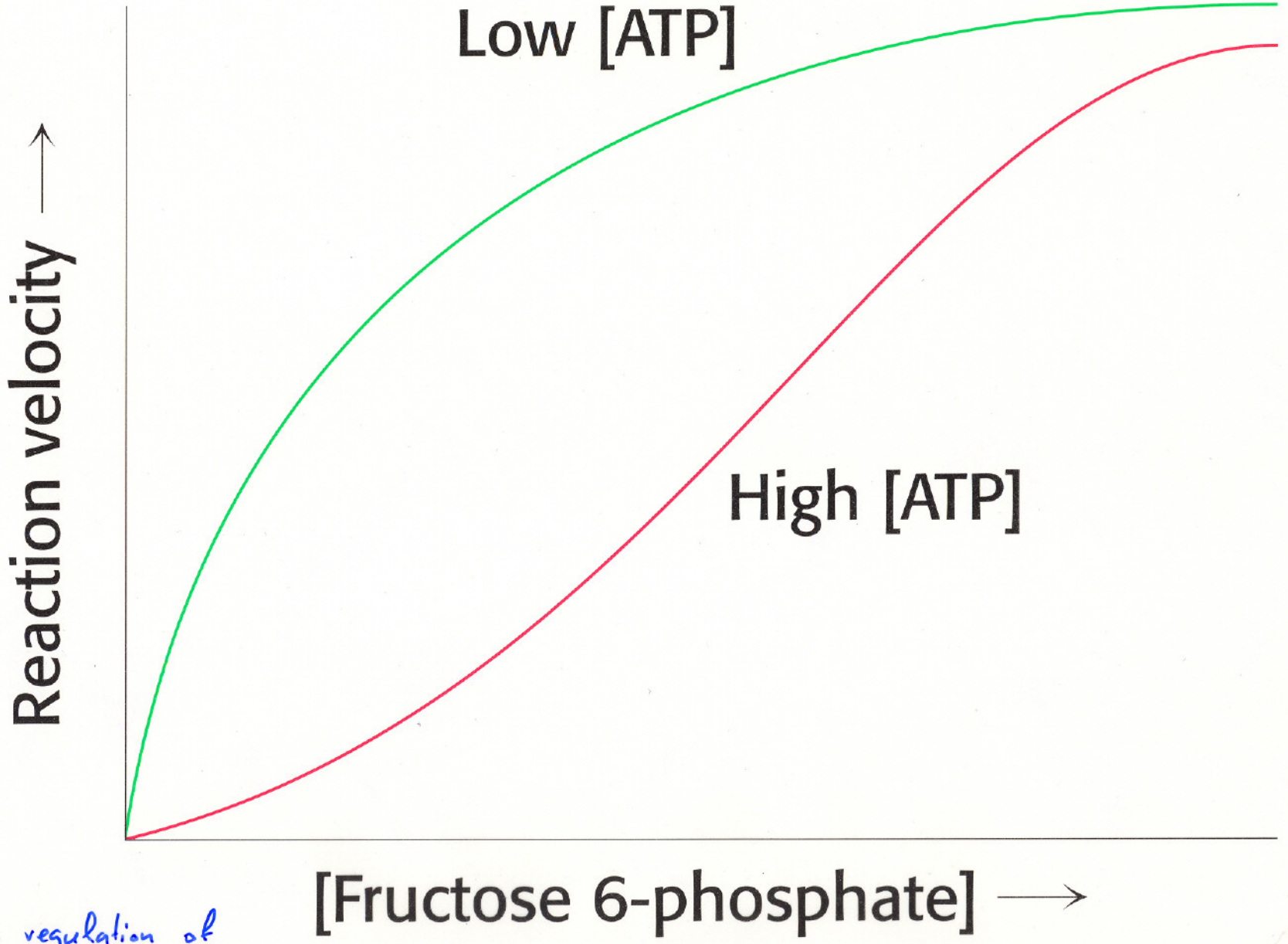
INHIBITORS

1. **ATP**
2. **H^+**
3. **Citrate (intermediate of TCA Cycle)**



Structure of phosphofructokinase

Figure 16-16
Stryer, Tymoczko, & Berg, BIOCHEMISTRY, Fifth Edition.



Allosteric regulation of phosphofructokinase

Figure 16-17
Stryer, Tymoczko, & Berg, BIOCHEMISTRY, Fifth Edition.

ACTIVATORS

1. **AMP, ADP**

2. **Fructose 2, 6- bisphosphate**

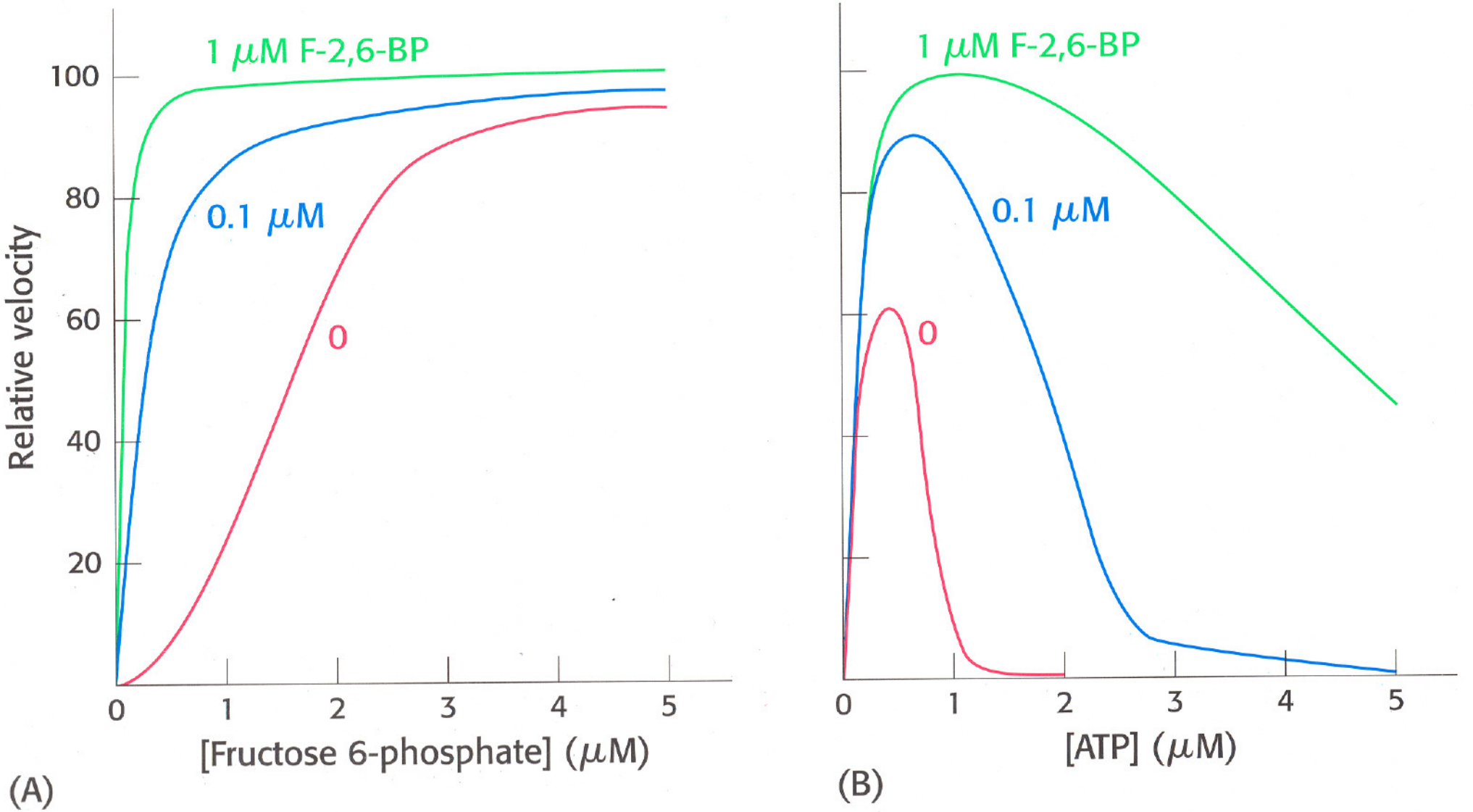
(example of Feedforward stimulation)

- **ATP is both a substrate and an allosteric inhibitor**

- **Each enzyme subunit has two binding sites for ATP, a substrate site, and an inhibitor site**

- **The substrate site binds ATP equally well in either conformation(R or T); the inhibitor site binds ATP almost exclusively in the T state**

- **The other substrates preferentially bind to the R state**



Activation of phosphofructokinase by fructose 2,6-bisphosphate
The inhibitory effect of ATP is reversed

Figure 16-18
Stryer, Tymoczko, & Berg, BIOCHEMISTRY, Fifth Edition.

Conformation of hexokinase: Induced fit

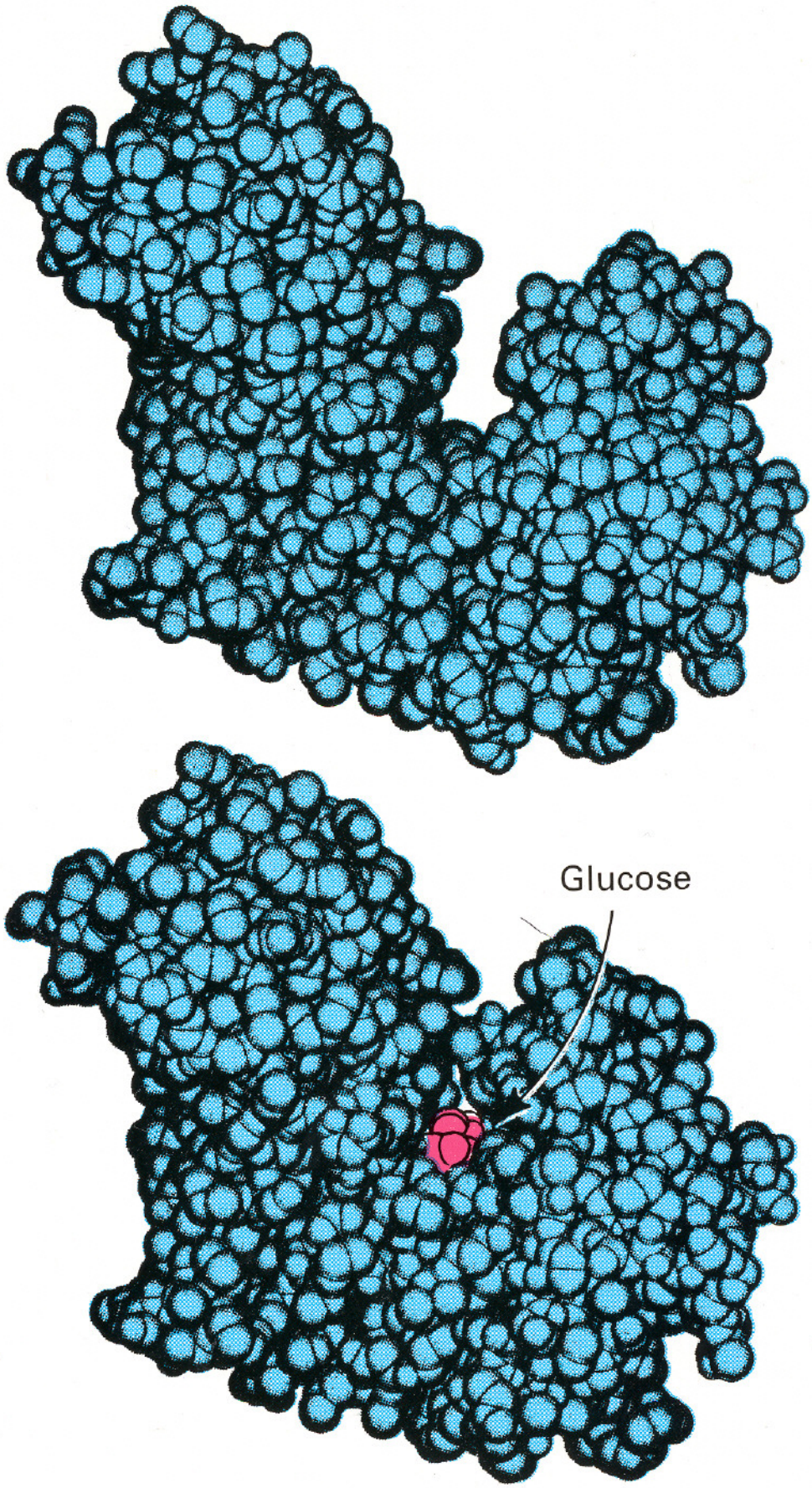
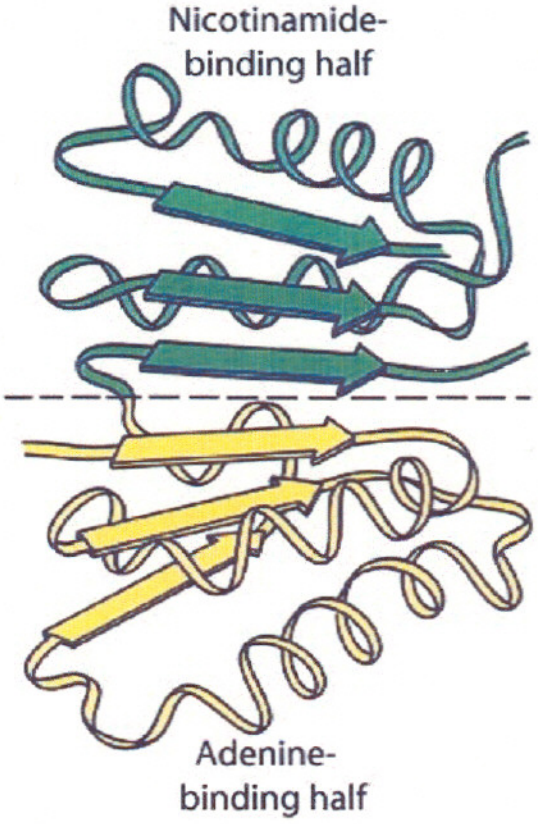


Figure 19-14, page 499

T-103

Set II

Schematic diagram of the NAD^+-binding region in dehydrogenases

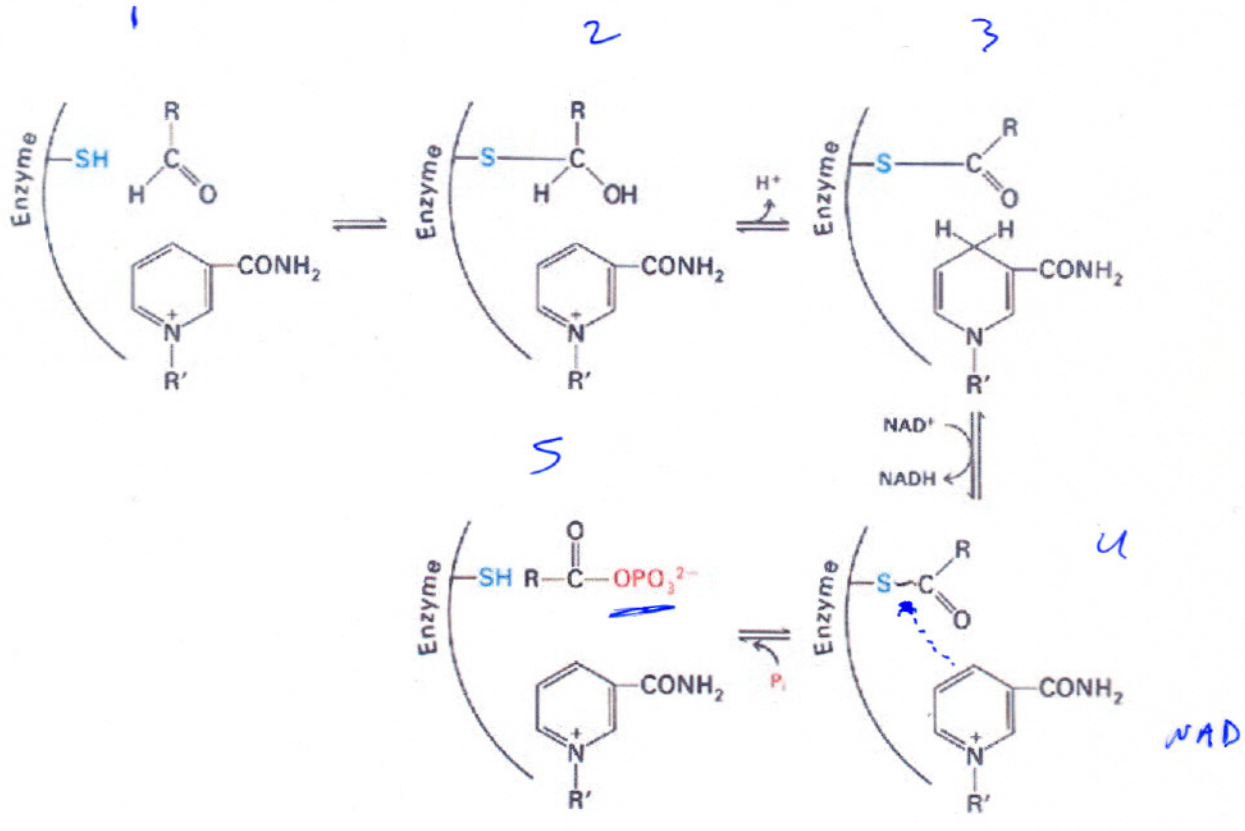


- alcohol dehydrogenase
- lactate dehydrogenase
- malate dehydrogenase
- glyceraldehyde 3-phosphate dehydrogenase

Fig 19-12

glyceraldehyde 3-phosphate + P_i + NAD^+ ⇌

1,3-Bisphosphoglycerate + NADH + H^+



Catalytic mechanism of glyceraldehyde 3-phosphate dehydrogenase

Fig 19-18

GLUCOSE TRANSPORTERS

- **Integral membrane proteins of mammalian cells**
- **Named GLUT 1 to 5**
- **Single polypeptide chain ~ 500 a. a.**
- **12 transmembrane ∝ –helices**

I. GLUT 1 & GLUT 3

- **Present in nearly all mammalian cells**
- **Responsible for basal glucose uptake**
- **Continually transport glucose at an essential constant rate**

II. GLUT 5

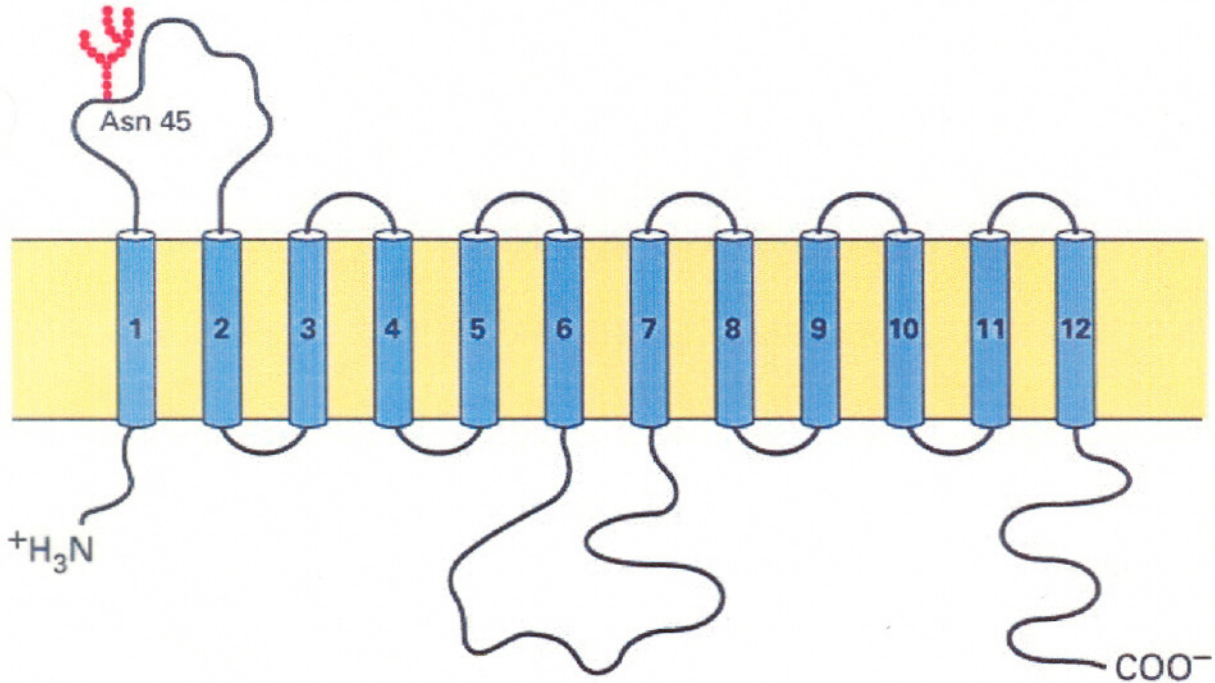
- Present in the small intestine
- Works in tandem with the Na^+– glucose symporter in the absorption of glucose from the gut
- Releases glucose into bloodstream

III. GLUT 2

- Present in liver and pancreatic β cells

IV. GLUT 4

- Mediates entry of glucose into muscle and fat cells


Asn 45
1
2
3
4
5
6
7
8
9
10
11
12
+H3N
COO−

BREWING BEER

Beer is made by alcohol fermentation of the carbohydrates in cereal grains (seeds) by yeast glycolytic enzymes

PROCEDURE:

1. **Malting: The seeds are allowed to germinate until they form the hydrolytic enzymes required to break down their polysaccharides. The product is called "malt"**

2. **Preparing the wort: The malt is mixed with water and then mashed or crushed. Digestion of the polysaccharides. Separation of the cell matter from the liquid wort.**

3. **Adding the yeast cells: First aerobic glycolysis and citric acid cycle. When oxygen is consumed, anaerobic fermentation**

4. **Adjustment of the amount of foam of head of the beer.**

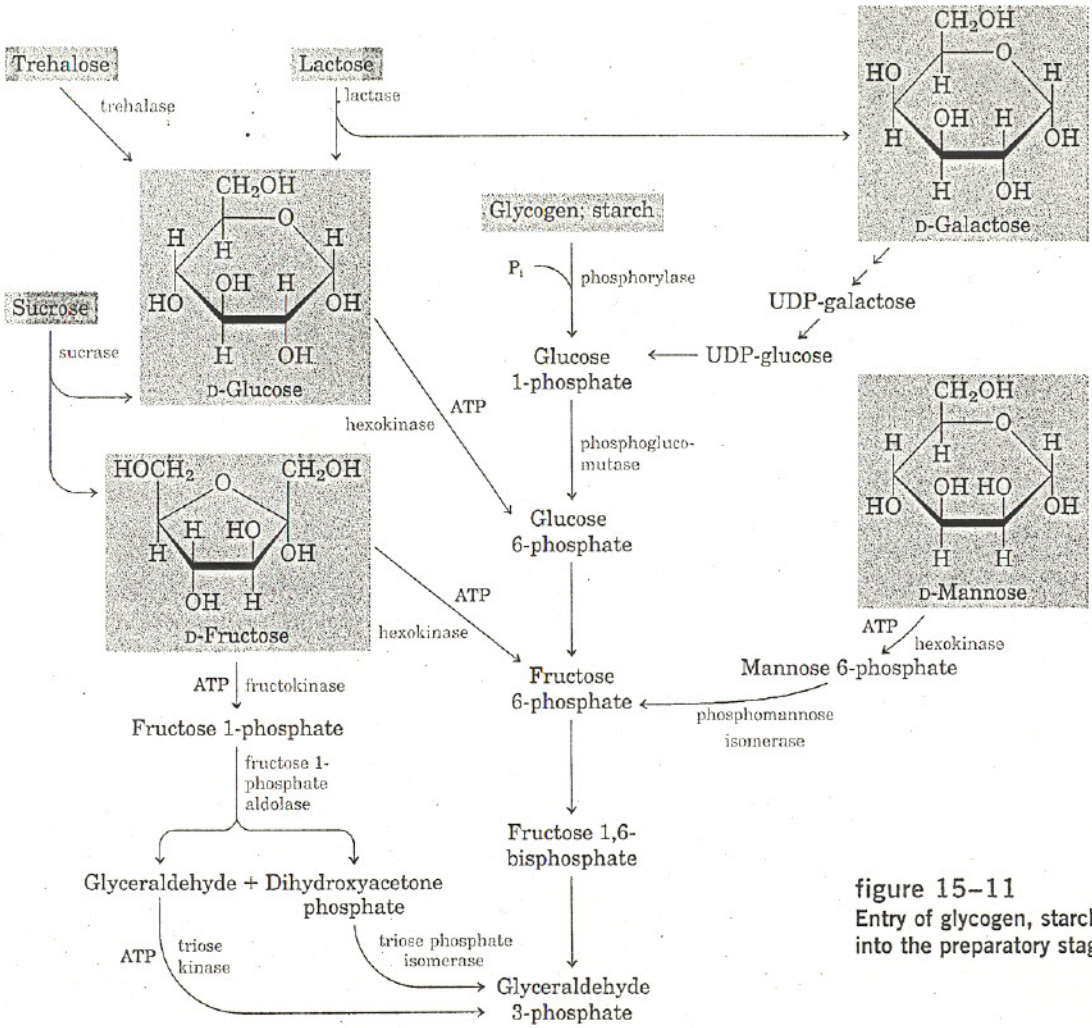
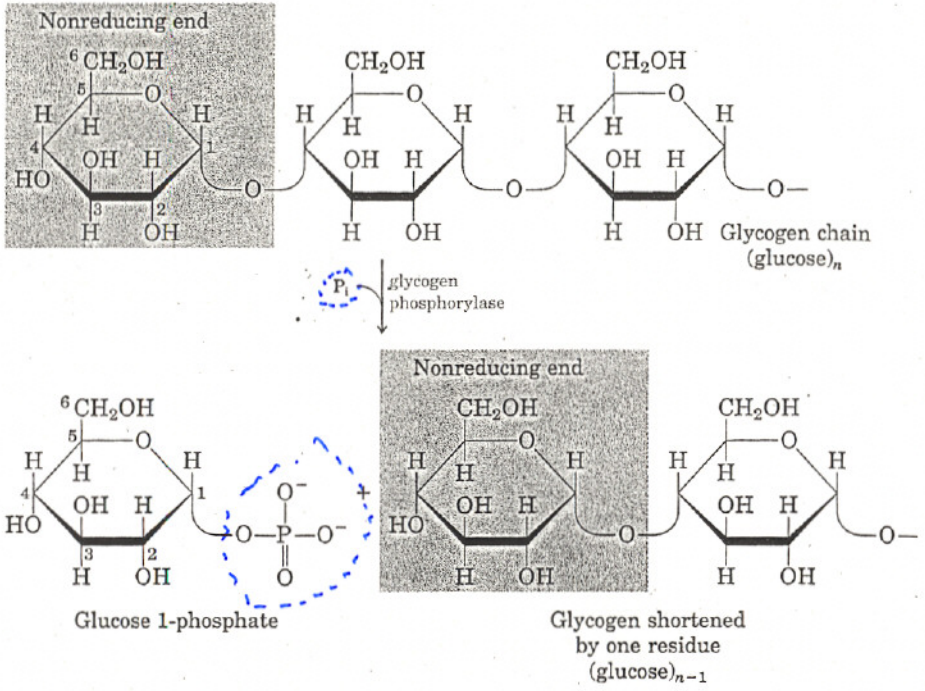


figure 15–11
Entry of glycogen, starch, disaccharides, and hexoses into the preparatory stage of glycolysis.

e 15–12

val of a terminal glucose residue from the ducing end of a glycogen chain by glycogen horylase. This process is repetitive; the enzyme ves successive glucose residues until it reaches urth glucose unit from a branch point (see .5–13). Amylopectin is degraded in a similar on by starch phosphorylase.



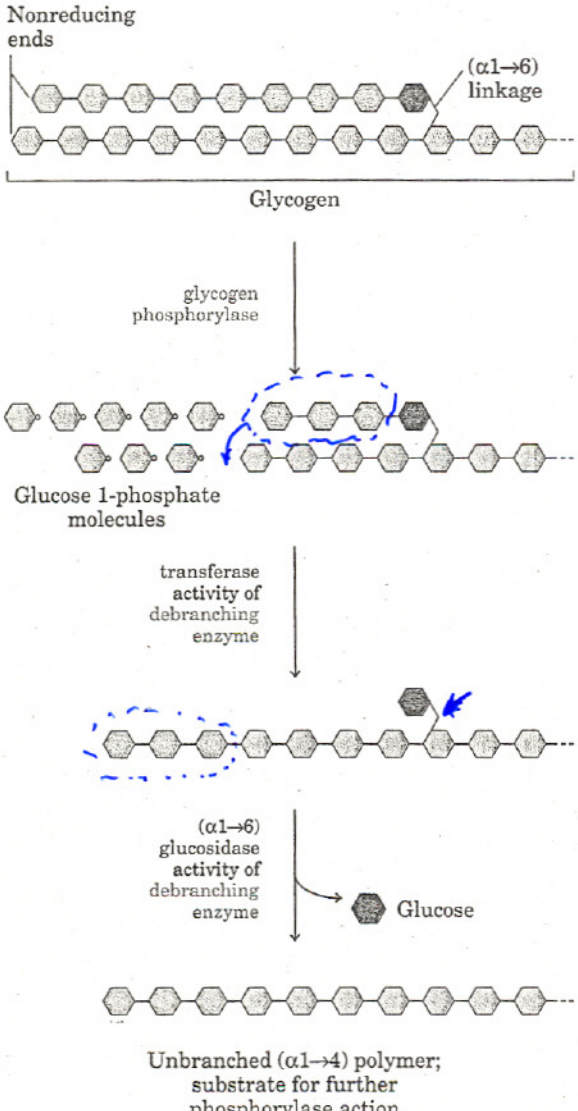


figure 15–13

Glycogen breakdown near an (α1→6) branch point. Following the sequential removal of terminal glucose residues by glycogen phosphorylase (see Fig. 15–12), glucose residues near a branch are removed in a two-step process that requires a bifunctional "debranching enzyme." First, the transferase activity of the enzyme shifts a block of three glucose residues from the branch to a nearby nonreducing end, to which they are re-attached in (α1→4) linkage. The single glucose residue remaining at the branch point, in (α1→6) linkage, is then released as free glucose by the debranching enzyme's (α1→6) glucosidase activity. The glucose residues are shown here in shorthand form.