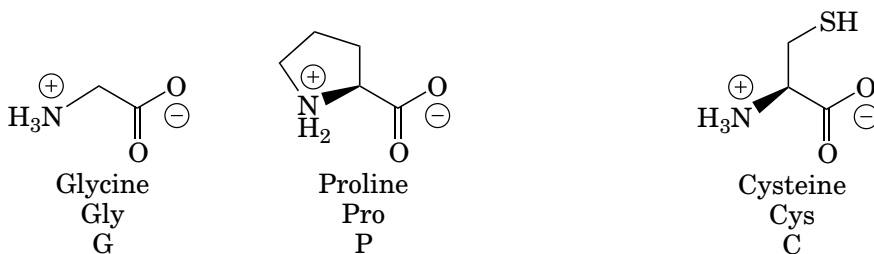
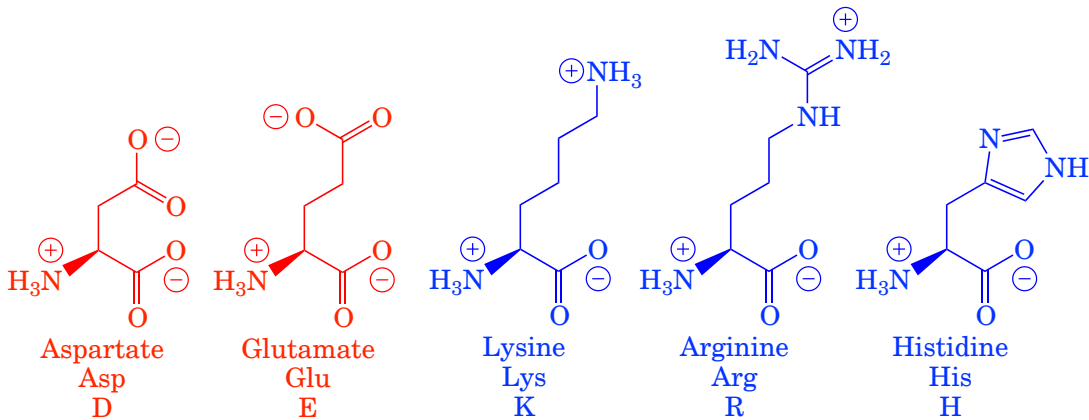
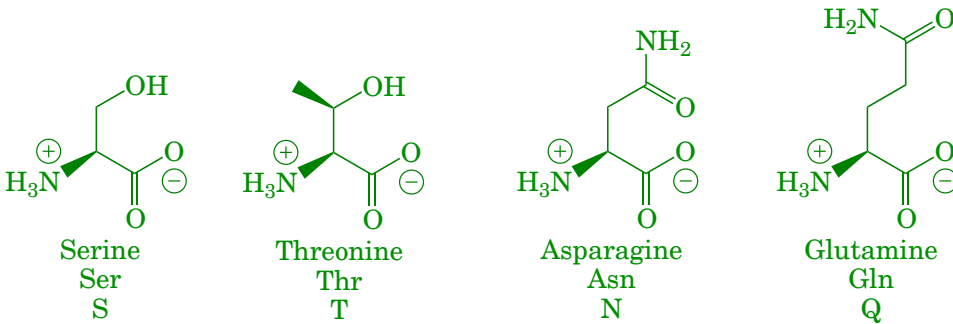
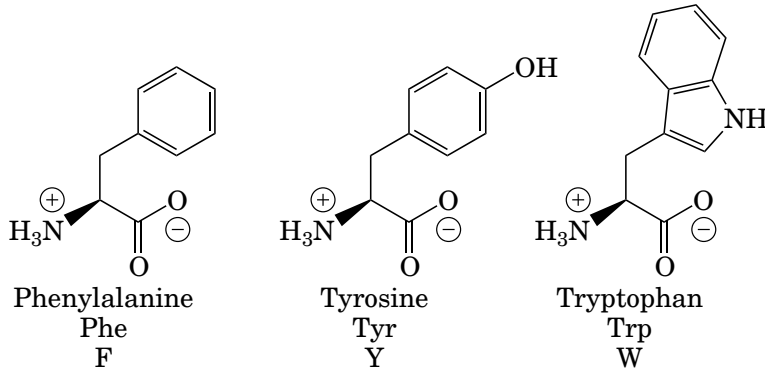
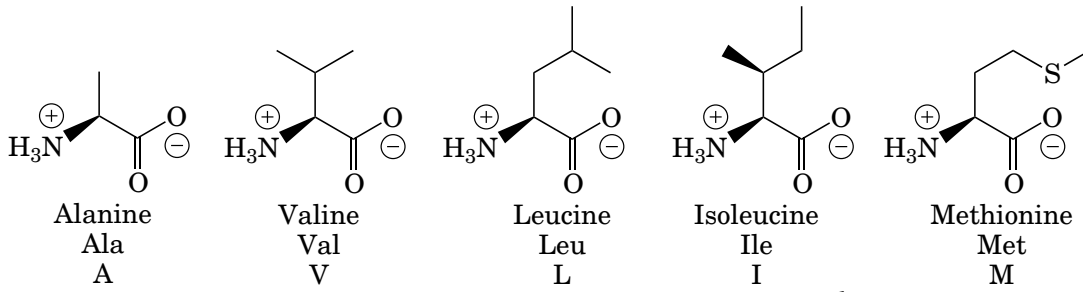
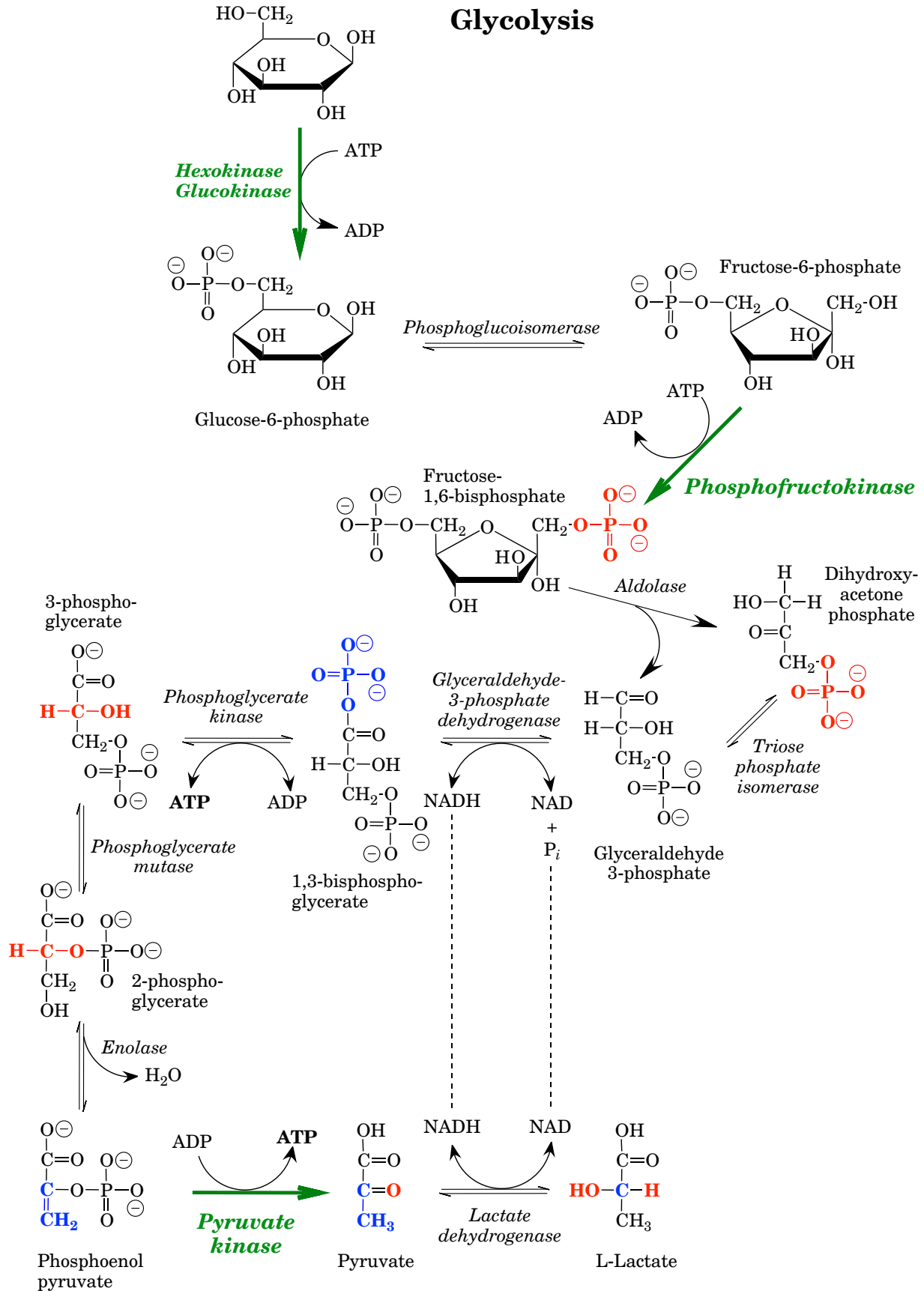


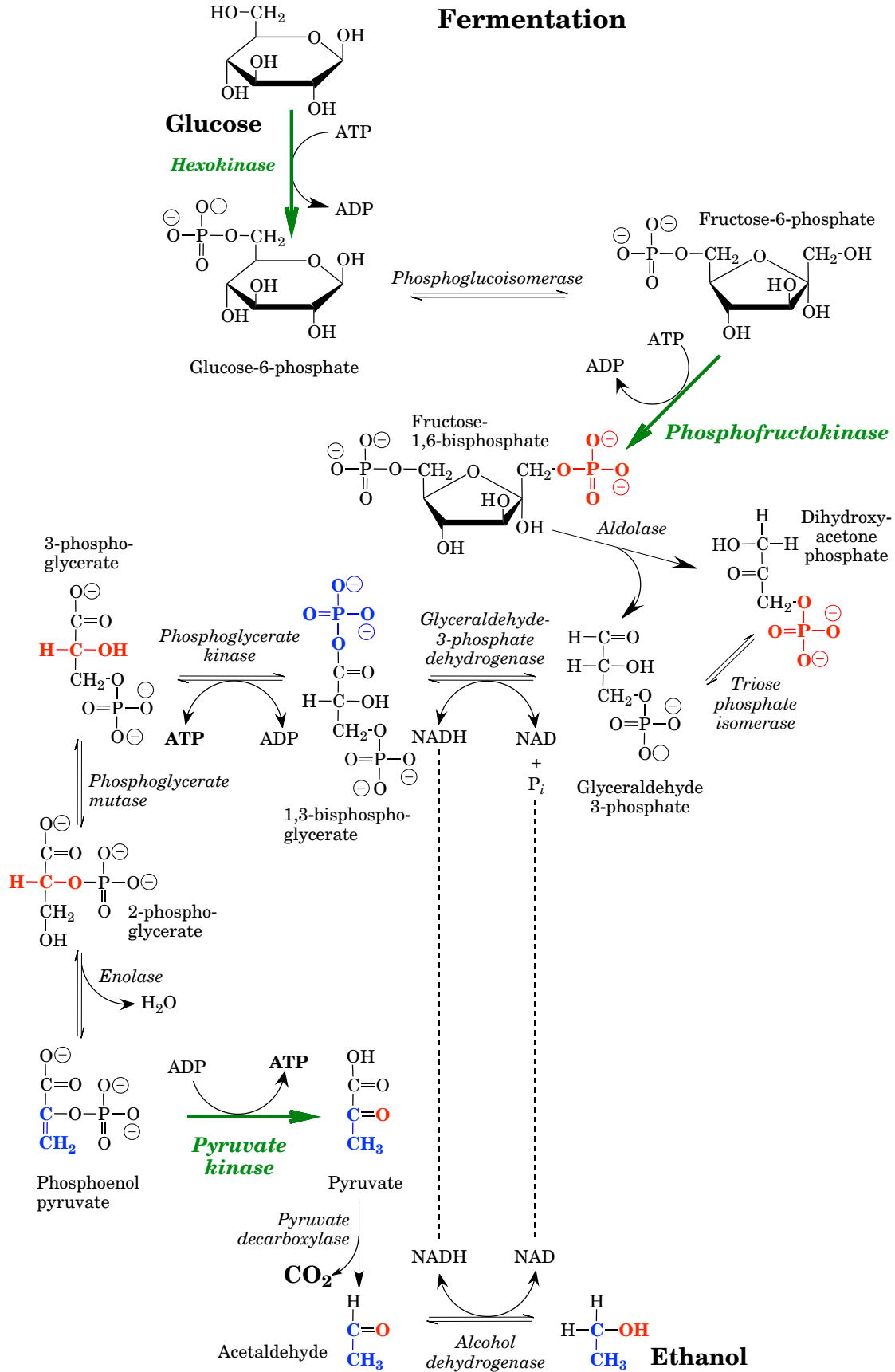
Amino Acid Structures



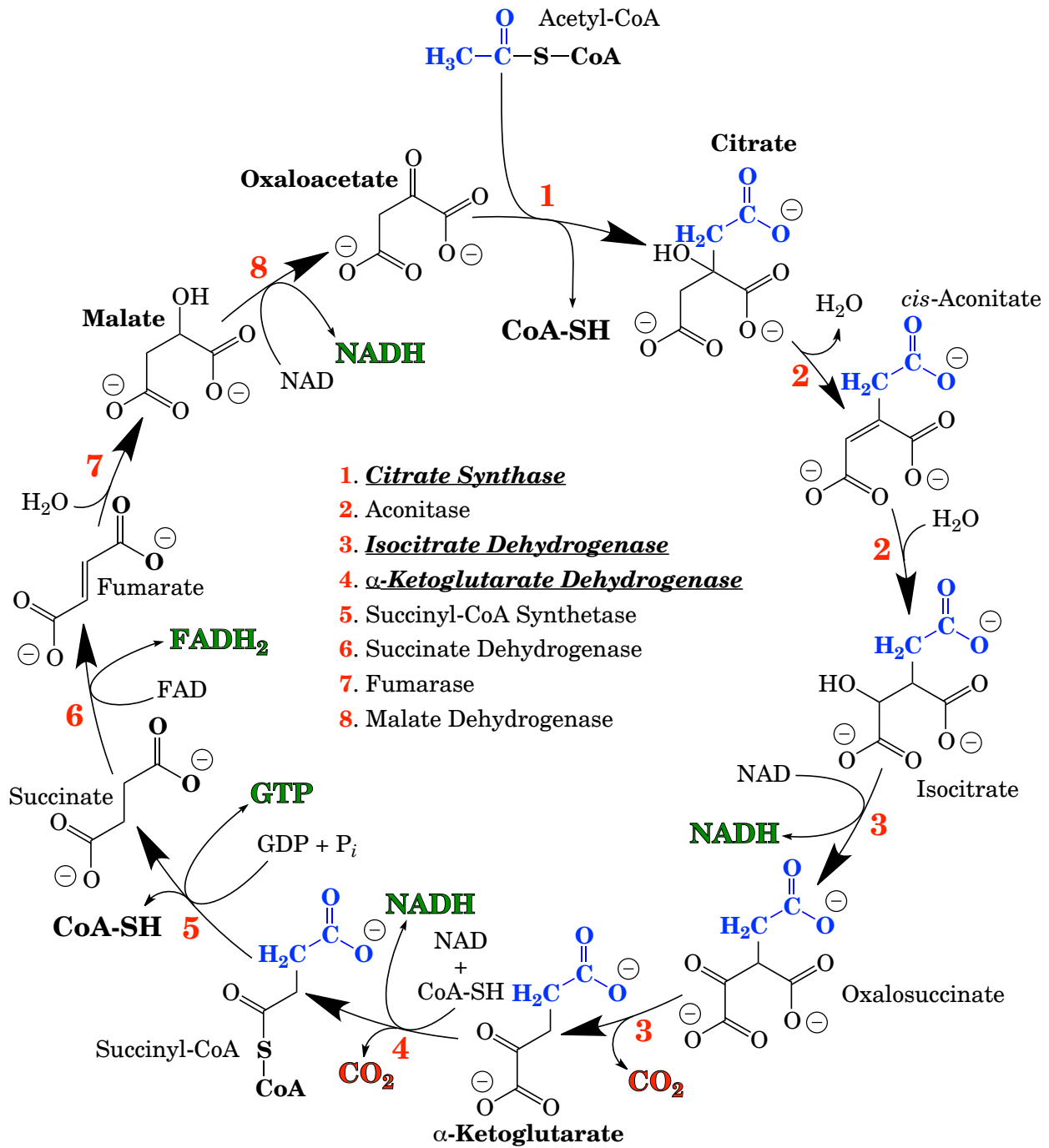
Glycolysis

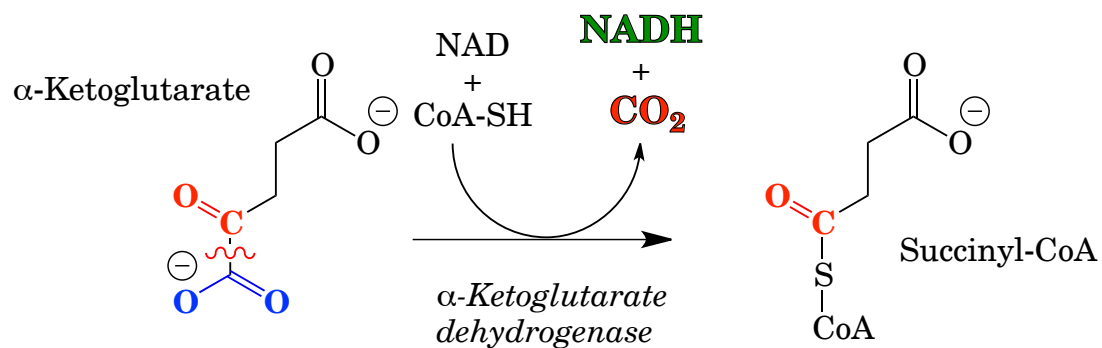
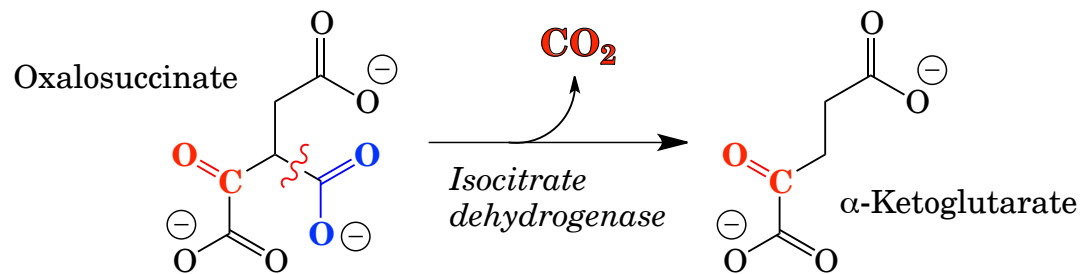
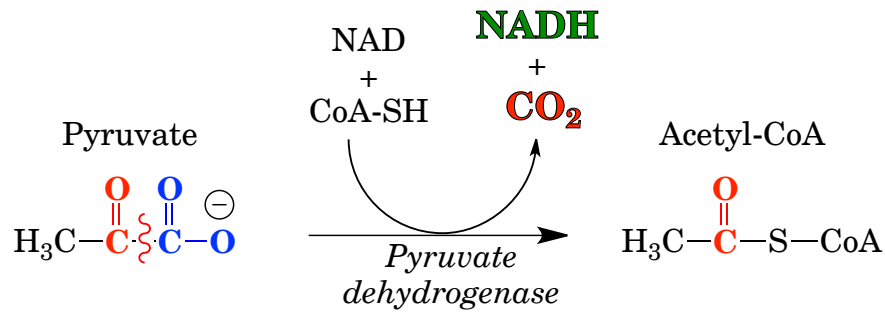
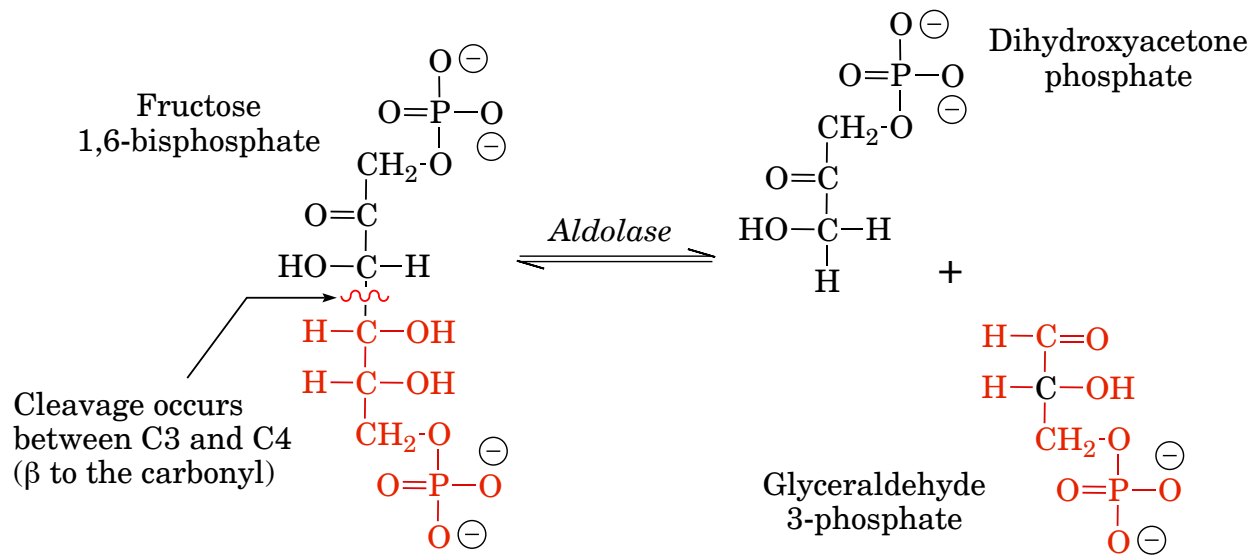


Fermentation

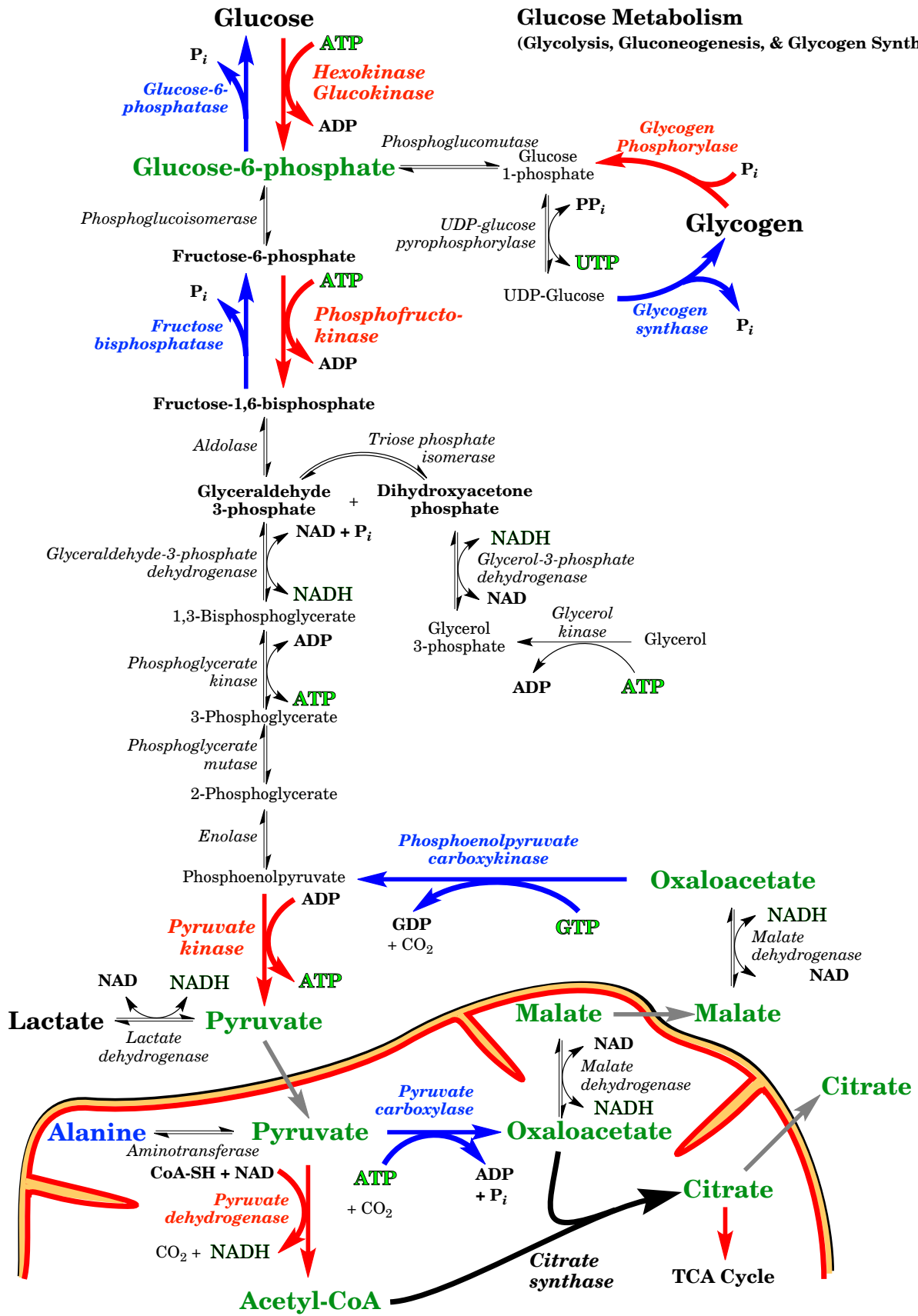


Tricarboxylic Acid Cycle

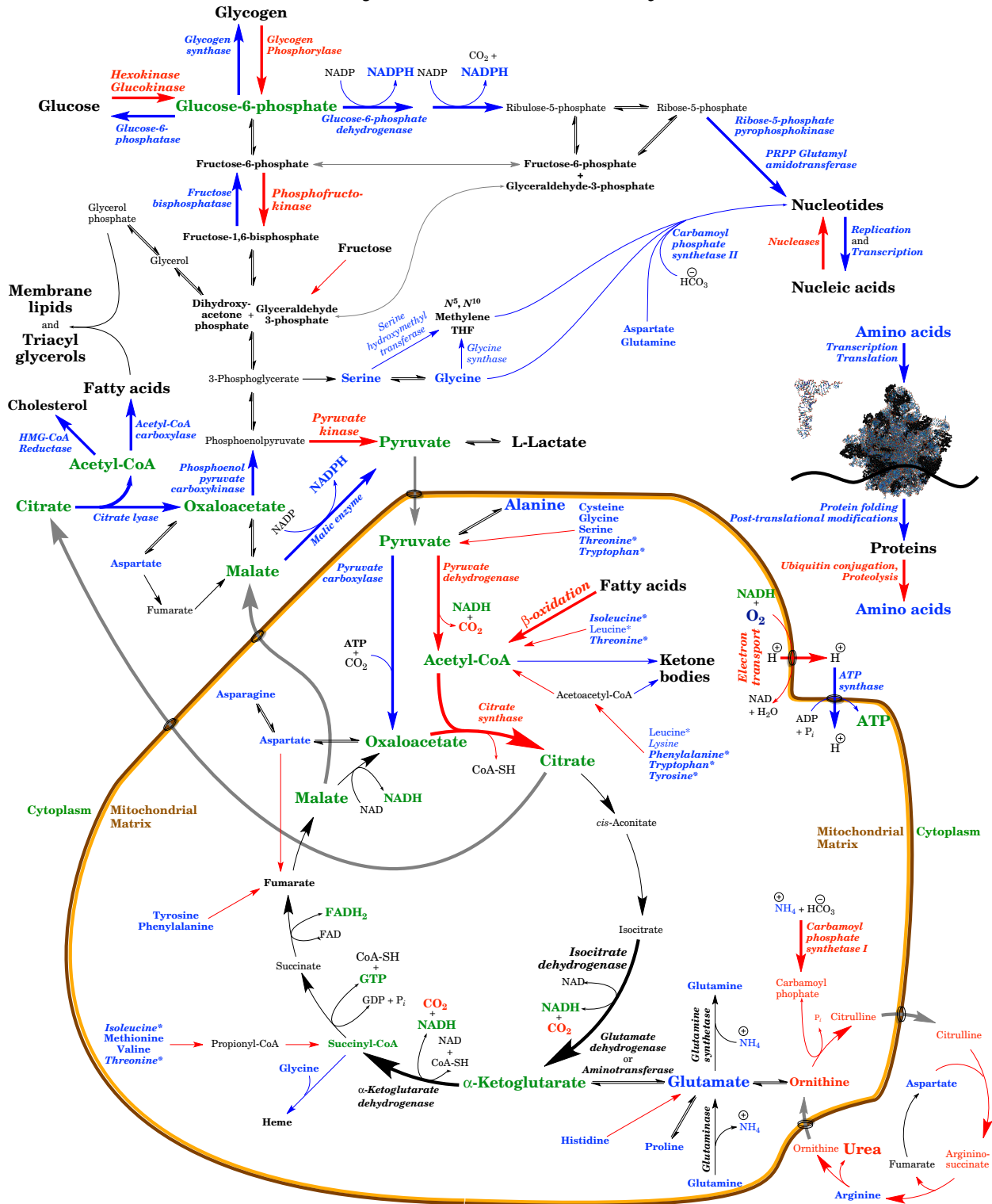




Glucose Metabolism (Glycolysis, Gluconeogenesis, & Glycogen Synthesis)



Major Metabolic Pathways

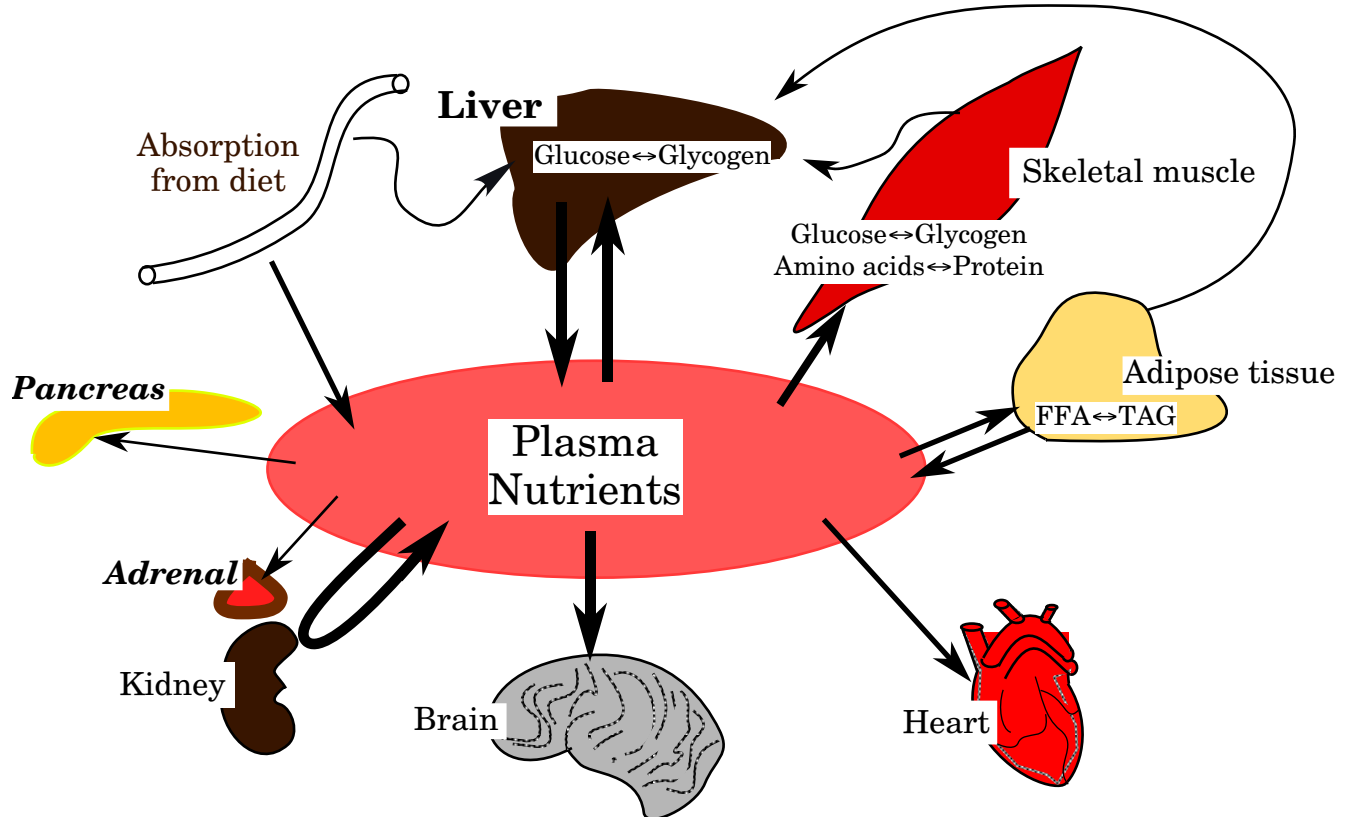


Notes: Only regulatory enzymes are shown.
Red enzyme name and arrow = predominantly catabolic process
Blue enzyme name and arrow = predominantly anabolic process

Green compound name = branch-point compound
Blue compound name = amino acid or ammonium

Major Metabolic Control Hormones

| Hormone | Receptor | Second messenger | Mechanism | Target tissues |
|--|---|---|--|---|
| Insulin (51 amino acid heterodimeric peptide) | Tyrosine kinase | Phosphorylated proteins decreased cAMP | Δ Enzyme activity Gene transcription | Liver, muscle, adipose, pancreas, many others |
| Glucagon (29 amino acid peptide) | G-protein coupled | cAMP | Δ Enzyme activity Sometimes gene transcription | Liver, pancreas |
| Cortisol (steroid) | Transcription factor | Altered level of specific mRNA | Gene transcription | Nearly all |
| Epinephrine (tyrosine derivative) | G-protein coupled (at least four types) | cAMP decreased cAMP PI hydrolysis | Δ Enzyme activity | Liver, muscle, adipose, brain, pancreas, cardiovascular |
| Growth hormone (191 amino acid protein) | Cytokine family cell surface | Tyrosine kinase PI hydrolysis | Δ Enzyme activity Sometimes gene transcription | Liver, muscle, adipose; others mediated by IGF-I |



Regulation of Liver Metabolism

| Pathway | Regulatory enzyme | Stimulators | Inhibitors | Hormones affecting enzyme activity | Hormones affecting enzyme levels |
|-----------------------|---|---|---|--|---------------------------------------|
| Glycolysis | <i>Glucokinase</i> | [glucose] | | | Insulin ↑ Cortisol ↓ |
| | <i>Phosphofructokinase</i> | Fructose 2,6-bisphosphate, AMP | Citrate, ketone bodies, ATP, phosphoenolpyruvate | Insulin ↑ Glucagon ↓ Epinephrine ↓ (all via altered [F2,6bP]) | Insulin ↑ Cortisol ↓ |
| | <i>Pyruvate kinase</i> | AMP, Fructose-1,6-bisphosphate | ATP, alanine | Insulin ↑ Glucagon ↓ Epinephrine ↓ | Insulin ↑ Cortisol ↓ |
| Gluconeogenesis | <i>Phosphoenolpyruvate carboxykinase</i> | | | Glucagon ↑ | Insulin ↓ Cortisol ↑ Glucagon ↑ |
| | <i>Fructose 1,6-bisphosphatase</i> | | Fructose 2,6-bisphosphate, AMP | Insulin ↓ Glucagon ↑ Epinephrine ↑ | Insulin ↓ Cortisol ↑ |
| | <i>Glucose-6-phosphatase</i> | | | | Insulin ↓ Cortisol ↑ |
| | <i>Pyruvate carboxylase</i> | Acetyl-CoA | ADP | | Insulin ↓ Cortisol ↑ Glucagon ↑ |
| TCA Cycle | <i>Pyruvate dehydrogenase</i> | CoA, NAD, ADP, pyruvate, Ca ²⁺ | Acetyl-CoA, NADH, ATP | Insulin ↑ | |
| | <i>Citrate synthase</i> | NAD, [oxaloacetate] | Citrate, Long chain acyl-CoA, ATP, NADH, succinyl-CoA | | |
| | <i>Isocitrate dehydrogenase</i> | ADP, Ca ²⁺ | ATP, NADH | | |
| | <i>α-ketoglutarate dehydrogenase</i> | Ca ²⁺ | ATP, NADH, succinyl-CoA, GTP | | |
| Glycogen synthesis | <i>Glycogen synthase</i> | Glucose-6-phosphate | Glycogen | Insulin ↑ Glucagon ↓ Epinephrine ↓ | Insulin ↑ Cortisol ↑ |
| Glycogen breakdown | <i>Glycogen phosphorylase</i> | AMP | Glucose-6-phosphate, ATP | Insulin ↓ Glucagon ↑ Epinephrine ↑ | |
| Hexose mono-phosphate | <i>Glucose-6-phosphate dehydrogenase</i> | NADP | NADPH | | Insulin ↑ |
| Urea cycle | <i>Glutamate dehydrogenase</i> | ADP | ATP, GTP, NADH | | |
| | <i>Carbamoyl phosphate synthetase I</i> | N-acetyl-glutamate [substrate] | | | |
| Fatty acid synthesis | <i>Acetyl-CoA carboxylase</i> | Citrate | Long-chain acyl-CoA | Insulin ↑ Glucagon ↓ | Insulin ↑ |
| Fatty acid breakdown | <i>Carnitine acyl transferase I</i> | AMP | Malonyl-CoA | | |
| Ketone body synthesis | <i>HMG-CoA synthase</i> | Acetyl-CoA | | | Glucagon ↑ |
| Cholesterol synthesis | <i>HMG-CoA reductase</i> | | Cholesterol, bile acids | Insulin ↑ Glucagon ↓ | |
| Purine synthesis | <i>Ribose-phosphate pyrophosphokinase</i> | | Adenine, Guanine and Thymine nucleotides | | |
| | <i>PRPP glutamyl amidotransferase</i> | PRPP | Adenine and Guanine nucleotides | | |
| Pyrimidine synthesis | <i>Carbamoyl phosphate synthetase II</i> | ATP, PRPP | Uridine nucleotides, GTP | | |
| | <i>Aspartate transcarbamoylase</i> | | CTP | | |

Regulation of Skeletal Muscle Metabolism

| Pathway | Regulatory enzyme | Stimulators | Inhibitors | Hormones affecting enzyme activity | Hormones affecting enzyme levels |
|--------------------|---|--|-----------------------------|--|--|
| Glycolysis | <i>Glucose transporter (GLUT 4)</i> | (Muscle contraction) | | Insulin ↑ Cortisol ↓ (change amount in plasma membrane) | Insulin ↓ Cortisol ↑ |
| | <i>Hexokinase</i> | | Glucose-6-phosphate | | |
| | <i>Phosphofructokinase</i> | Fructose 2,6-bisphosphate, AMP, (Muscle contraction) | Citrate, ketone bodies, ATP | | Cortisol ↓ |
| Glycogen synthesis | <i>Glycogen synthase</i> | Glucose-6-phosphate, low Glycogen levels | Ca ²⁺ , AMP | Insulin ↑ Epinephrine ↓ | Insulin ↑ |
| Glycogen breakdown | <i>Glycogen Phosphorylase</i> | Ca ²⁺ , AMP | Glucose-6-phosphate, ATP | Insulin ↓ Epinephrine ↑ | |
| Protein synthesis | <i>Transcription and translation initiation</i> | | | | Insulin ↑ Growth hormone ↑ Androgens ↑ Cortisol ↓ |
| Protein breakdown | <i>Protease activation</i> | | | | Insulin ↓ Cortisol ↑ |

Regulation of Adipose Tissue Metabolism

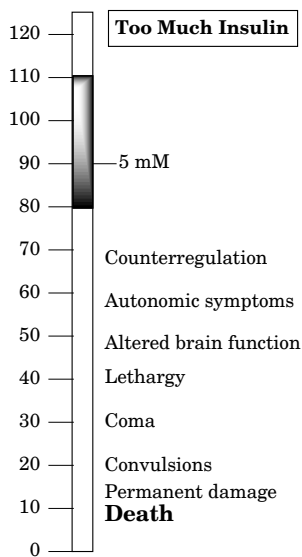
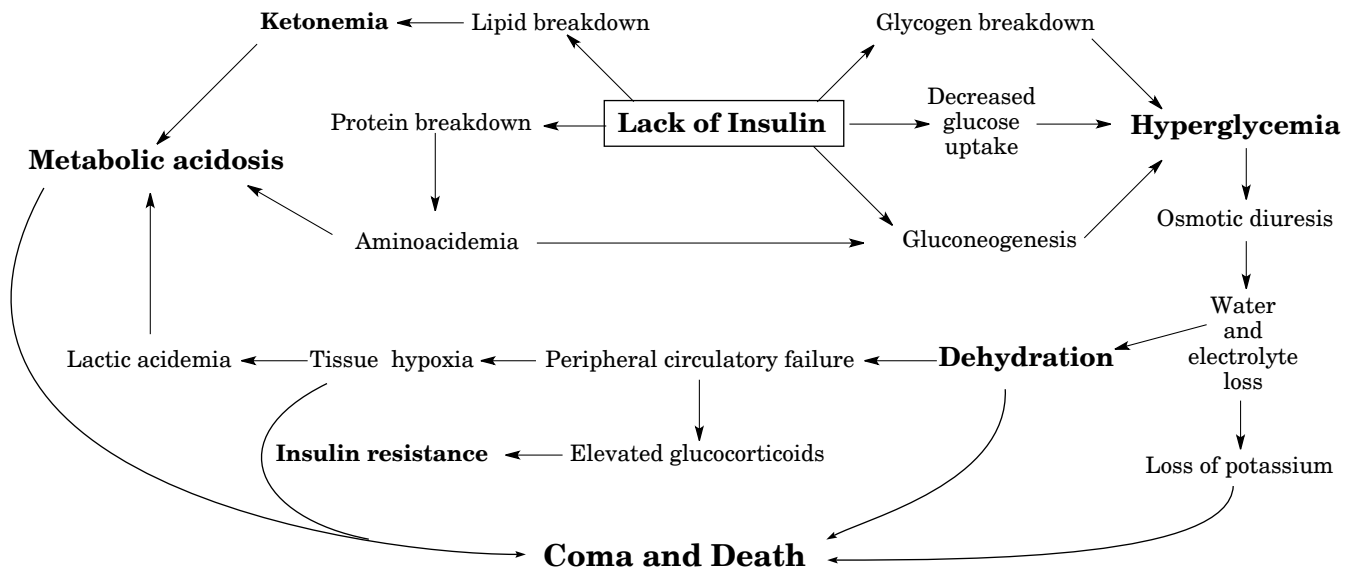
| Pathway | Regulatory enzyme | Stimulators | Inhibitors | Hormones affecting enzyme activity | Hormones affecting enzyme levels |
|---------------------------|---|--------------------------------|---------------------------------|--|----------------------------------|
| Glycolysis | <i>Glucose transporter (GLUT 4)</i> | | | Insulin ↑ Cortisol ↓ (change amount in plasma membrane) | Insulin ↓ Cortisol ↑ |
| | <i>Hexokinase</i> | | Glucose-6-phosphate | | |
| | <i>Phosphofructokinase</i> | Fructose 2,6-bisphosphate, AMP | Citrate, ketone bodies, ATP | | Cortisol ↓ |
| Triacylglycerol synthesis | <i>Lipoprotein lipase</i> | (high VLDL, chylomicrons) | | | Insulin ↑ |
| | <i>Glycerol phosphate acyltransferase</i> | | (low glycerol phosphate levels) | | |
| Triacylglycerol breakdown | <i>Hormone-sensitive lipase</i> | | | Insulin ↓ Epinephrine ↑ | Insulin ↓ Cortisol ↑ |

Diabetes Mellitus: Type I

Insulin-dependent diabetes mellitus (IDDM)
 “Juvenile-onset” diabetes

Diabetic Ketoacidosis (DKA)

- Frequent urination (Polyuria) – Osmotic diuresis
- Extreme thirst (Polydipsia)
- Extreme hunger (Polyphagia)
- Peripheral neuropathy
- Weakness
- Kussmaul respiration
- Vision alterations



Diabetes Mellitus: Type II

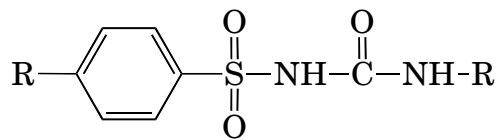
Non-insulin-dependent diabetes mellitus (NIDDM)

“Adult-onset” diabetes

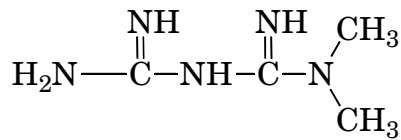
Hyperglycemic HyperOsmotic Non-Ketotic Coma

(HONK)

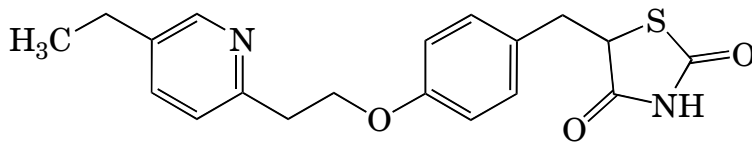
Oral Antihyperglycemic Drugs



Sulfonylurea

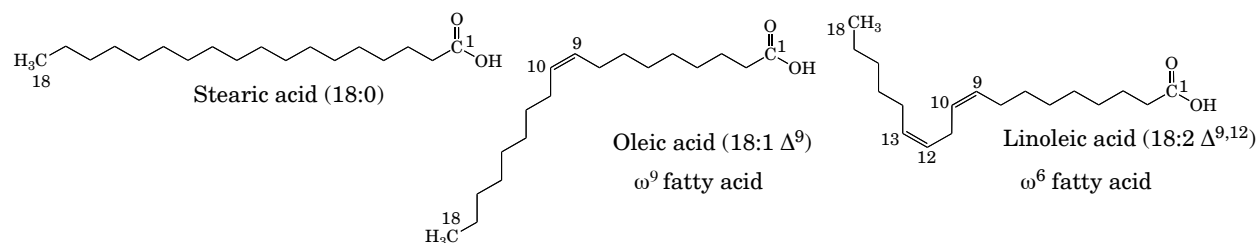


Biguanide
(metformin)

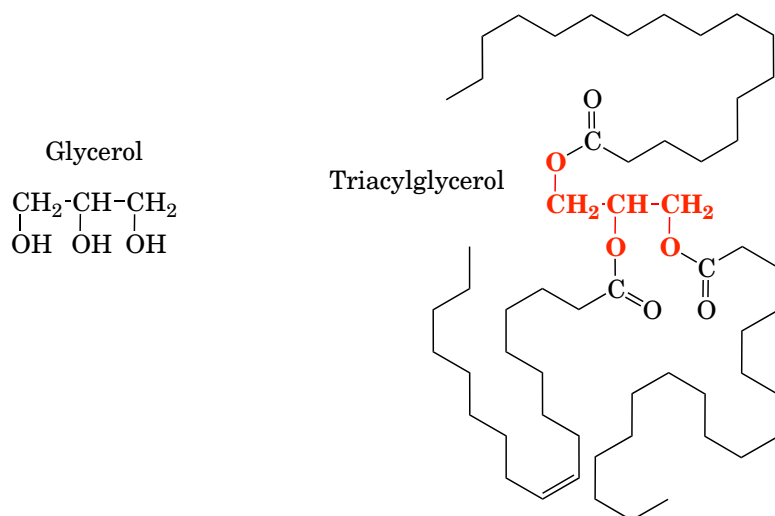


Thiazolidinedione
(pioglitazone)

Fatty Acid and Related Lipid Nomenclature and Properties

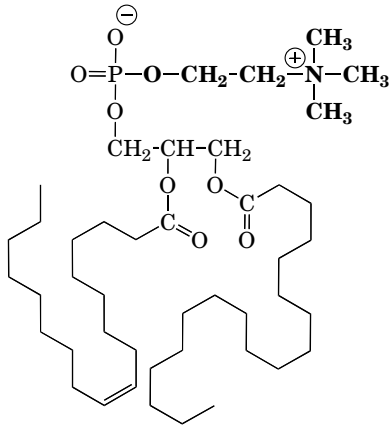


| Number of Carbons | Name | Symbol | Structure | Melting Point (°C) |
|-------------------|----------------------------------|---------------------------|---|--------------------|
| 12 | Lauric acid (dodecanoic acid) | 12:0 | $\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$ | 44 |
| 14 | Myristic acid | 14:0 | $\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$ | 53 |
| 16 | Palmitic acid | 16:0 | $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ | 63 |
| 18 | Stearic acid | 18:0 | $\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$ | 70 |
| 16 | Palmitoleic acid | 16:1 Δ^9 | $\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ | -0.5 |
| 18 | Oleic acid | 18:1 Δ^9 | $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ | 13 |
| 18 | Linoleic acid | 18:2 $\Delta^{9,12}$ | | -5 |
| 18 | α -Linolenic acid | 18:3 $\Delta^{9,12,15}$ | | -11 |
| 18 | γ -Linolenic acid | 18:3 $\Delta^{6,9,12}$ | | -11 |
| 20 | Arachidonic acid | 20:4 $\Delta^{5,8,11,14}$ | | -50 |

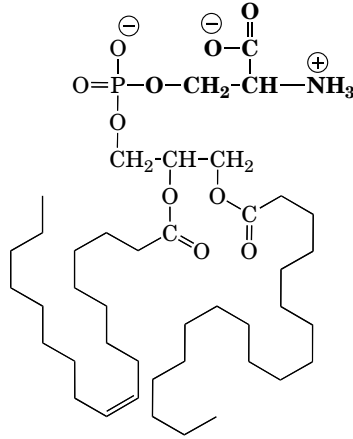


Membrane Lipids

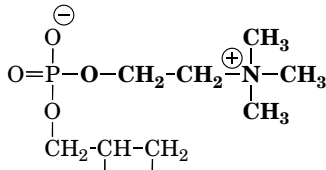
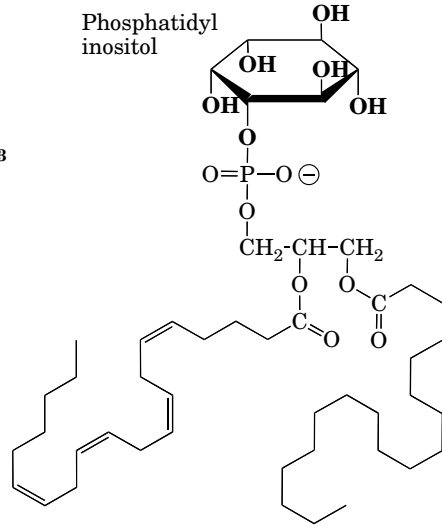
Phosphatidylcholine



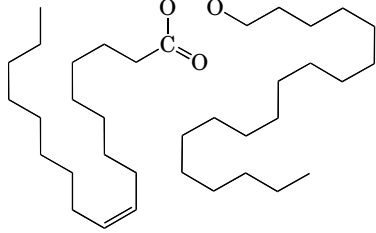
Phosphatidylserine



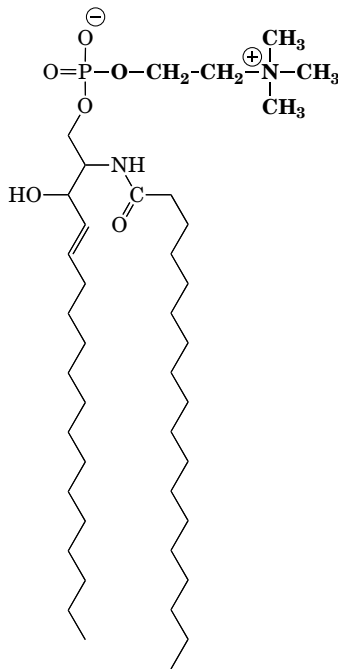
Phosphatidyl inositol



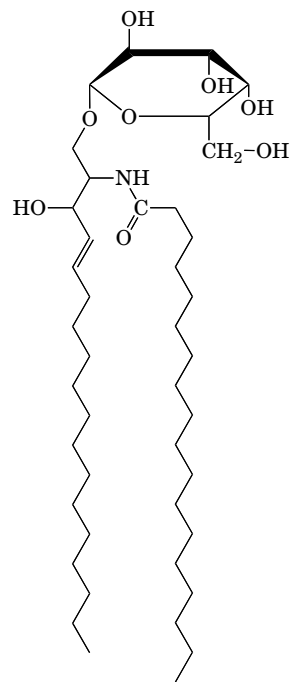
Ether phosphatidylcholine
(1-alkyl, 2-acyl phosphatidylcholine)



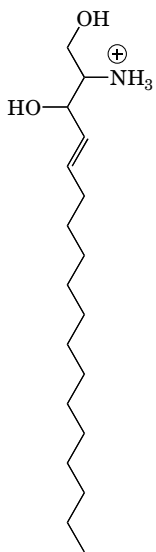
Sphingomyelin



Cerebroside



Sphingosine



Ceramide

