

2.2

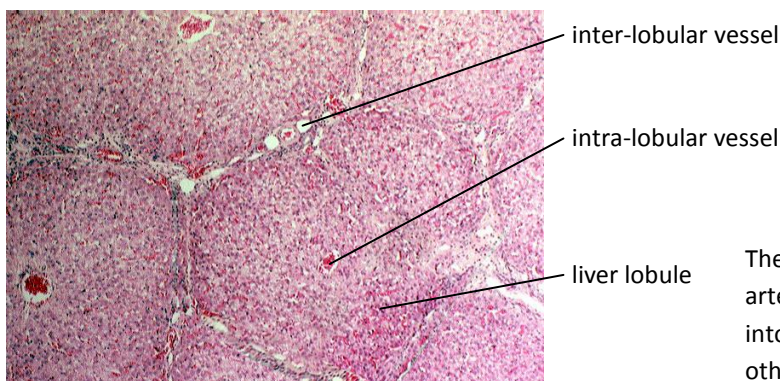
The liver

The histology and excretory functions of the liver

Structure of the liver

You will remember from the first unit of this module that the liver has fundamental roles in homeostasis. But **hepatocytes** (liver cells) actually carry out hundreds of metabolic functions beyond this. It is therefore essential that the organ has a rich blood supply to as many hepatocytes as possible, and the liver really does have many secure connections to the blood system. The liver receives, oddly, *oxygenated* blood from the heart (via the **hepatic artery**) and *deoxygenated* blood from the digestive system. The deoxygenated blood enters the liver through the **hepatic portal vein**. This blood supplied is rich in the products of digestion, and may contain toxic substances that have been absorbed in the intestine.

Blood leaves the liver through the **hepatic vein** which rejoins the vena cava and returns to normal circulation. There is also the **bile duct** leaving the liver, where **bile** is secreted. This has both digestive and excretory functions. The bile duct runs from the liver to the gall bladder, where bile is stored until needed for digestion.



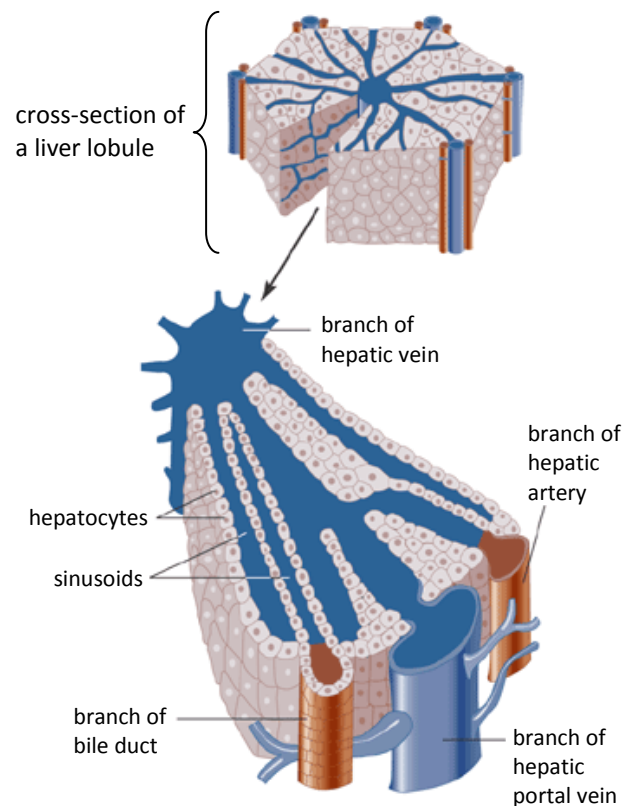
The arrangement of cells within the liver has been adapted so that each cell has optimal blood supply from adjacent blood vessels, aided further by the supply of blood from two different sources. The liver is divided into **lobes** which are further divided into small **lobules**.

The vessels of the hepatic portal vein and hepatic artery, both of which supply the liver with blood, split into smaller and smaller vessels, and run alongside other vessels called **inter-lobular vessels**.

At intervals, branches of the hepatic portal vein and the hepatic artery meet, entering lobules, where the fluid from each is mixed inside specialised chambers called **sinusoids** (the diagram below shows these chambers which allow the fluids to mix). The sinusoids, lined by regular hepatocytes, end up draining into **intra-lobular vessels** within the lobule. This intra-lobular vessel is a branch of the hepatic vein. These branches all join together at the main hepatic vein vessel, where the fluid is drained and leaves the liver to return to normal circulation.

Blood flowing along the sinusoids is in close contact with the hepatocytes lining the walls, and these cells can pass molecules into the blood, as well as remove molecules from the blood as it flows past. These hepatocytes have many **microvilli** on their surface for increased surface area for exchange.

Inside the sinusoids you can find **Kupffer cells**, which are specialised *macrophages* moving about within sinusoids. They are involved with the breakdown and recycling of erythrocytes (or red blood cells). One of the materials produced as a result of haemoglobin breakdown is **billirubin**, which is excreted as part of the bile, and also in faeces – this is the brown coloured pigment in faeces.



CAREFUL: not to confuse the four vessels involved here. The hepatic artery, hepatic portal vein, hepatic vein and the bile duct are all connected to the liver and have very different functions

Functions of the liver

As mentioned before, the liver has a large number of functions, and these include:

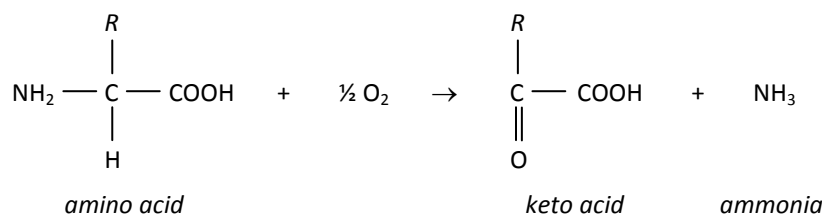
- detoxification – removing toxins from the blood (for example, alcohol)
- storage (for example of glucagon, glycogen and vitamins)
- production of bile and the breakdown of old red blood cells
- synthesis of plasma proteins, cholesterol and erythrocytes in the foetus
- deamination and the formation of urea

Formation of urea

The body needs proteins to function, but at any one time it is easily possible that protein intake exceeds that of their requirements. When this occurs the excess amino acids from proteins which we do not need cannot be stored, because their **amine groups** make them toxic. But as they contain a lot of energy, rather than excrete the entire molecule, the molecule is modified under two processes so that the amine component can be excreted alone.

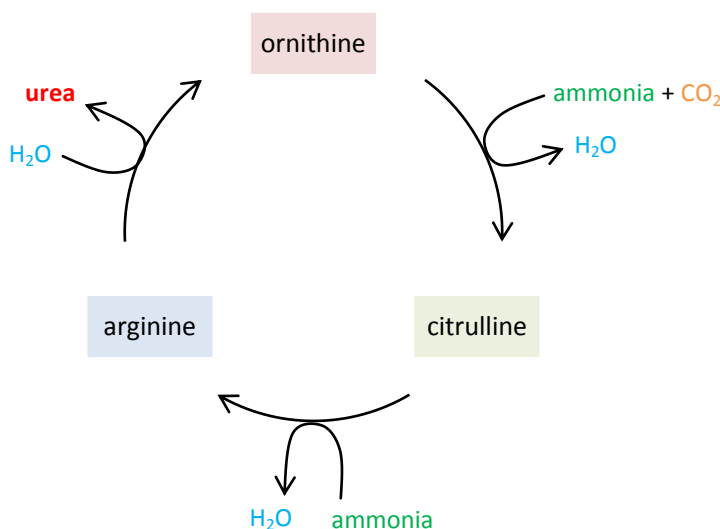
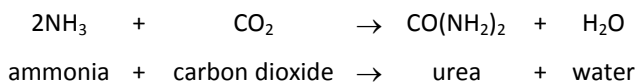
Deamination

This is the removal of the amine group from an amino acid. **Deamination** produces the compound **ammonia**, which again is very toxic and so mustn't be allowed to accumulate. Another by-product of the process is **keto acid**, an organic compound which directly enters the mitochondrion and is respired aerobically.



Ornithine cycle

The **ornithine cycle** is the second process. Ammonia is very soluble and very toxic, so it needs to be converted into a much less harmful substance very quickly. The ammonia is combined with carbon dioxide to produce **urea** in the ornithine cycle. The ornithine cycle can be summarised as below on the left, and the diagram also the full cycle.



Detoxification of alcohol

The liver is able to **detoxify** many harmful substances, that is to convert toxic molecules into less toxic or non-toxic molecules. Alcohol and drugs can be detoxified in the liver. Hepatocytes are filled with enzymes which have detoxification functions, such as *catalase*, which converts hydrogen peroxide (very toxic) into water and oxygen.

Alcohol (**ethanol**) is broken down in the liver using the enzyme **ethanol dehydrogenase** to produce **ethanal**, which is broken down using **ethanal dehydrogenase** into **ethanoic acid**. This end product combines with coenzyme-A to produce **acetyl coenzyme-A** which can be directly respired (used in the link reaction – see 4.3 Krebs cycle). The hydrogen atoms released in this reaction can also combine with a molecule of NAD to produce reduced NAD. The diagram below outlines this process:

