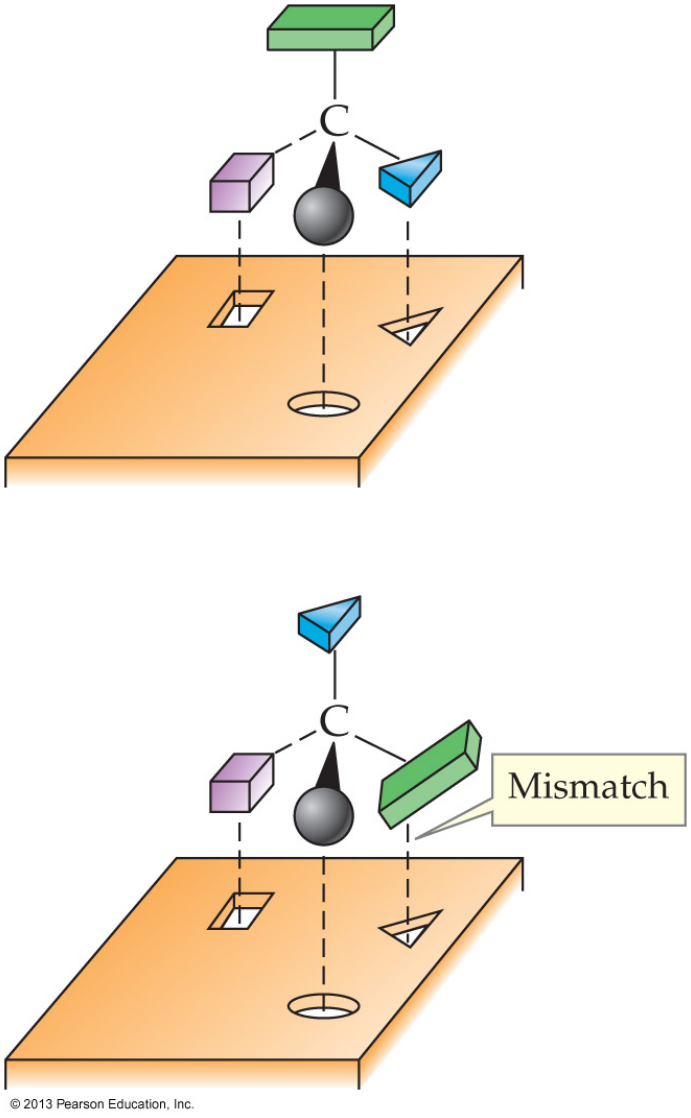
Chem 30B

Ch19: Enzymes and Vitamins

Enzyme Stereospecificity

Chiral reactant and chiral molecule

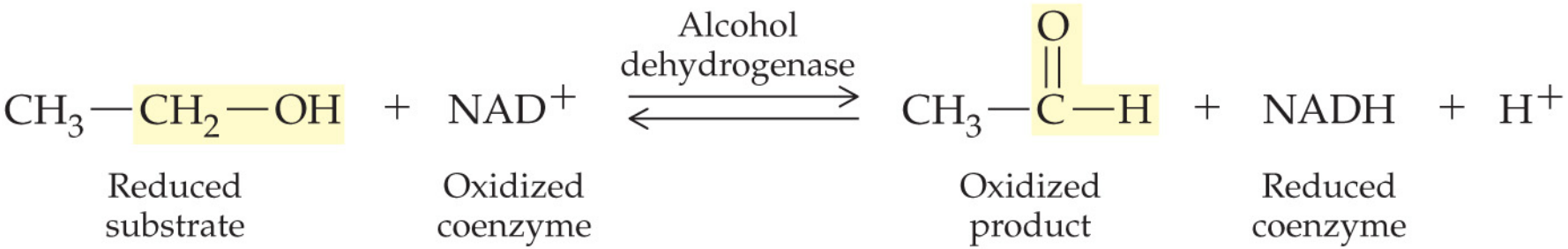


Enzyme Classification

Main Class and Subclass	Examples of Reaction Types Catalyzed
Oxidoreductases	**Oxidation–reduction reactions**
Oxidases	Addition of O_2 to a substrate
Reductases	Reduction of a substrate
Dehydrogenases	Removal of two atoms to form a double bond
Transferases	**Transfer of functional groups**
Transaminases	Transfer of amino group between substrates
Kinases	Transfer of a phosphoryl group between substrates
Hydrolases	**Hydrolysis reactions**
Lipases	Hydrolysis of ester groups in lipids
Proteases	Hydrolysis of peptide bonds in proteins
Nucleases	Hydrolysis of phosphate ester bonds in nucleic acids
Isomerases	**Isomerization of a substrate**
Lyases	**Group elimination to form double bond or addition to a double bond**
Dehydrases	Removal of H_2O from substrate to give double bond
Decarboxylases	Replacement of a carboxyl group by a hydrogen
Synthases	Addition of small molecule to a double bond
Ligases	**Bond formation coupled with ATP hydrolysis to provide energy**
Synthetases	Formation of bond between two substrates
Carboxylases	Formation of bond between substrate and CO_2 to add a carboxyl group ($—COO^-$)

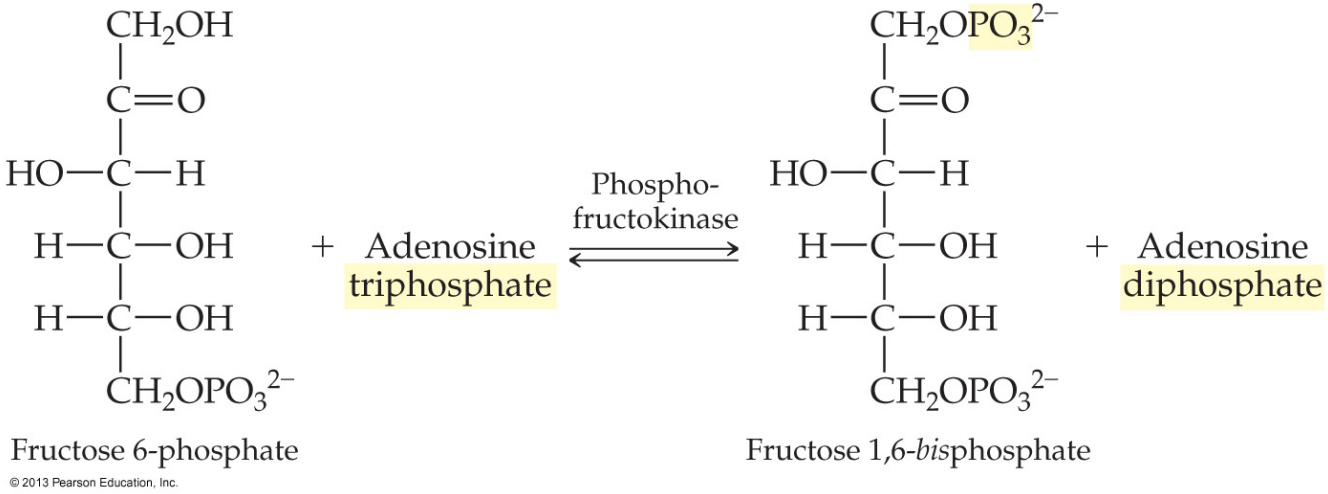
Oxidoreductases

- Catalyze oxidation–reduction reactions. Require coenzymes that act as oxidizing or reducing agents.



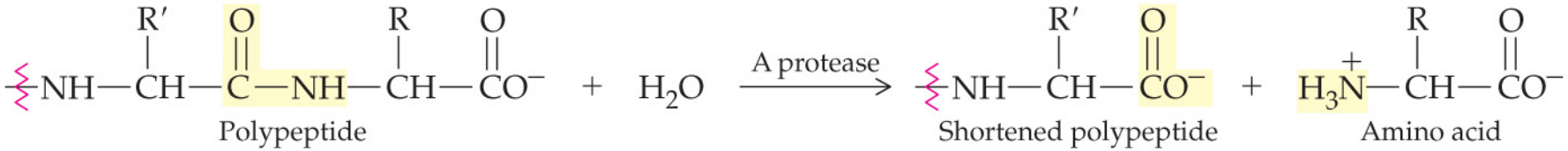
Transferases

- Catalyze transfer of a group from one molecule to another.
  - Transaminases transfer amino group.
  - Kinases transfer phosphoryl group (eg. from ATP)



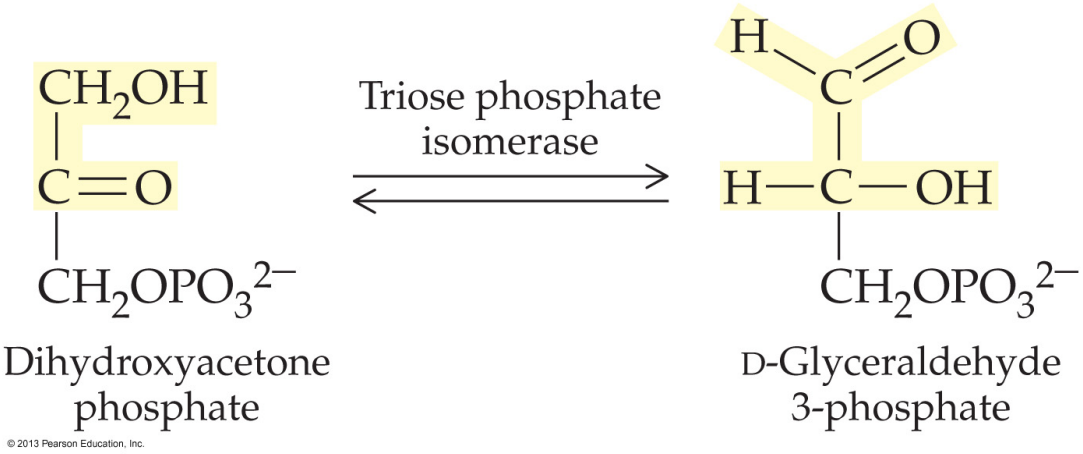
Hydrolases

- Catalyze hydrolysis. Particularly important for digestion (of proteins and carbohydrates).



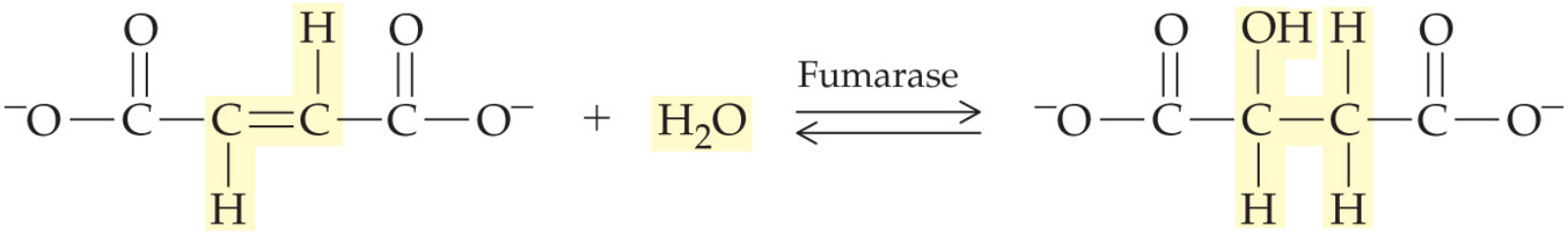
Isomerases

- Catalyze isomerization (rearrangement of atoms). In some metabolic pathways, a molecule must be isomerized for next step of pathway.



Lyases

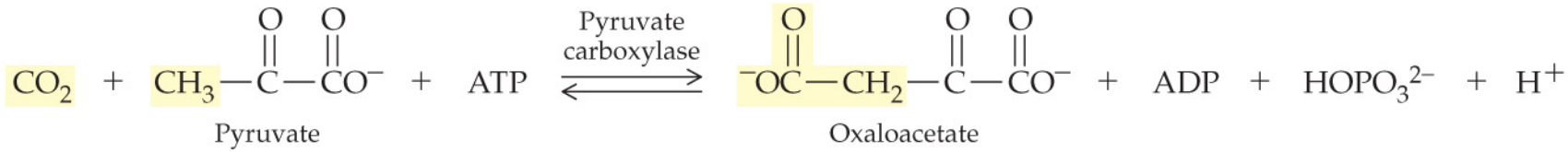
- Catalyze <u>addition</u> (of a molecule like H_2O, CO_2, NH_3) to a double bond, <u>or elimination</u> to create a double bond.



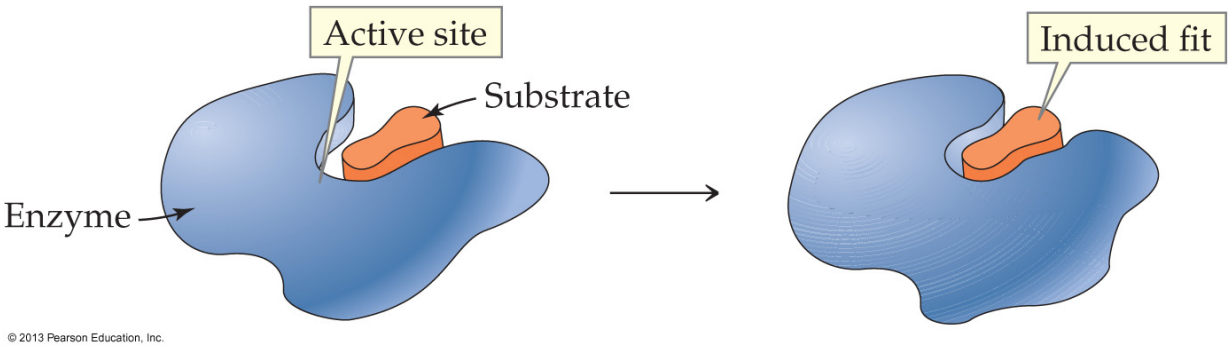
Fumarate + H_2O ⇌ L-Malate

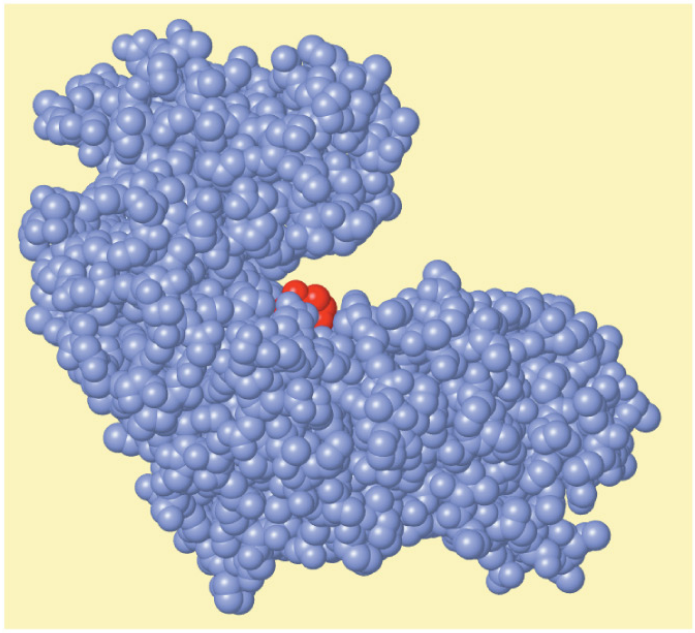
Ligases

- Catalyze bonding together of two molecules. Such reactions often require energy from ATP hydrolysis. Involved in synthesis of biological polymers such as proteins and DNA.

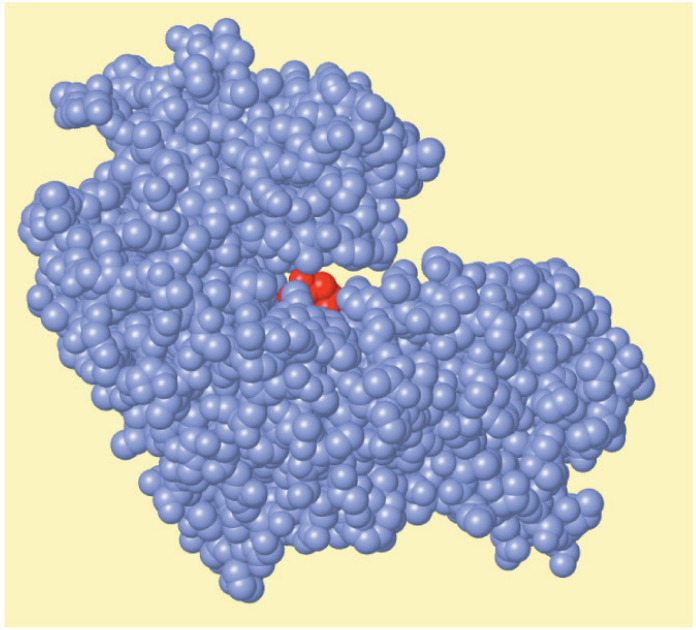


Induced Fit Model of Enzyme Action





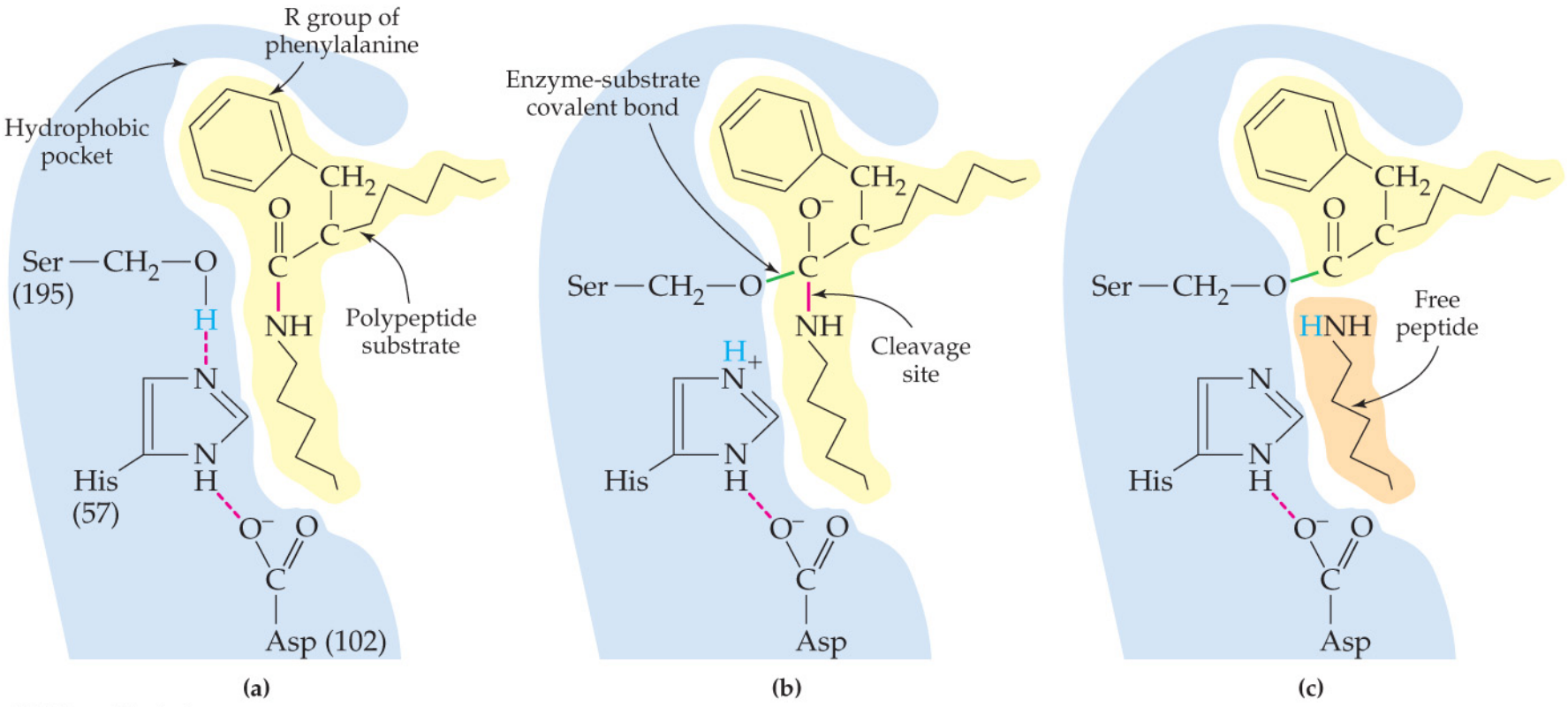
(a)



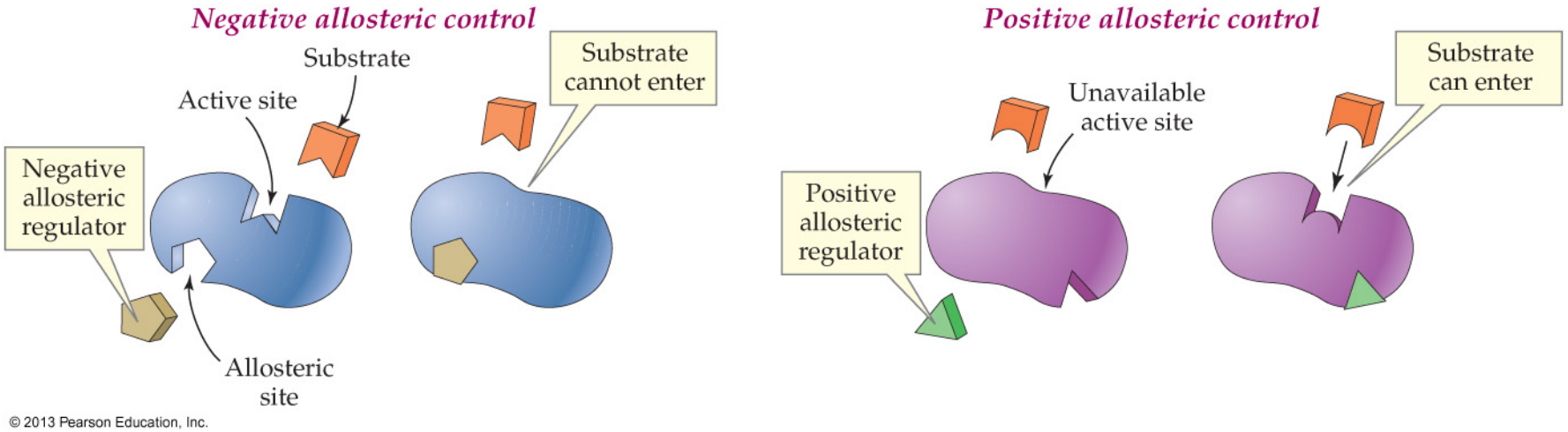
(b)

hexokinase

Peptide Hydrolysis by Chymotrypsin

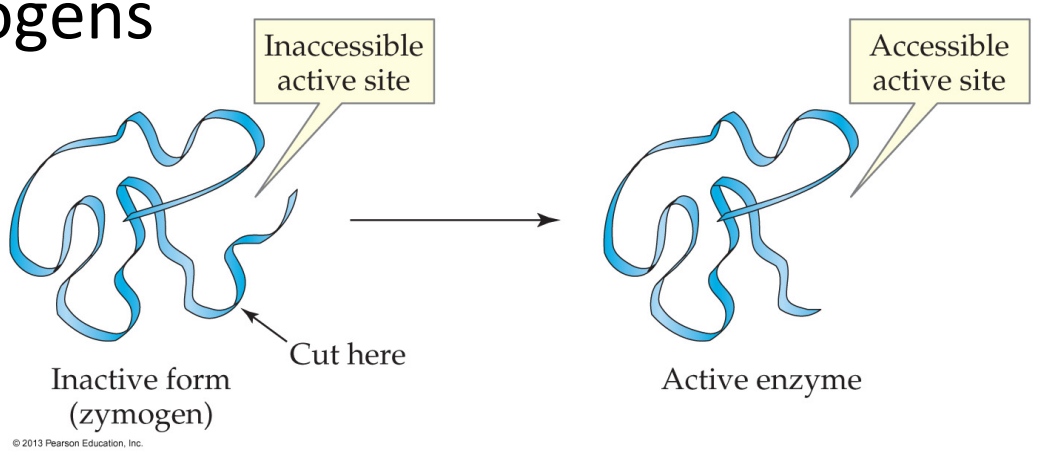


Allosteric Control

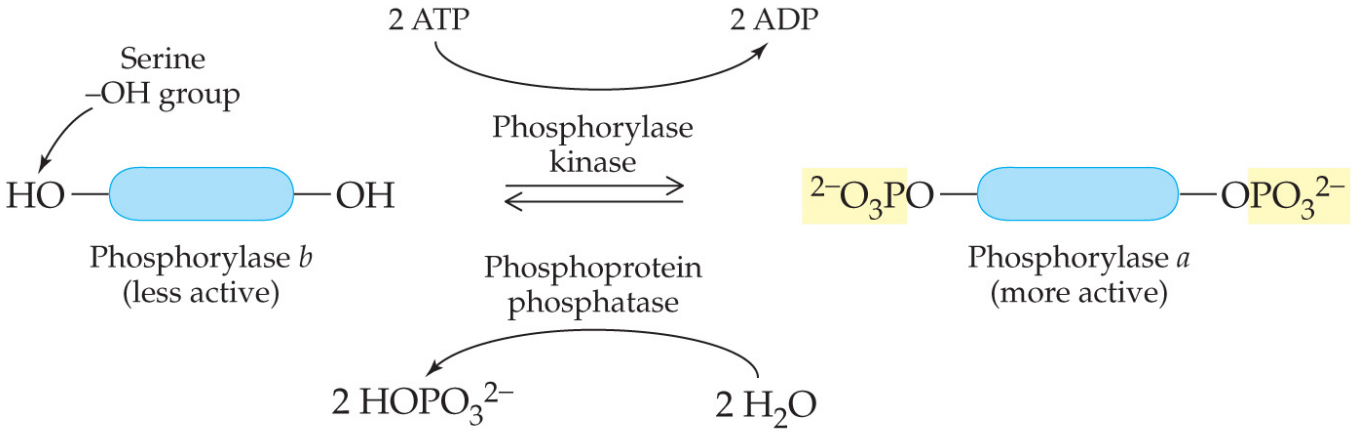


Covalent Modification

Zymogens



Phosphorylation

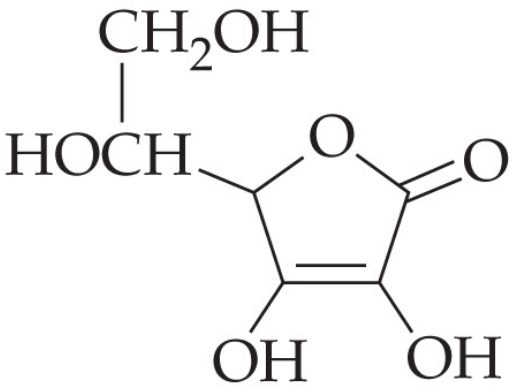


Water-Soluble Vitamins

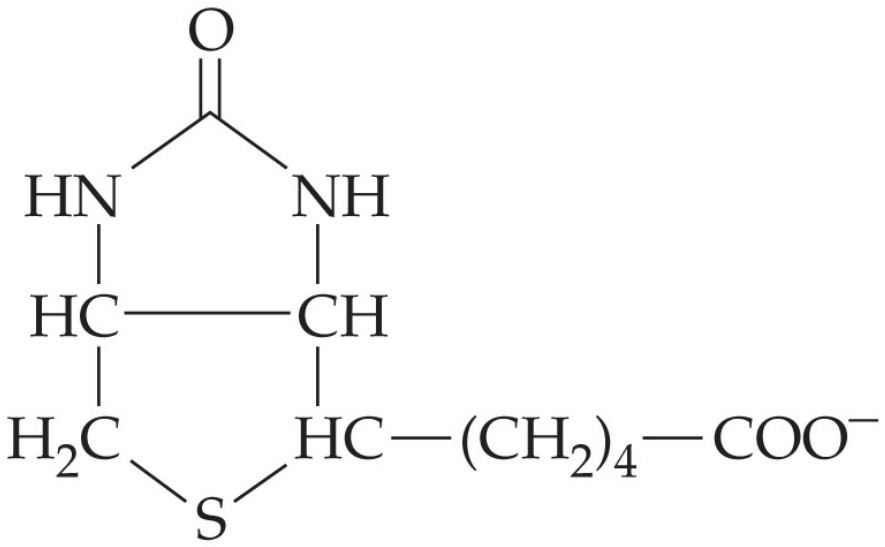
TABLE 19.3 The Water-Soluble Vitamins*

Vitamin	Significance	Sources	Reference Daily Intake**	Effects of Deficiency	Effects of Excess
Thiamine (B_1)	In coenzyme for decarboxylation reactions	Milk, meat, bread, legumes	1.5 mg	Muscle weakness, and cardiovascular problems including heart disease; causes beriberi	Low blood pressure
Riboflavin (B_2)	In coenzymes FMN and FAD	Milk, meat	1.7 mg	Skin and mucous membrane deterioration	Itching, tingling sensations
Niacin (nicotinic acid, nicotinamide, B_3)	In coenzyme NAD^+	Meat, bread, potatoes	2.0 mg	Nervous system, gastrointestinal, skin, and mucous membrane deterioration; causes pellagra	Itching, burning sensations, blood vessel dilation, death after large dose
B_6 (pyridoxine)	In coenzyme for amino acid and lipid metabolism	Meat, legumes	2.0 mg	Retarded growth, anemia, convulsions, epithelial changes	Central nervous system alterations, perhaps fatal
Folic acid	In coenzyme for amino acid and nucleic acid metabolism	Vegetables, cereal, bread	0.4 mg	Retarded growth, anemia, gastrointestinal disorders; neural tube defects	Few noted except at massive doses
B_{12} (cobalamin)	In coenzyme for nucleic acid metabolism	Milk, meat	6 μg	Pernicious anemia	Excess red blood cells
Biotin	Coenzyme for carboxylation reactions	Eggs, meat, vegetables	0.3 mg	Fatigue, muscular pain, nausea, dermatitis	None reported
Pantothenic acid (B_5)	In coenzyme A	Milk, meat	10 mg	Retarded growth, central nervous system disturbances	None reported
C (ascorbic acid)	Coenzyme; delivers hydride ions; antioxidant	Citrus fruits, broccoli; greens	60 mg	Epithelial and mucosal deterioration, causing scurvy	Kidney stones

Water-Soluble Vitamins



Vitamin C
(Ascorbic acid)

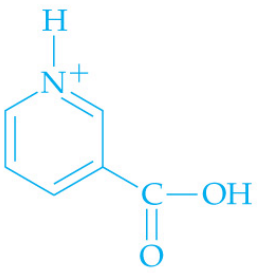


Biotin

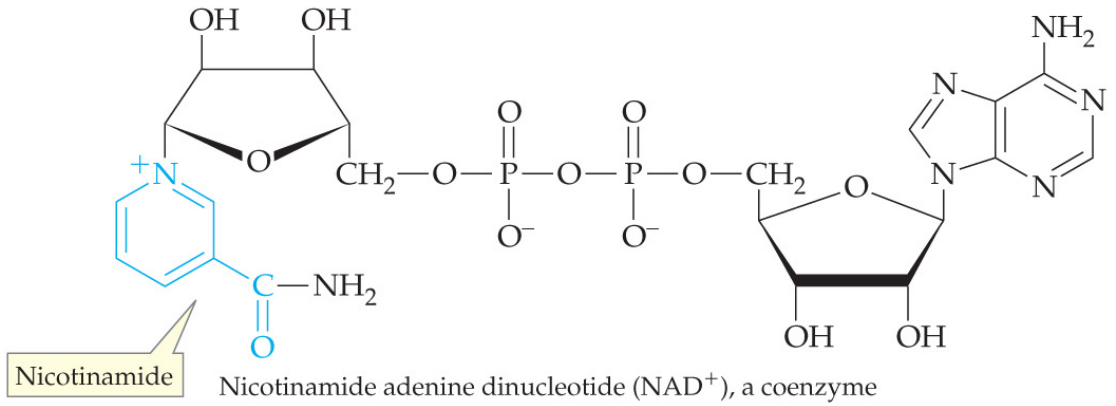
These are also vitamins that are coenzymes.

Vitamins as Components of Coenzymes

B3

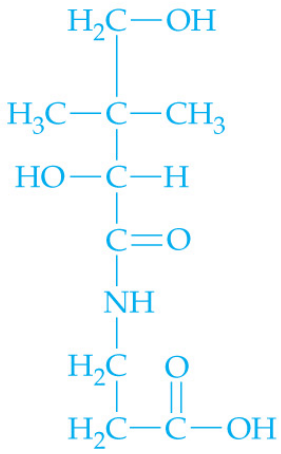


Niacin
(Nicotinic acid)

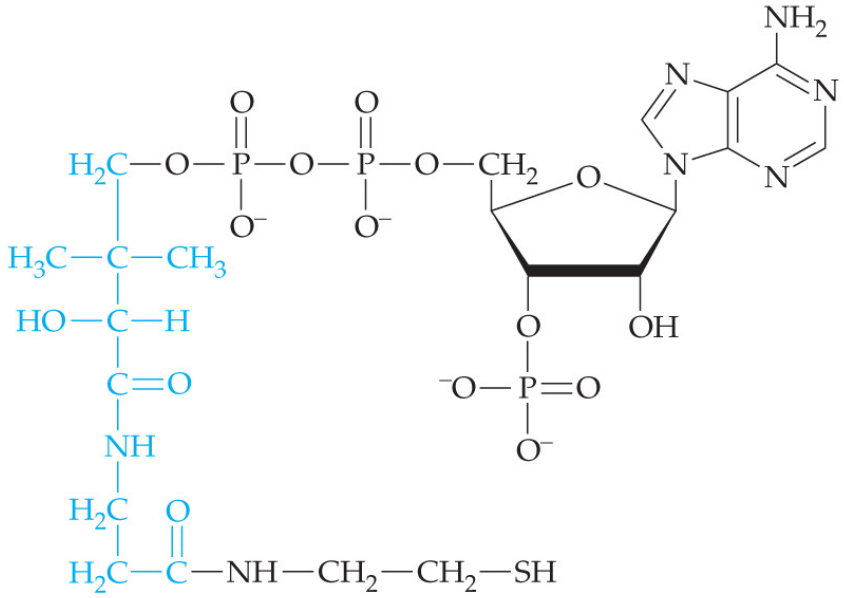


Nicotinamide adenine dinucleotide (NAD^+), a coenzyme

B5



Pantothenic acid



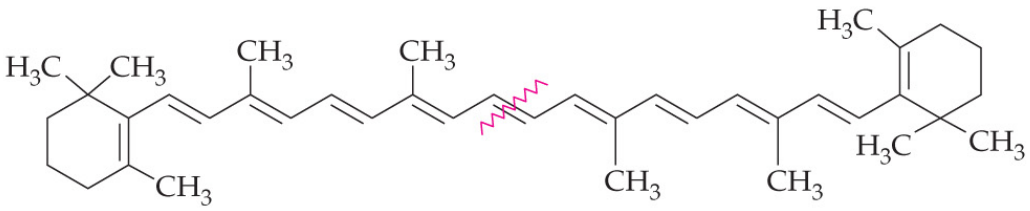
Coenzyme A

Fat-Soluble Vitamins

TABLE 19.4 The Fat-Soluble Vitamins*

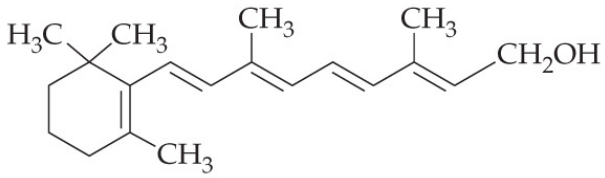
Vitamin	Significance	Sources	Reference Daily Intake**	Effects of Deficiency	Effects of Excess
A	Maintains epithelia; required for synthesis of visual pigments; antioxidant	Leafy green and yellow vegetables	1000 μg	Retarded growth, night blindness, deterioration of epithelial membranes	Liver damage, skin peeling, central nervous system effects (nausea, anorexia)
D	Required for normal bone growth, calcium and phosphorus absorption at gut, and retention in kidneys	Synthesized in skin exposed to sunlight	10 μg	Rickets, skeletal deterioration	Calcium deposits in many tissues, disrupting functions
E	Prevents breakdown of vitamin A and fatty acids; antioxidant	Meat, milk, vegetables	10 mg	Anemia; other problems suspected	None reported
K	Essential for liver synthesis of prothrombin and other clotting factors	Vegetables; production by intestinal bacteria	80 μg	Bleeding disorders	Liver dysfunction, jaundice

Fat-Soluble Vitamins

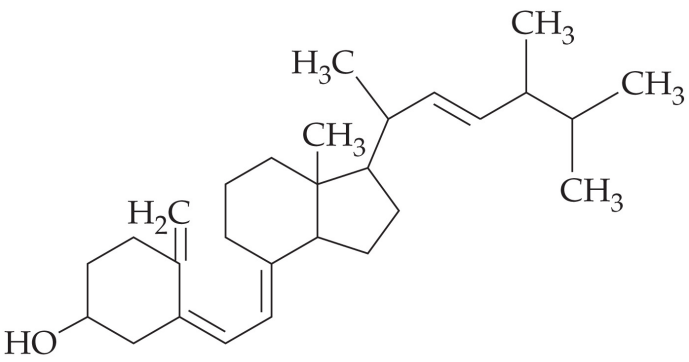


β-Carotene

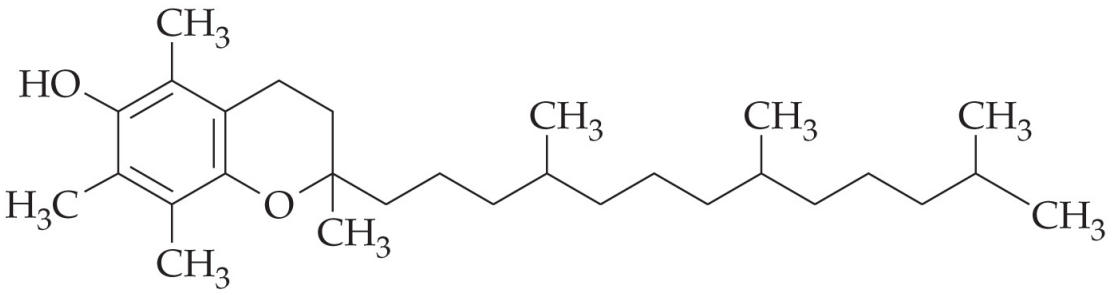
2



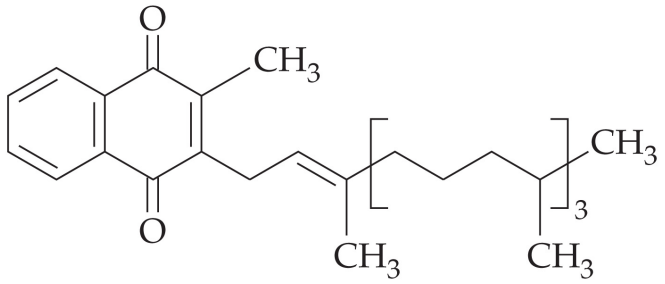
Vitamin A



Vitamin D



Vitamin E



Vitamin K

Minerals

TABLE 19.5 Macro and Trace Minerals

Mineral	Significance	Sources	Effects of Deficiency	Effects of Excess
Calcium	Bone formation, muscle contraction	Dairy, eggs, beans	Osteoporosis, muscle cramps	Kidney stones, heart arrhythmias
Phosphorus	Bone formation, component of DNA and energy molecules	Any protein	Muscle weakness	Impaired calcium metabolism
Potassium	Osmotic balance inside cells	Fruit, vegetables, meat	Loss of appetite, muscle cramps	Inhibited heart function
Chloride	Primary negative ion in extracellular fluid	All foods, especially processed	Convulsions (rare)	Hypertension
Sodium	Nerve impulse conduction; electrolyte (osmotic balance)	All foods, especially processed	Muscle cramps, nausea	Hypertension
Magnesium	Protein synthesis, glucose metabolism	Dairy, whole grain, plants	Muscle weakness	Nausea
Iron	Hemoglobin and cytochrome component	Meat, whole grains, legumes	Fatigue, anemia	Hemochromatosis
Fluoride	Part of vitamin B_{12}	Milk, eggs, seafood	Dental cavities	Discolored teeth
Zinc	Enzyme cofactor; smell and taste functions	Meat, dairy, whole grains	Poor immune function; slow wound healing	Poor immune system; increased LDL cholesterol
Copper	Enzymes for oxidations and connective tissue formation	Meat, nuts, eggs, bran cereal	Anemia	Nausea
Selenium	Cofactor for glutathione peroxidase	Meat, whole grains	Cardiac muscle damage	Nausea, hair loss
Manganese	Coenzyme for many enzymes in energy metabolism	Whole grains, legumes	Poor growth	Weakness, mental confusion
Iodine	Production of thyroid hormones	Iodized salt, seafood	Goiter	Depressed thyroid activity
Molybdenum	Coenzyme	Meat, whole grains, legumes	Not found	Not found
Chromium	Enhances insulin function	Meat, whole grain	Glucose intolerance	Rare from diet