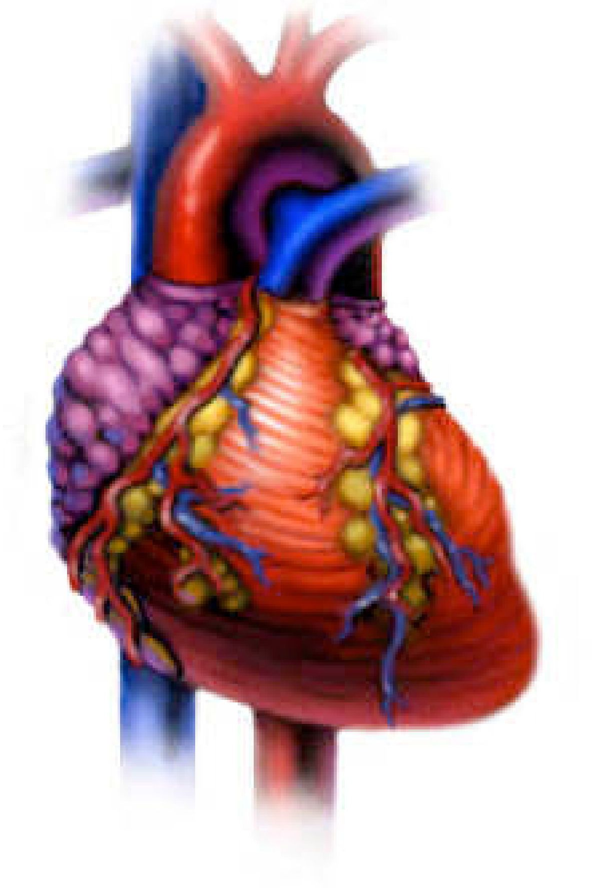
Metabolic Characteristics of the Major Organs and Tissues

The Heart



The heart contains almost no stored energy (glycogen, triacylglycerol).

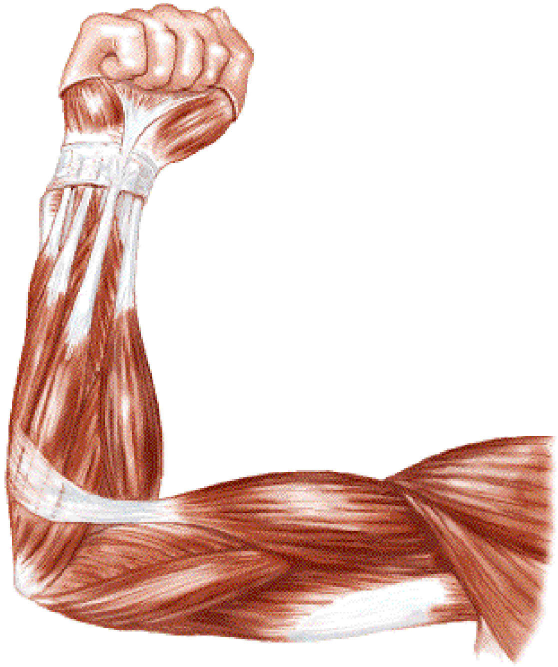
The heart can use a variety of metabolic fuels (glucose, fatty acids, lactate, and ketone bodies) but most of its energy comes from the oxidation of fatty acids.

About 50% of a heart cell's volume is taken up by mitochondria which supply a constant source of energy to the beating heart muscle.

Unlike skeletal muscle, heart muscle cannot function anaerobically, even for a short time.

Interruption of the flow of oxygenated blood to the heart results almost immediately in cell death leading to a **myocardial infarction** (heart attack).

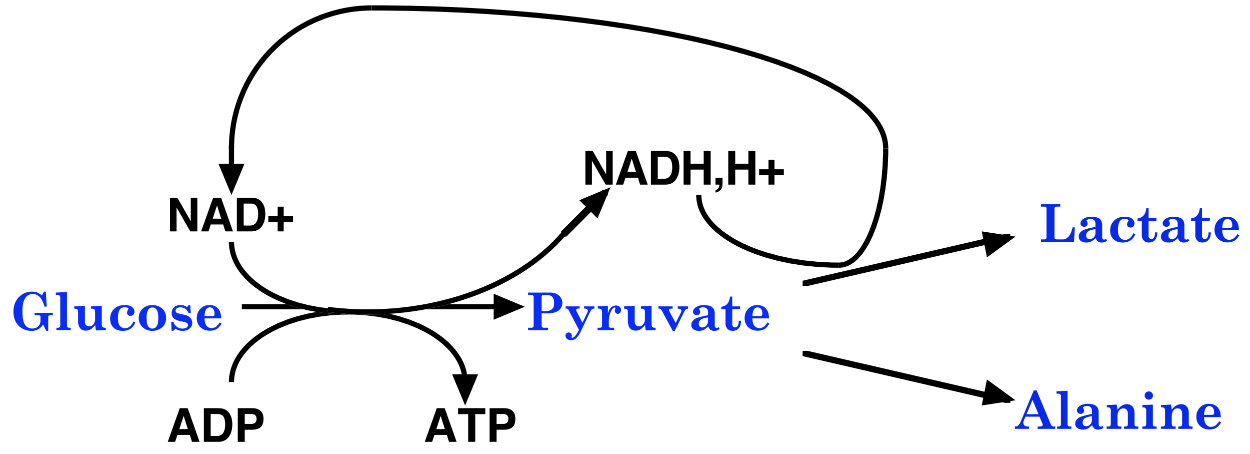
Skeletal Muscle



Muscle can utilize **several fuels**, but the choice depends upon the degree of activity of the muscle.

At rest, the principle energy source is **fatty acid oxidation**.

Upon exertion, **glycogen reserves** are mobilized to supply glucose to the glycolytic pathway. The glycolytic pathway is capable of supplying energy at a much faster rate than the oxidation of fatty acids or of pyruvate.



The end product of glycolysis under conditions of muscular exertion is **lactic acid**, which accumulates in the muscles and is released into the blood.

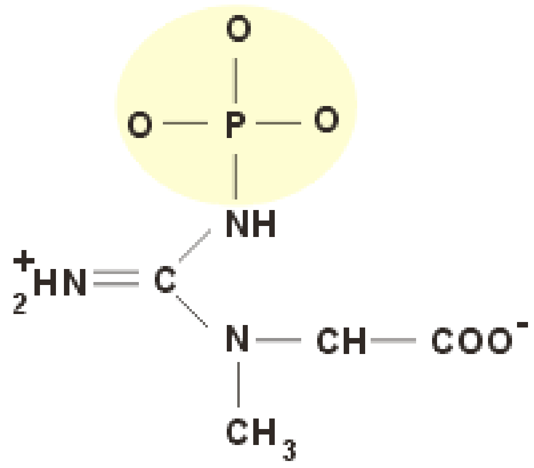
In addition, **excess pyruvate** is transaminated to alanine which is also released into the blood.

The **lactate and alanine** are transported to the liver where they are converted into glucose through gluconeogenesis.

The glucose is re-released into the blood for transport back to the muscles.

Creatine Phosphate

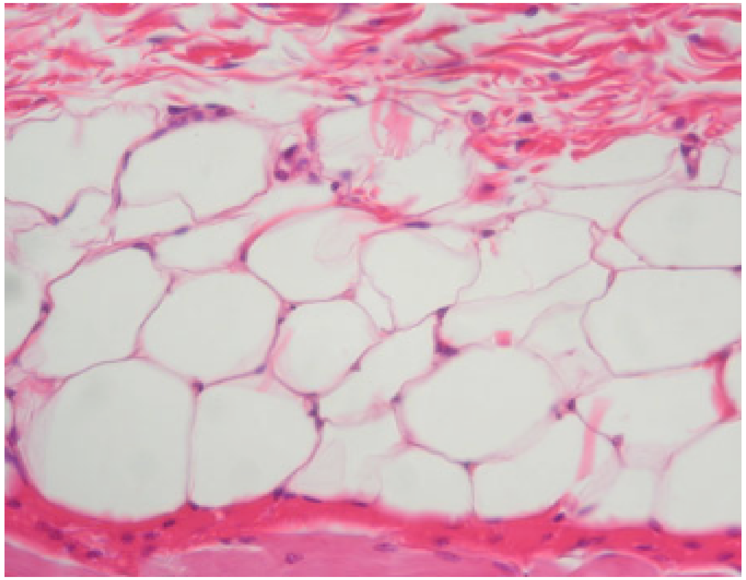
In addition to glycolysis and the citric acid cycle, muscles possess an energy storage depot, **creatine phosphate**.



Creatine phosphate can supply energy for short periods of extreme exertion by phosphorylating ADP:

ATP + H_2O → ADP + P_i + energy	(muscular exertion)
ADP + CP → ATP + C	(rephosphorylation)
CP + H_2O → C + P_i + energy	(overall reaction)

Adipose Tissue



The cells in adipose tissue are called **adipocytes**.

A 70 kg human male is about 17% triacylglycerol, stored in adipose tissue. This represents 110,000 kcal of stored energy, or enough to sustain life for a few months.

When chylomicrons from the intestines reach adipocytes, **lipoprotein lipase** on the adipocyte cell surface liberates fatty acids. These fatty acids either bind to serum albumin for transport to other tissues or are absorbed into the adipocyte for storage.

Lipid Components in the Blood

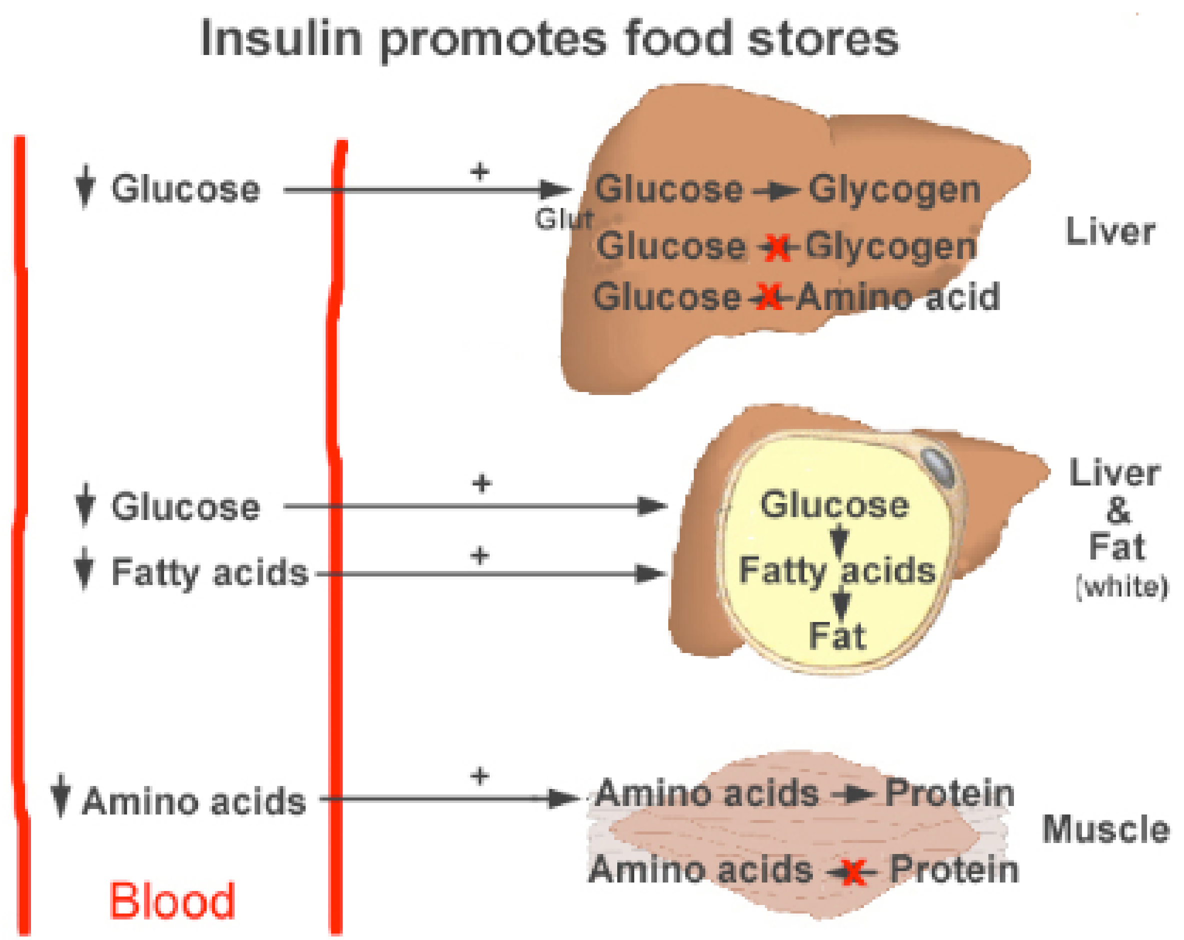
Free fatty acids released from the adipocytes combine with serum albumin in the blood to form soluble complexes (**lipoproteins**) which are transported to the peripheral tissues.

The **glycerol component** of the triacylglycerols is also released into the blood and travels to the liver where it is converted into glucose through gluconeogenesis.

The synthesis of triacylglycerols is dependent upon a supply of **glycerol-3-phosphate**. This molecule is obtained from the reduction of dihydroxyacetone phosphate, a glycolytic intermediate.

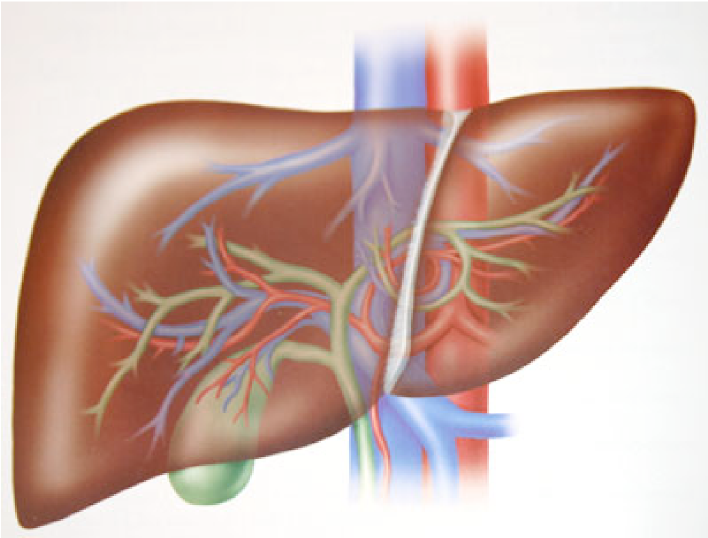
Insulin

Insulin stimulates the uptake of glucose, as well as fatty acids, in adipocytes, and triacylglycerol synthesis will take place as long as the blood glucose supply is adequate.



The Liver

With the exception of triacylglycerols, all nutrients absorbed by the intestinal tract are transported directly to the liver where they are processed and distributed to other organs and tissues.

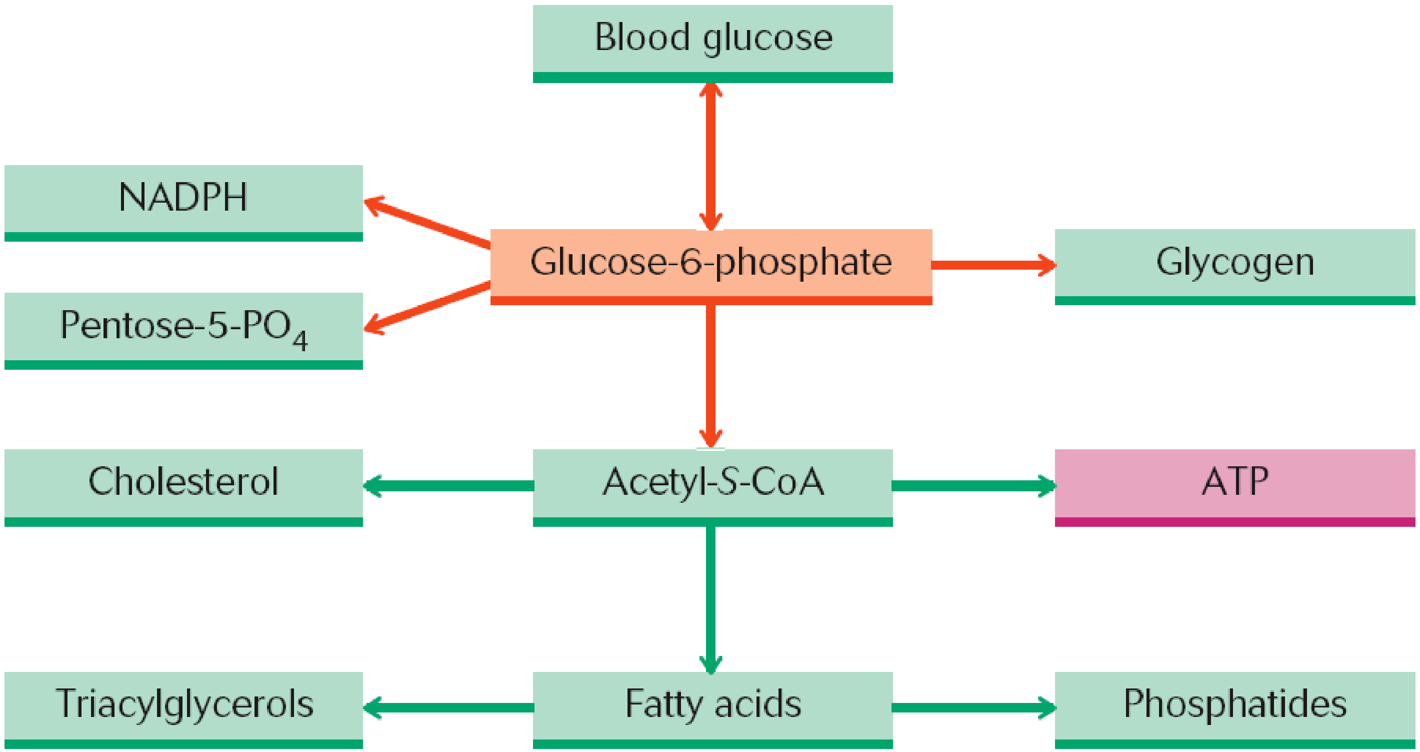


Glucose

After a high carbohydrate meal, the glucose-rich blood from the intestines is transported directly to the liver through the portal vein.

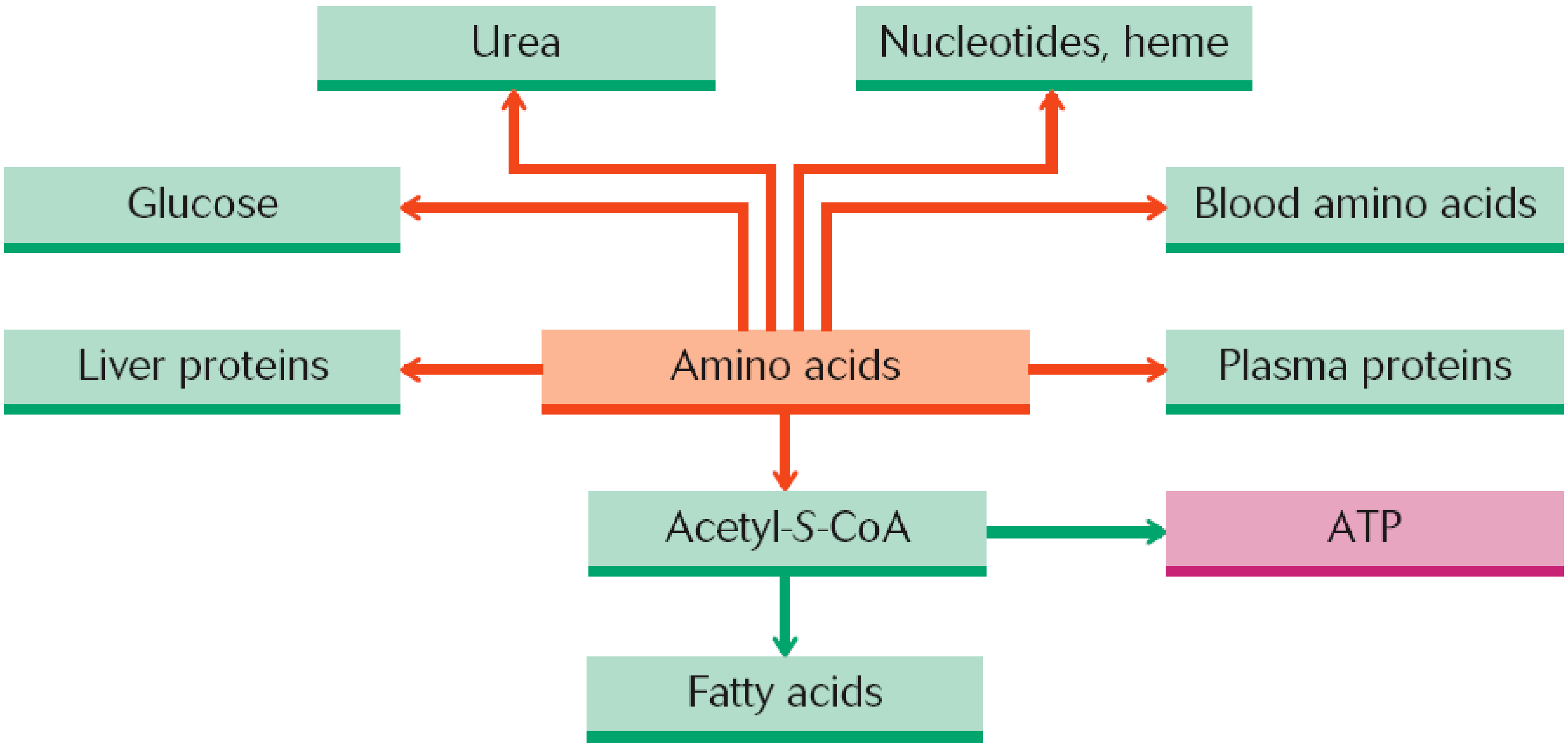
The liver has a form of hexokinase called **glucokinase** that only phosphorylates glucose to glucose-6-phosphate when the glucose concentration is high. At the normal blood glucose concentration of 5mM, glucokinase is inactive.

Glucose-6-phosphate is at the center of all the needs of the body's organs.



Amino acids

If amino acids enter the liver they may follow a number of metabolic pathways:



A significant portion of the amino acids entering the liver are used in **liver protein biosynthesis.**

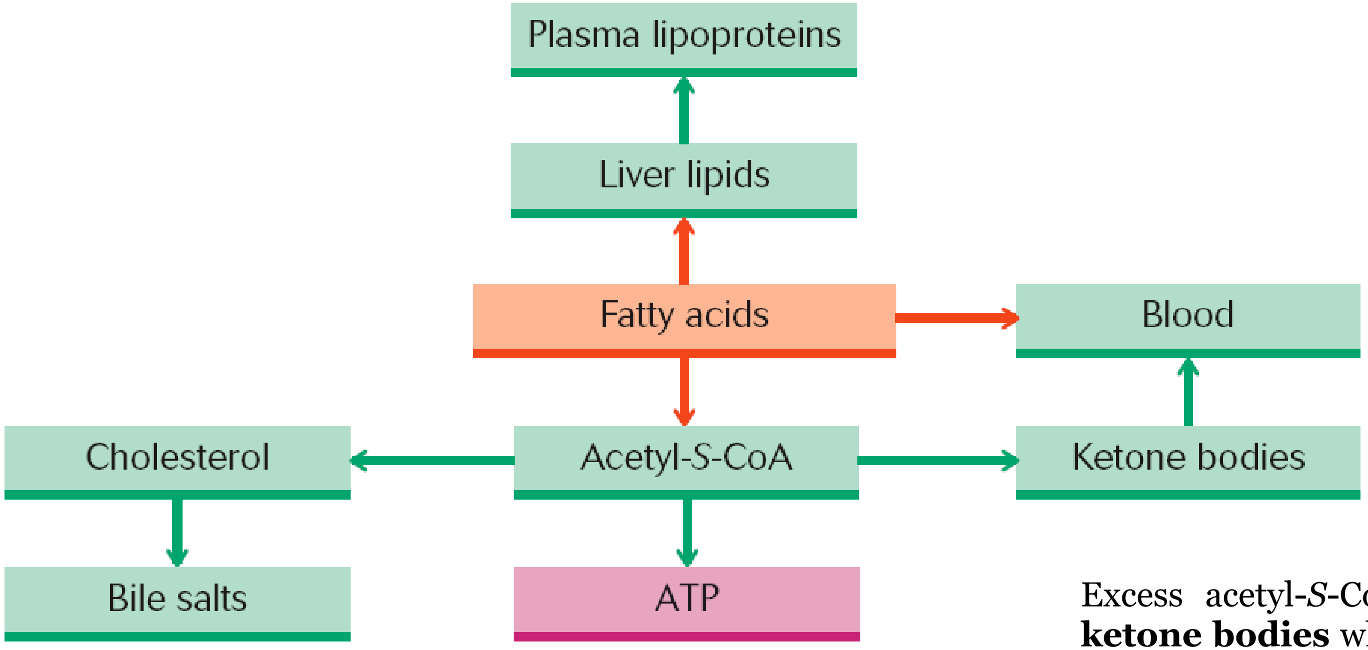
Another portion of amino acids is used to synthesize the **plasma proteins** of blood.

Excess amino acids are deaminated. The ammonium ions produced are converted into **urea**, and the **carbon skeletons** are oxidized to produce energy, or are converted into glucose through gluconeogenesis.

The liver is also part of the **glucose-alanine cycle**. Alanine from actively exercising muscles is absorbed from the blood by the liver and converted into glucose. This glucose is then released back into the blood where it can be reabsorbed by the muscles.

Fatty Acids

Plasma lipoproteins synthesized in the liver incorporate fatty acids into their structures. These lipoproteins transport dietary lipids to the adipose tissue for storage.



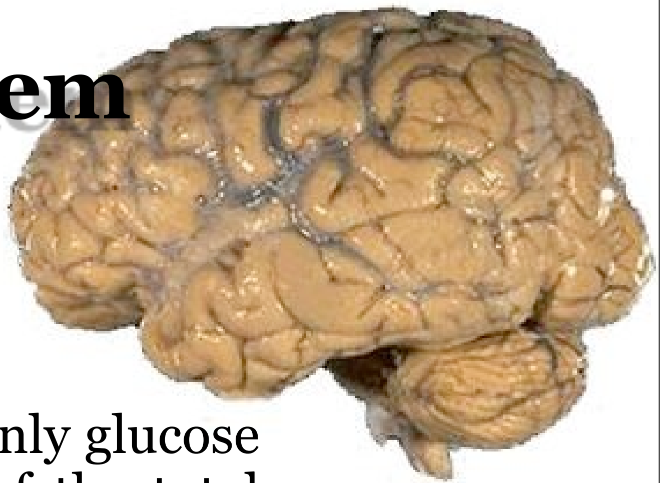
Excess acetyl-*S*-CoA is converted into **ketone bodies** which are exported into the blood for use by other tissues. Ketone bodies supply up to one third of the energy requirements of the heart.

Bile salts are synthesized in the liver from cholesterol, which in turn is synthesized from the acetyl-*S*-Co-A derived from fatty acids.

Fatty acids are the chief **oxidative fuel** of the liver. Fatty acids are converted into **acetyl-*S*-CoA** in the liver by β-**oxidation**

Acetyl-*S*-CoA is then oxidized to CO_2 and H_2O by the **citric acid cycle** and the electron transport chain.

The Brain and the Nervous System



The brain contains **no stored energy sources** and uses only glucose for its energy needs. The brain accounts for about 60% of the total resting human glucose consumption.

The brain also uses about 20% of the total resting oxygen consumption.

Because the **brain** contains no stored energy, it **must be constantly supplied with glucose and oxygen** from the circulating blood. The brain can suffer rapid irreversible loss of function when deprived of glucose, even for very short periods of time.

The brain can adapt to use **3-hydroxybutyrate** as an energy source under certain conditions, such as starvation.

The **absorption of glucose** by the brain **is not insulin dependent**. (*The absorption of glucose in diabetics is normal, provided that minimal blood glucose concentrations are maintained.*)