Liver – Functions of energy metabolism (stores glycogen, releases glucose, absorbs fats & fat soluble vitamins, produces cholesterol), detoxification (including bilirubin) & synthesis of plasma proteins in blood (clotting factors, albumin, binding proteins) and for secretion of bile in the gut. The liver has blind ended bile canals and hepatic sinusoids, which are both in contact with hepatocytes. Blood from the hepatic portal vein enters the sinusoids, such that blood can be filtered and drains into the central vein. Bile is secreted into canaliculi by hepatocytes and flow to a branch of the bile duct (bile is thrombogenic so separation from blood is important).

Bile
Bile has bile acids for digestion & absorption of fats and alkaline juice for neutralisation. It is also a route of excretion of GI products.

- **Bile Acid Dependent Component** – Secreted into canaliculi by hepatocytes, contains:
  - **Bile Acids** – Cholesterol derived molecules that are conjugated to amino acids and travel in bile as micelles. These are needed for digestion & absorption of fat. After fatty acids are absorbed these are released into the lumen and travel to the terminal ileum where they are actively absorbed into the epithelia to return in hepatic portal blood to hepatic sinusoids to be secreted into canaliculi. Most bile acids are recovered to go round in the enterohepatic circulation, however some are unconjugated by bacterial action in the gut and are lost, and are replaced by hepatocytes which synthesise new ones.
  - **Gall Bladder** – Sphincters in the biliary system cause backflow of bile such that it enters and is stored in the gall bladder. The gall bladder epithelium secretes sodium & water to concentrate the bile, this however increases risk of gall stones; these can cause biliary colic or obstruction. CCK is released by the duodenum in response to gastric emptying and stimulates the contraction of the gall bladder muscle thus ejecting concentrated bile acids.
  - **Bile Pigments** – Excretory products (e.g. bilirubin) which are excreted in the faeces
- **Bile Acid Independent Component** – Alkaline juice (HCO₃⁻) secreted by cells lining intra-hepatic bile ducts.

Digestion of Fat – Bile acids emulsify fat into smaller globules which increases their surface area for lipases (linked to bile acids by colipase) to act upon. Released fatty acids form micelles, with polar groups of bile acids on the outside and hydrophobic fatty acids within. Micelles are a way to carry hydrophobic molecules through the ‘unstirred mucous layer’ into epithelial cells. Fatty acids are released slowly into cells where they are re-synthesised to lipids and exported to lymphatics as chylomicrons.

Intestines

The intestines receive the chyme that is conditioned in the duodenum and absorb nutrients, water & electrolytes from it. Absorption requires a large surface area & slow movement through it.

Small Intestines
Mucosa is folded into villi and has microvilli on the luminal surface which greatly increase the surface area by producing a brush border. Cells on villi secrete enzymes into the unstirred layer on the brush border through which absorption is slowed & trapped enzymes complete digestion, steadily releasing small molecules for absorption.

Glucose enters mucosal cells via Na⁺/glucose transporter (SGLT1) which also transports galactose; glucose leaves the cell to the extracellular fluid via facilitated diffusion in the GLUT2 transporter. The uptake of Na⁺ with glucose generates an osmotic gradient which water follows; this is the concept of oral rehydration fluid which is a mixture of glucose, salt & water.

Proteins are digested to oligopeptides in the stomach by pepsin and in the duodenum in which by pepsidases released by the pancreas. The brush border breaks down oligopeptides further

Steatorrhoea – Inadequate secretion of bile acids or pancreatic enzymes leads to fat appearing in faeces which are pale, floating & foul smelling; with anaemia is a sign of malabsorption, syndromes such as coeliac disease, chronic pancreatitis and following a gastrectomy.