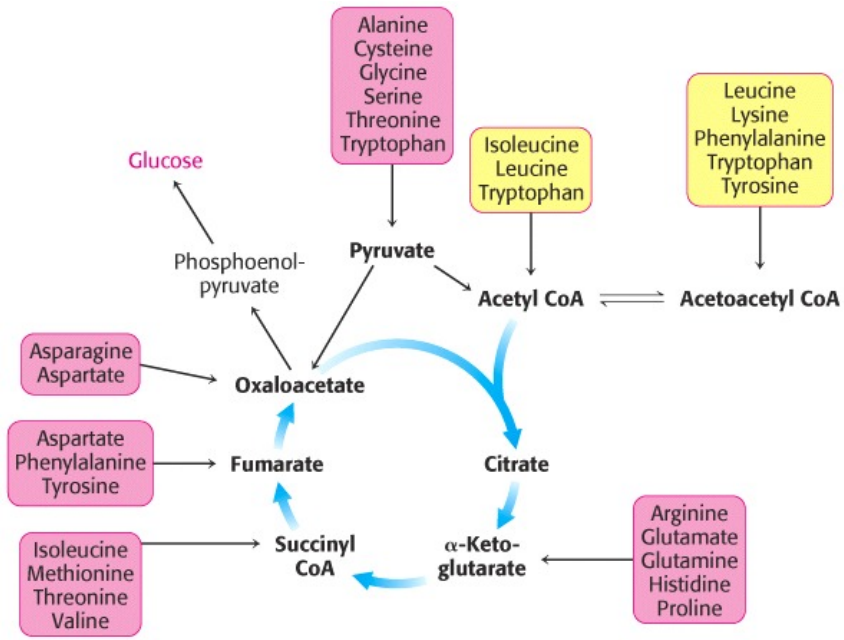
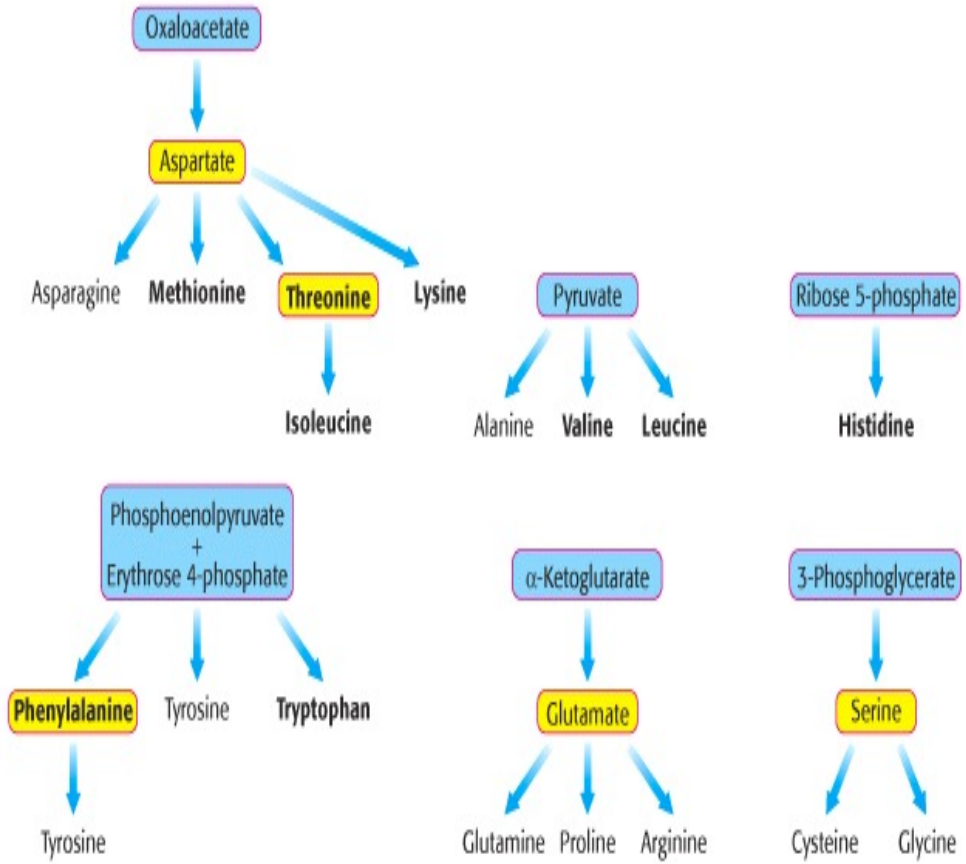
Amino Acid Biosynthesis

- Families of Amino Acids
- Essential vs Non-Essential Amino Acids
- Synthesis
- One carbon carriers
- Synthesis from Amino Acids



Families of Amino Acids

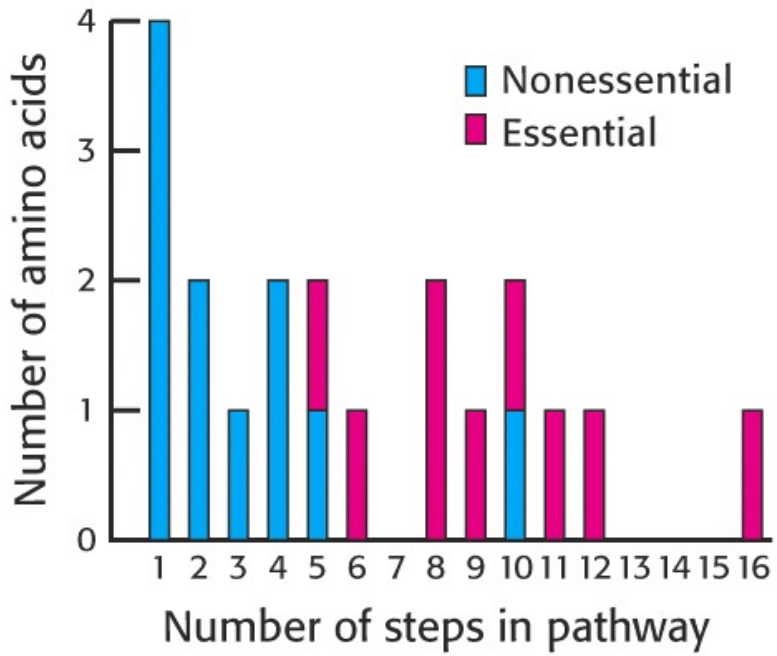
- OAA
- PEP + Erythrose 4P
- pyruvate
- Ribose 5P
- ketoglutarate
- 3-phosphoglycerate



Essential vs Non-Essential Amino Acids

TABLE 24.1 **Basic set of 20 amino acids**

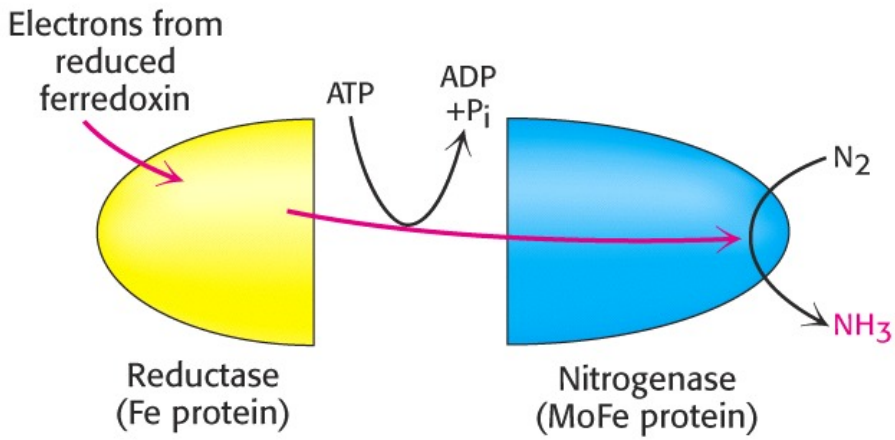
Nonessential	Essential
Alanine	Histidine
Arginine	Isoleucine
Asparagine	Leucine
Aspartate	Lysine
Cysteine	Methionine
Glutamate	Phenylalanine
Glutamine	Threonine
Glycine	Tryptophan
Proline	Valine
Serine	
Tyrosine	



Nitrogen

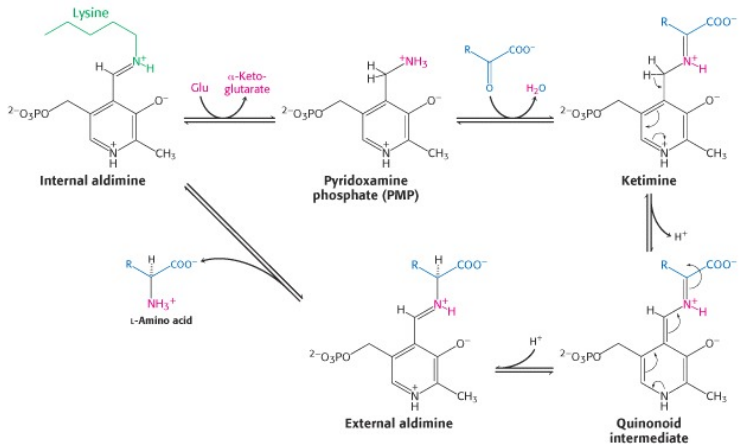
- Atmospheric N_2 is the ultimate source of biological nitrogen
- **Nitrogen fixation**: a few bacteria possess nitrogenase which can reduce N2 to ammonia
- Nitrogen is recycled in nature through the nitrogen cycle

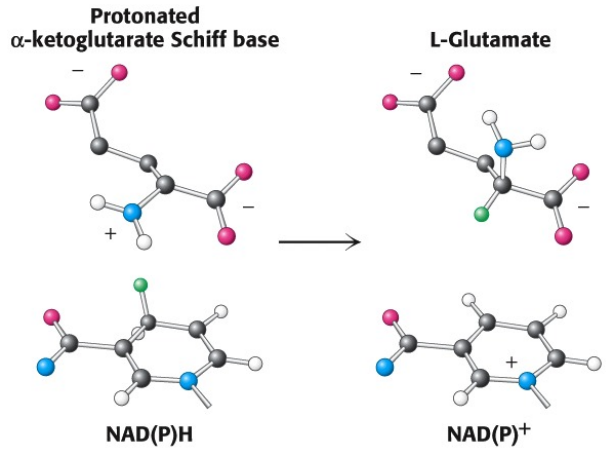
Synthesis



- Prokaryotic cells
- Nitrogenase reaction:
- **N2 + 8 H+ + 8 e- + 16 ATP →**
- **2 NH3 + H2 + 16 ATP + 16 Pi**
- Ammonia assimilated in amino acids

Transamination

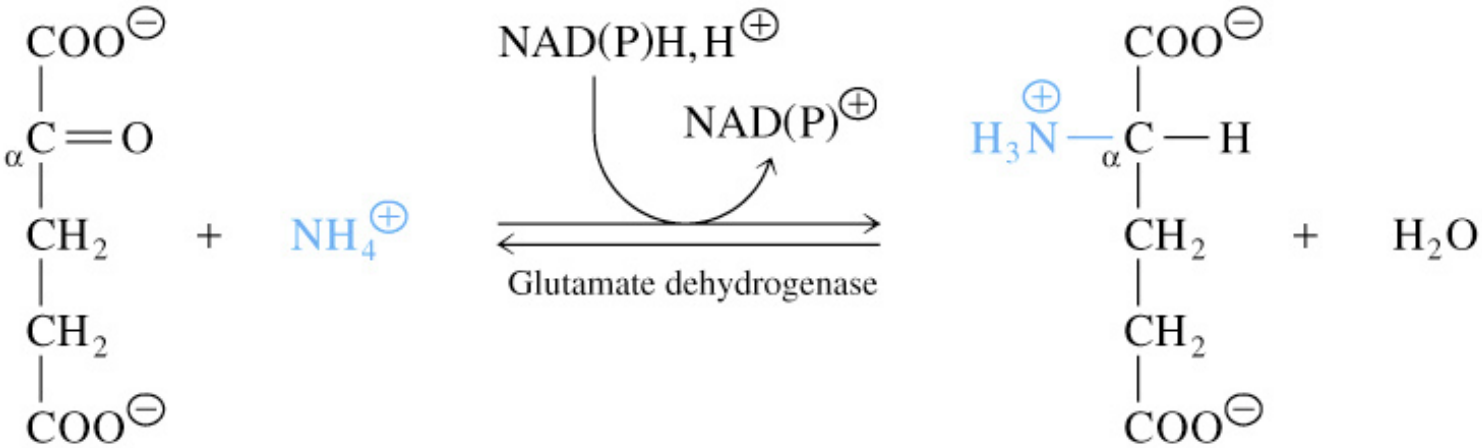




- Transamination reaction
- Determines chirality

Ammonia Is Incorporated into Glutamate

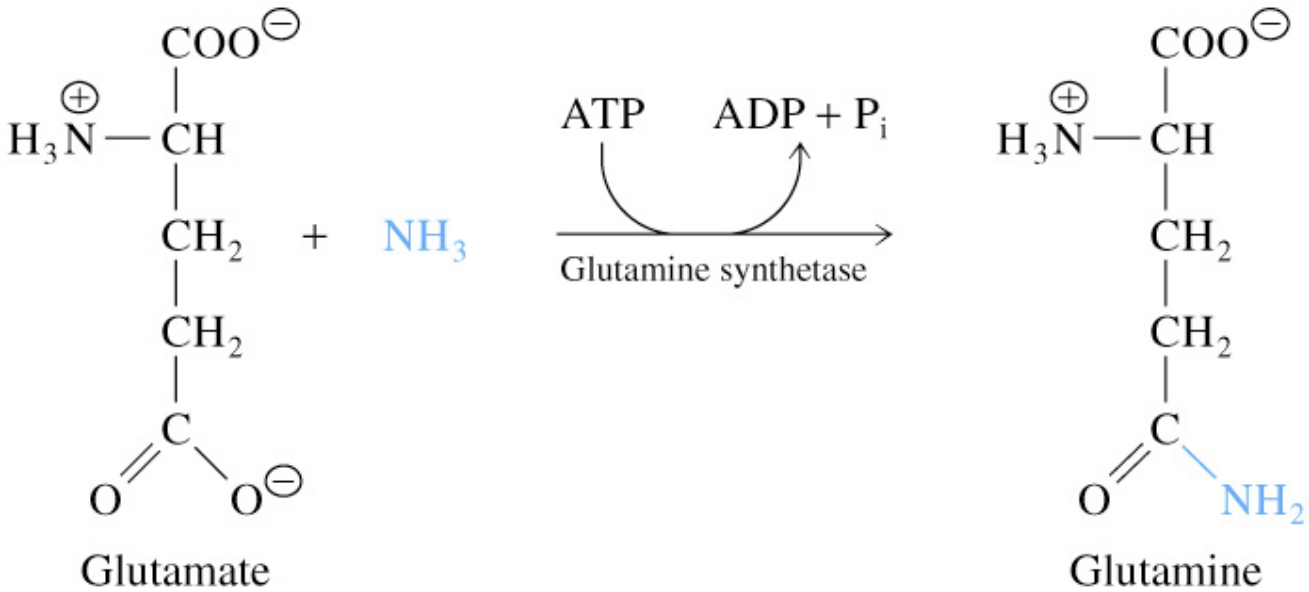
- Reductive amination of α-ketoglutarate by glutamate dehydrogenase occurs in plants, animals and microorganisms



(17.3)

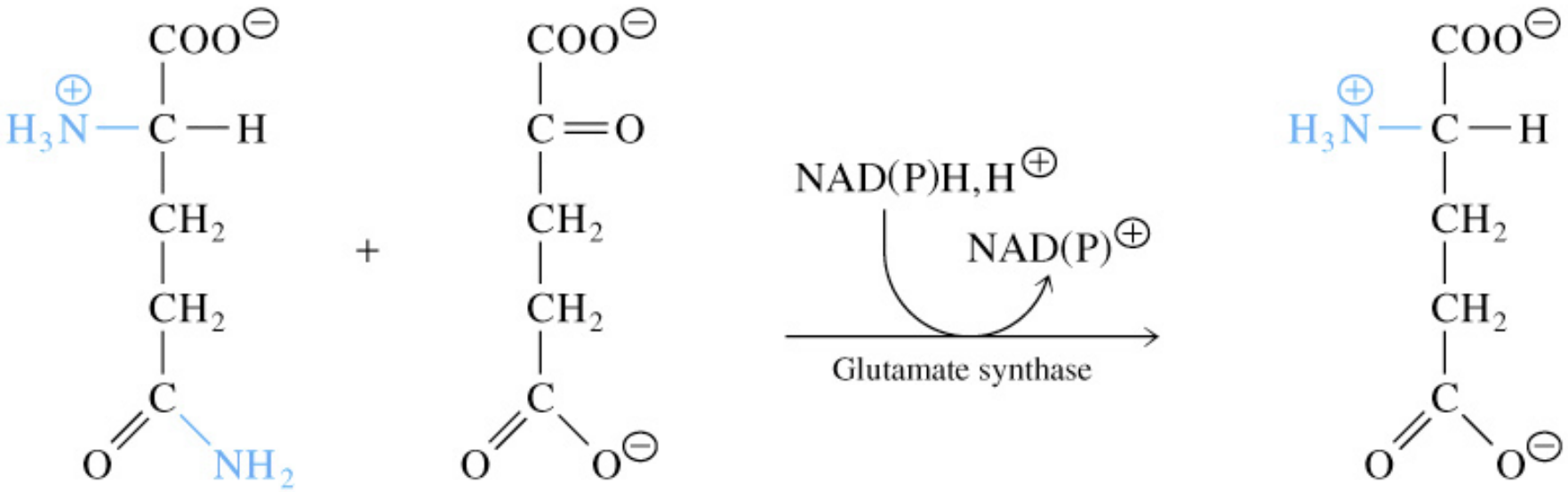
Glutamine Is a Nitrogen Carrier

- A second important route in assimilation of ammonia is via glutamine synthetase



(17.4)

Glutamate synthase transfers a nitrogen to α-ketoglutarate



(17.5)

Synthesis of Nonessential Amino Acids

- Most bacteria and plants (not mammals) synthesize all 20 common amino acids
- Nonessential amino acids for mammals are usually derived from intermediates of glycolysis or the citric acid cycle
- Amino acids with the largest energy requirements are usually essential amino acids

Synthesis of amino acids

- One step synthesis of some amino acids
- pyruvate to alanine
- OAA to aspartate
- ketoglutarate to glutamate

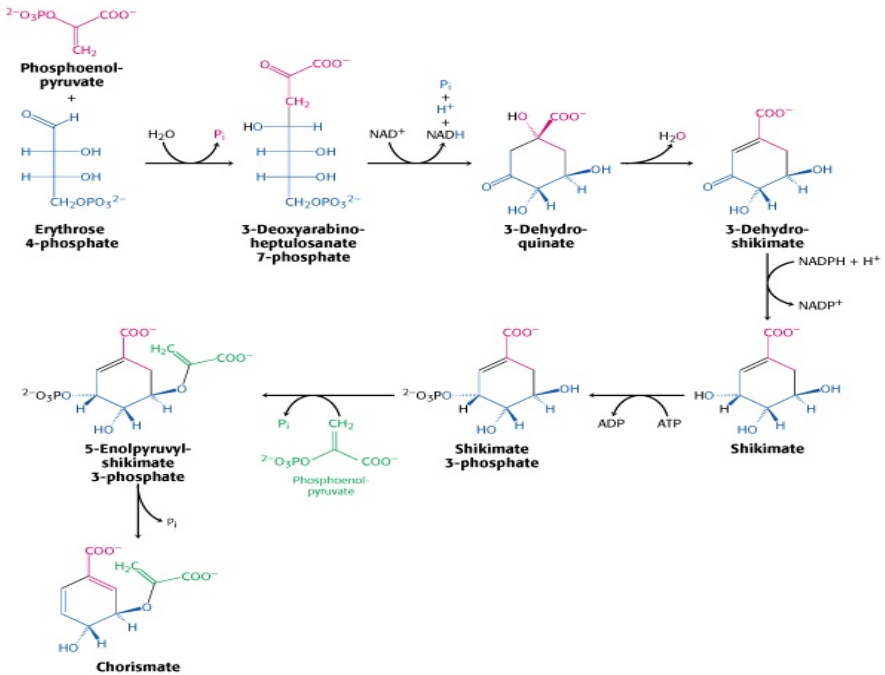
TABLE 17.1 Essential and nonessential amino acids with energetic requirements for their biosynthesis

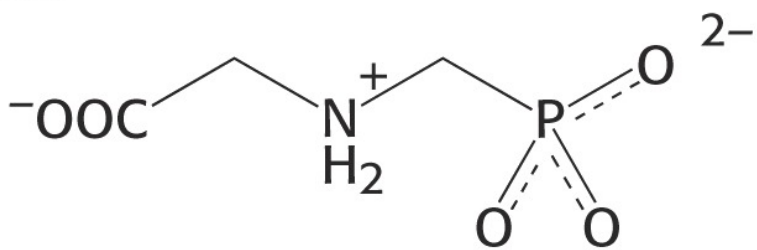
Amino acid	Moles of ATP required per mole of amino acid produced[a]	
	Nonessential	Essential
Glycine	12	
Serine	18	
Cysteine	19[b]	
Alanine	20	
Aspartate	21	
Asparagine	22–24	
Glutamate	30	
Glutamine	31	
Threonine		31
Proline	39	
Valine		39
Histidine		42
Arginine	44[c]	
Methionine		44
Leucine		47
Lysine		50 or 51
Isoleucine		55
Tyrosine	62[d]	
Phenylalanine		65
Tryptophan		

[a] Moles of ATP required includes ATP used for

Aromatic Amino acids

- long biochemical pathways
- shikimate acid pathway
- produce phenylalanine, tyrosine & tryptophan
- glyphosphate (roundup) inhibits

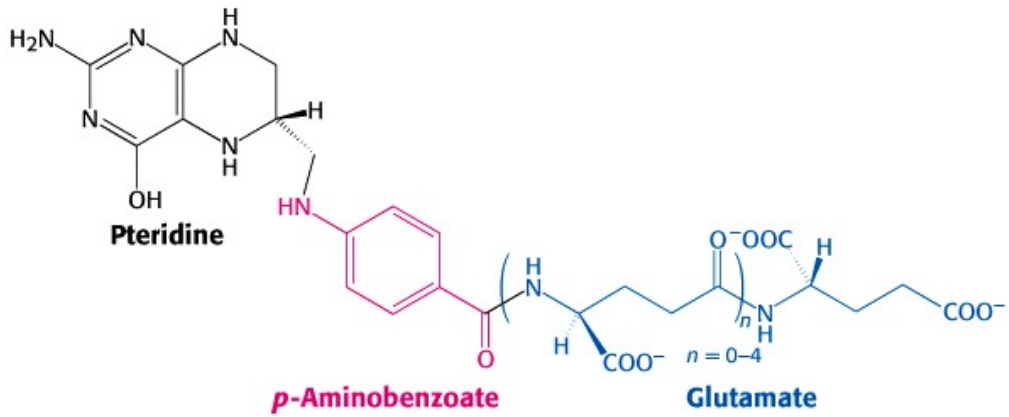




Glyphosate
(Roundup)

One carbon carriers

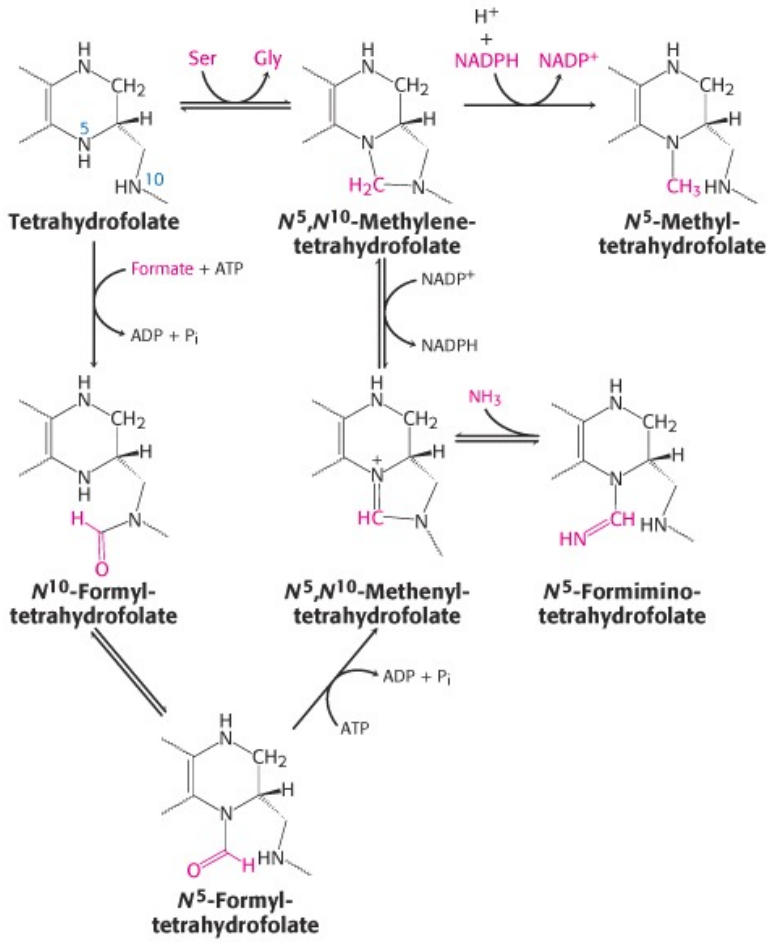
- Tetrahydrofolate (THF)
- one carbon carrier
- different oxidation states
- usually not reduced
- sulfa drugs inhibit bacteria
- mammals cannot synthesize



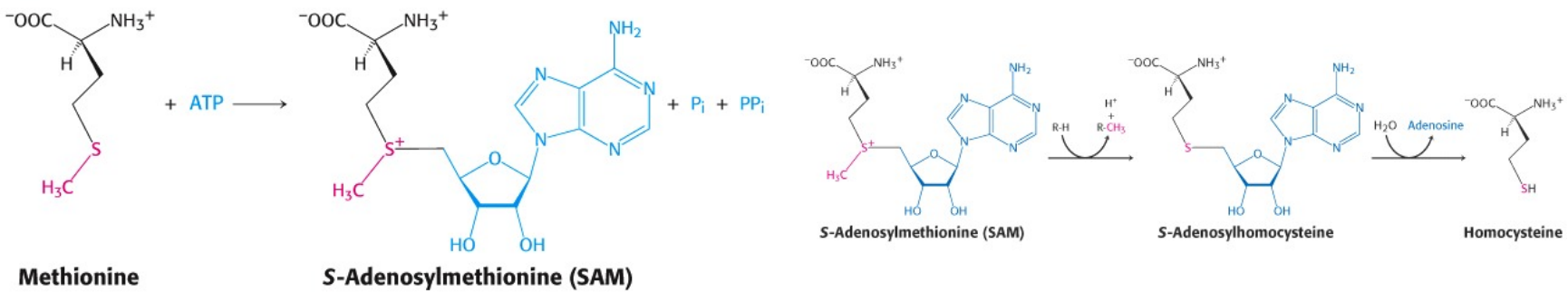
THF

TABLE 24.2 **One-carbon groups carried by tetrahydrofolate**

Oxidation state	Group	
Most reduced (= methanol)	$-CH_3$	Methyl
Intermediate (= formaldehyde)	$-CH_2-$	Methylene
Most oxidized (= formic acid)	–CHO	Formyl
	–CHNH	Formimino
	–CH=	Methenyl

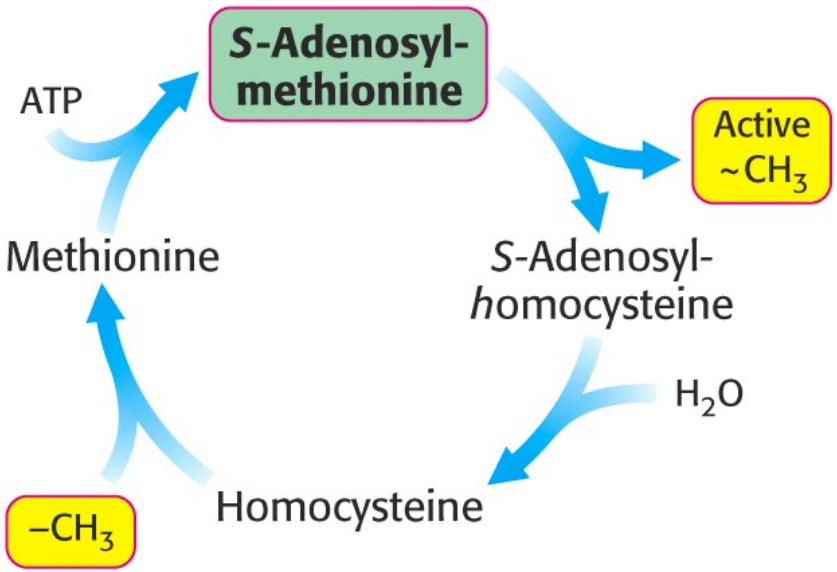


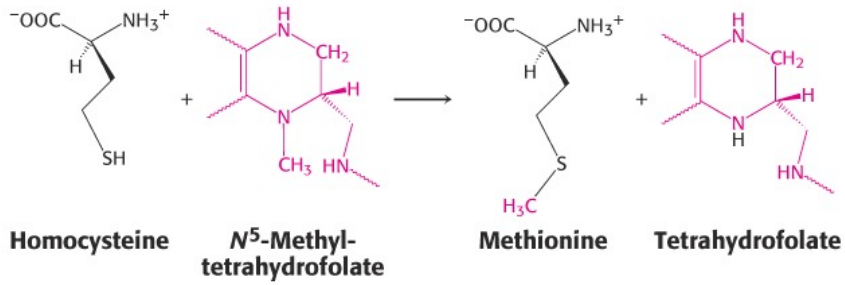
S-Adenosylmethionine



- donates methyl groups
- produced from methionine
- uses ATP

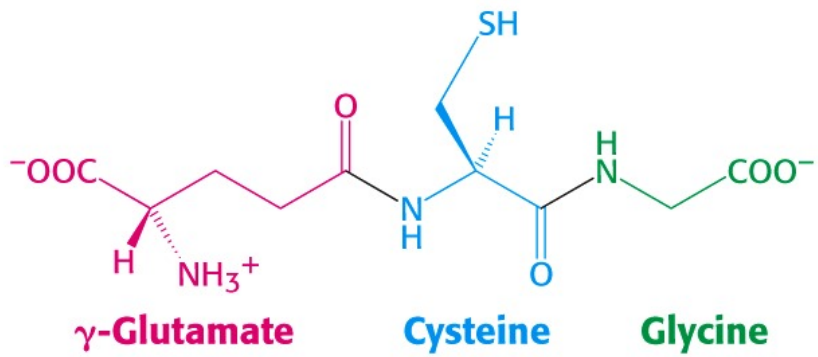
Methyl Cycle

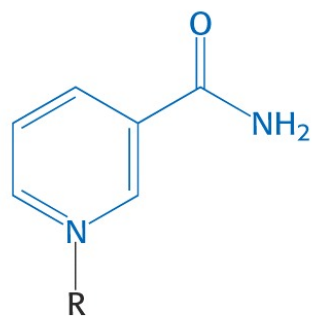




Synthesis from Amino Acids

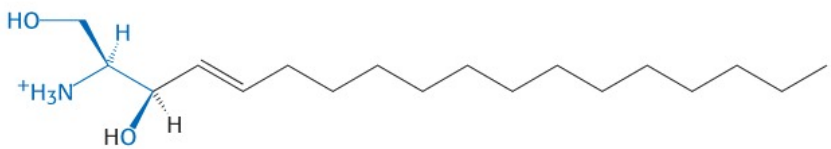
- Creatine
- glutathione
- porphyrins
- Nitric oxide
- hormones: thyroxine, epinephrine, histamine



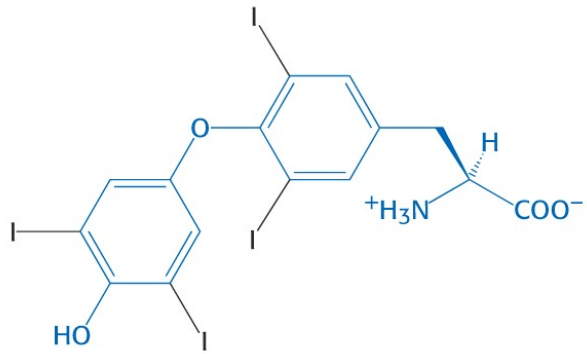


Nicotinamide unit of NAD^+

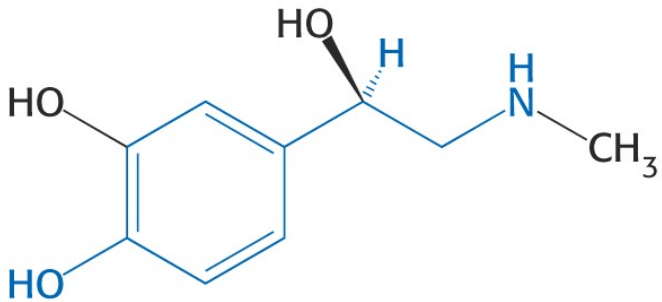
Hormones/lipids



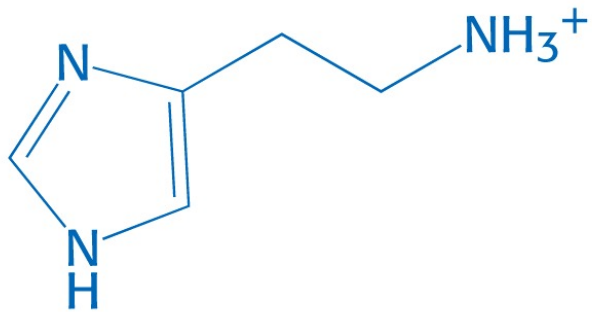
Sphingosine



Thyroxine
(Tetraiodothyronine)

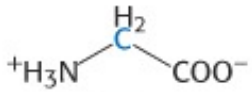


Epinephrine

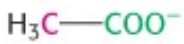


Histamine

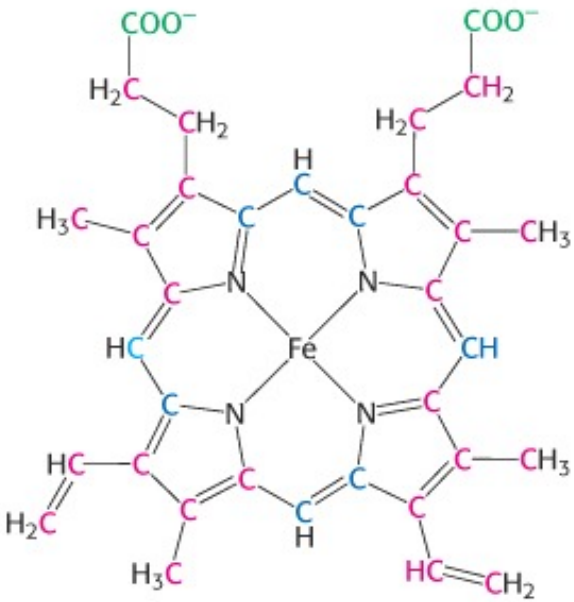
Heme



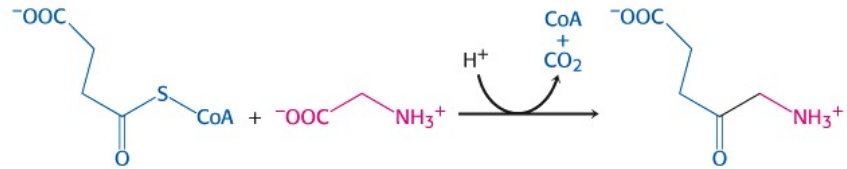
Glycine



Acetate

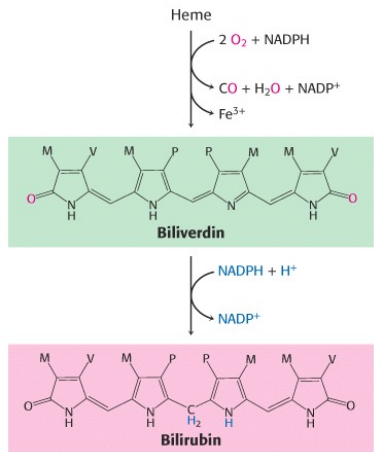


Heme



Succinyl CoA Glycine δ-Aminolevulinate

Degradation of Hemes



Synthesis of Nitric Oxide (NO) from Arginine

- Nitric oxide (·N=O) is a gas which can diffuse rapidly into cells, and is a messenger that activates guanylyl cyclase (GMP synthesis)
- NO relaxes blood vessels, lowers blood pressure, and is a neurotransmitter in the brain (high levels of NO during a stroke kill neurons)
- Nitroglycerin is converted to NO and dilates coronary arteries in treating angina pectoris

Conversion of arginine to NO via nitric oxide synthase