



Ask Weber Session 2 (01-04-2021)

Weber Liu



THE UNIVERSITY OF
SYDNEY

Topic 8

Excretion



THE UNIVERSITY OF
SYDNEY

Function of the kidney

The Kidney – Removers of waste, maintainers of balance

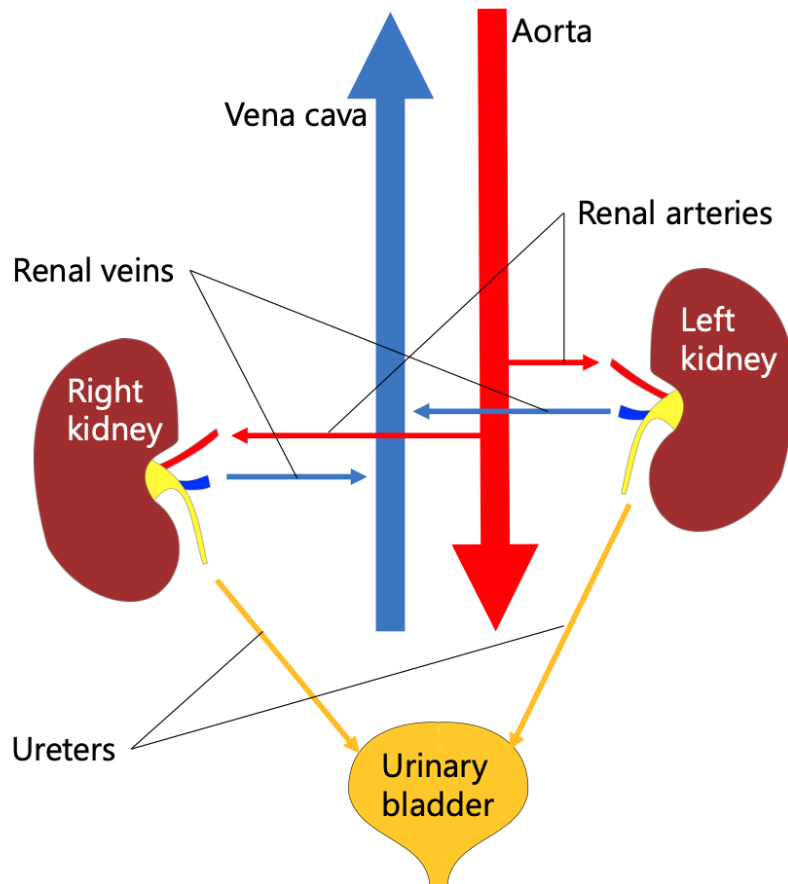
'Renal' – Pertaining to the kidney

- Maintaining extracellular fluid composition and volume
 - Maintaining mass balance/clearance
 - Filtration followed by reabsorption
 - Secretion of some waste products
 - Produce some hormones (erythropoietin)
-
- ***The kidneys together filter about 180 litres of fluid a day***

1. What are 3 functions of the kidney?

- a) Maintain electrolyte balance
- b) Maintain fluid balance
- c) Hormone production (E.g. EPO)
- d) Waste secretion

Anatomy of the kidney



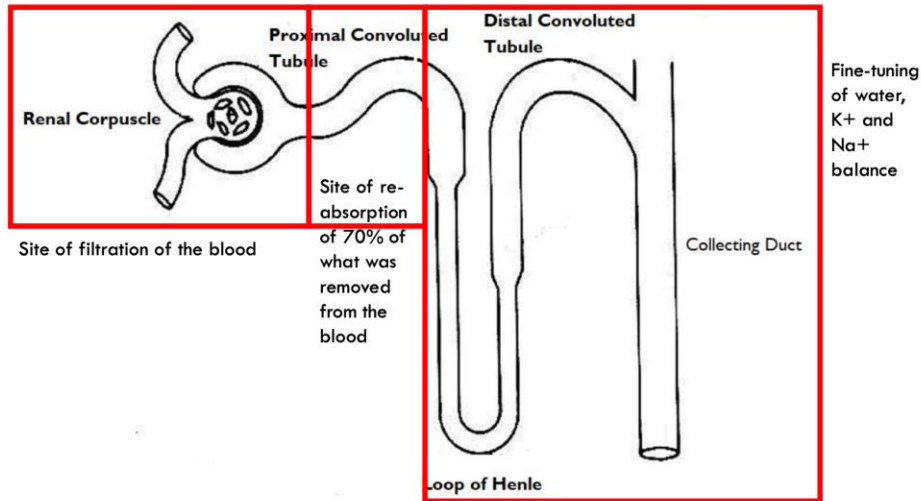
1. Where does fluid leave the kidney and where do these connect to?

- a) Blood – leaves via renal veins (connects to inferior vena cava)
- b) Urine – leaves via the URETERS (connects to the bladder)

2. Is the left renal vein longer or shorter than the right renal vein?

- 1. Left renal vein is longer because it has to cross the midline (and aorta) to reach the IVC

Renal anatomy 2



1. What is the name of the functional unit of the kidney?

a) Nephron

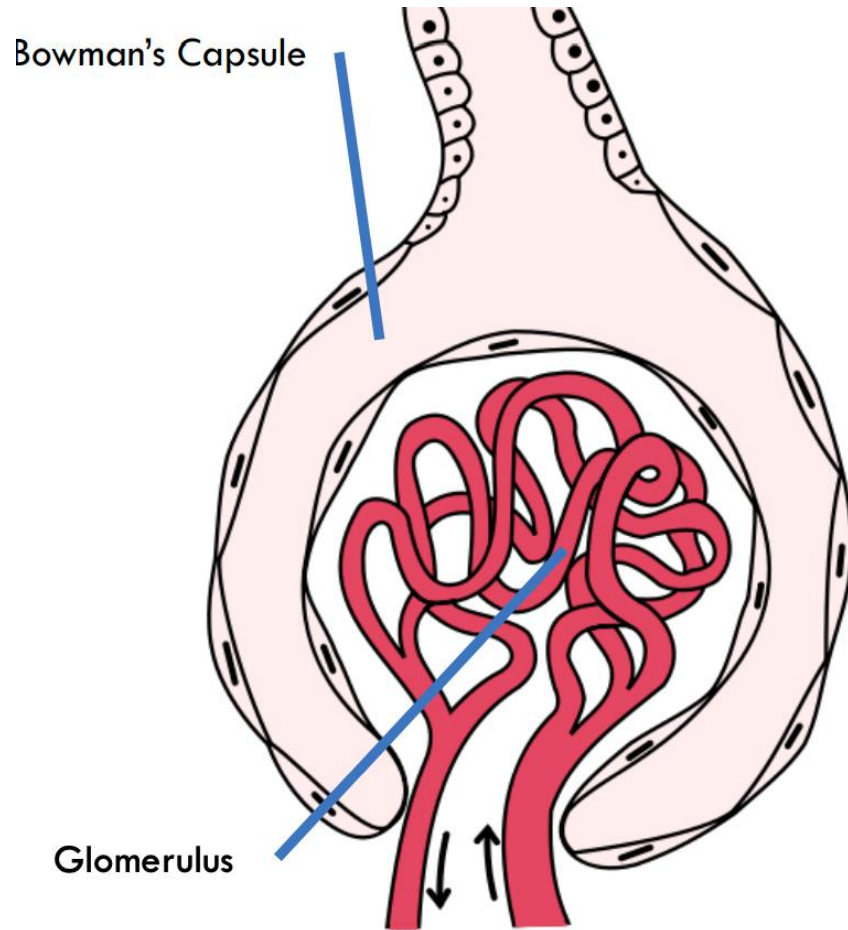
2. What is the component of the functional unit which transfers ultrafiltrate from the blood?

a) Glomerulus/renal corpuscle

3. Which component of the functional unit resorbs the majority of the ultrafiltrate back into the blood?

a) Proximal convoluted tubule

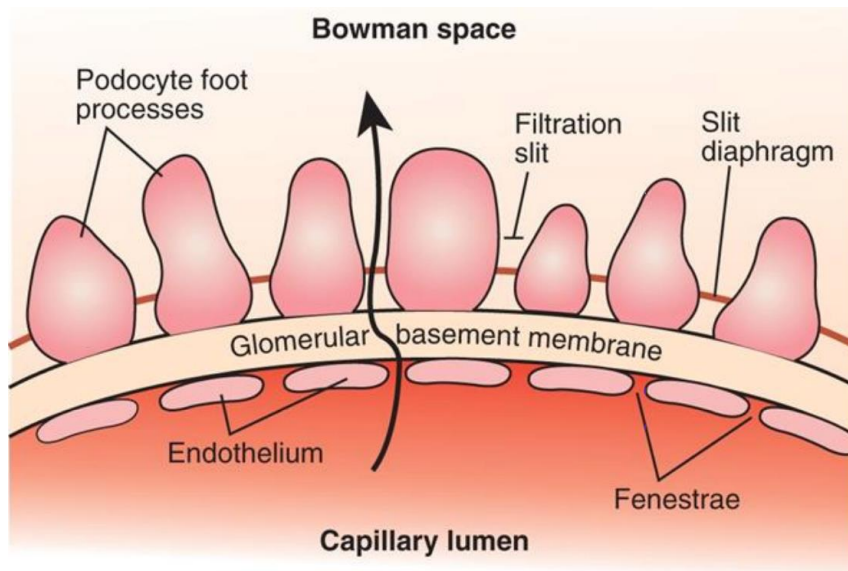
Renal anatomy



1. What 2 components make up the renal corpuscle?

- a) Glomerulus
- b) Bowman's capsule

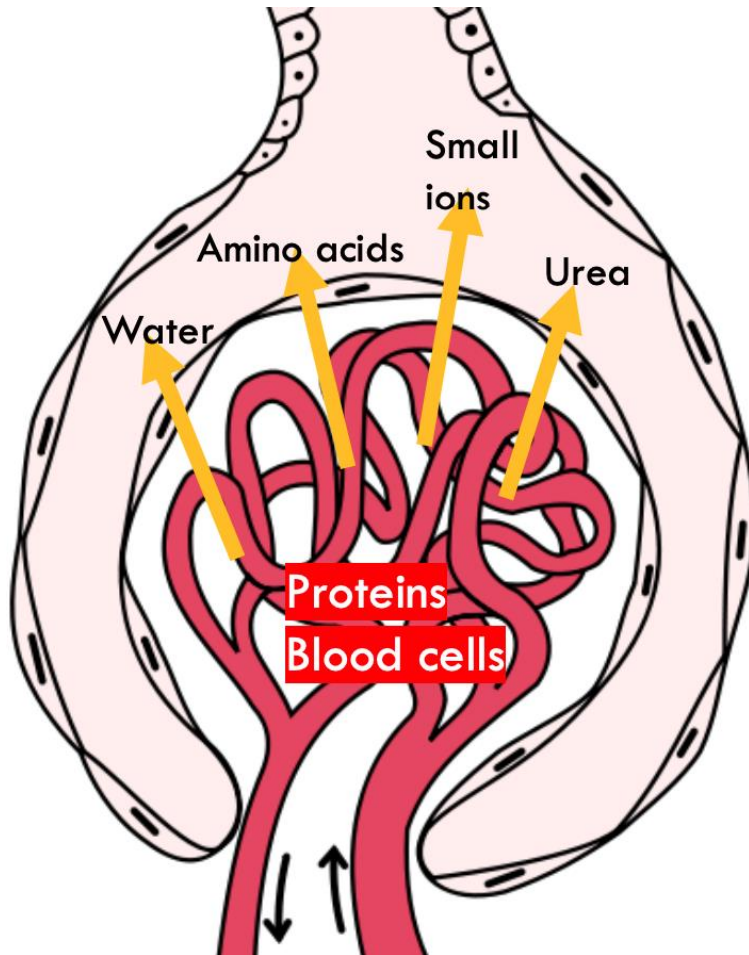
More renal anatomy



1. What are the 3 layers that blood plasma has to cross through in order to become ultrafiltrate at the renal corpuscle?

- a) Endothelium
- b) GBM (glomerular basement membrane)
- c) Podocyte foot processes

Renal physiology?



1. In most individuals, there is a small degree of protein in the urine, otherwise called the 'Tam Horsfall Protein'. This is present in the normal population. Where do you think this protein comes from?
 - a) Tam Horsfall proteins can be formed from sloughing of cells WITHIN the nephron. Remember – proteins normally do not pass through the renal corpuscle from blood into ultrafiltrate!

Renal physiology

The Kidney – Nephron – Measuring Glomerular Filtration Rate

Essentially a test of how much filtering the kidney is doing

2 common tests:

Inulin – plant carbohydrate – not reabsorbed at all by the kidney

Creatinine – muscle breakdown byproduct – not reabsorbed (and actually actively secreted a little)

$$\text{GFR} = \frac{\text{concentration in urine} \times \text{urine flow rate (mL/min)}}{\text{concentration in blood}}$$



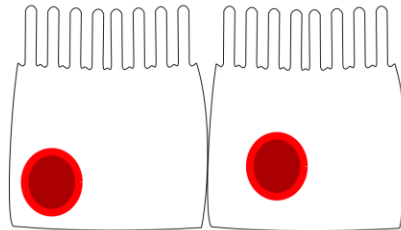
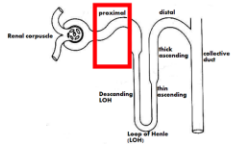
1. Clinically, patients who come in and get blood tests will generally have their serum creatinine levels measured. If there is a high serum creatinine (in an otherwise normal body weight, muscle size) 25 year old male with a history of lupus nephritis, what would this indicate regarding his kidneys?
 1. High serum creatinine means creatinine is not being removed enough by the kidneys – this could indicate a reduced kidney function.
 2. Inulin is generally not used as this is not naturally created
 3. Serum creatinine is used to ESTIMATE glomerular filtration rate (hence eGFR)

Renal physiology

The Kidney – Nephron – Proximal Convoluted Tubule

Lined with cells covered in microvilli

Main site of re-absorption most solutes (glucose, Na^+ , amino acids, vitamins, bicarbonate)



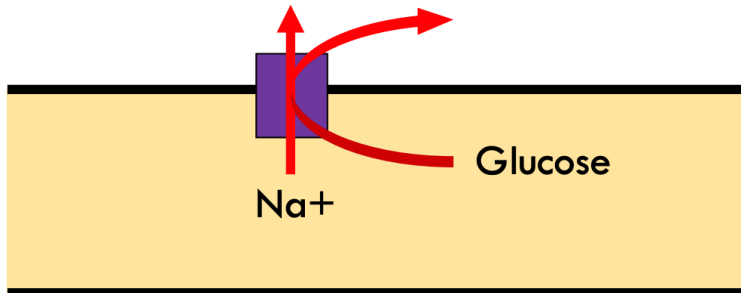
1. Where in the kidney would you find an SGLT2 transporter?

1. PCT is main area of glucose absorption

2. Acetazolamide is a carbonic anhydrase inhibitor – it is a medication used to reduce formation of HCO_3^- . As such, it can also inhibit the resorption of HCO_3^- . Where in the kidney would this drug have the largest effect?

1. PCT is main area of HCO_3^- (bicarbonate) absorption

More renal physiology



1. **Diabetic patients have a high chance of developing urinary tract infections compared to the normal population. This is because bacteria like sugary environments (acts as a source of energy). Why is it that a diabetic patient might have more sugar in their urine?**
 - a) Glucose is resorbed from ultrafiltrate at the PCT. As diabetics have poorer insulin control, their blood sugar rises. This results in more sugar in the ultrafiltrate. This can result in saturation of the SGLT2 cotransporters, resulting in not all the glucose being returned to circulation. This doesn't happen in the normal population due to lower levels of blood sugar.

Renal physiology just never ends

The Kidney – Hormonal Control

Aldosterone

- Produced by the adrenal gland (which sits on top of the kidney) in response to low blood pressure
- Increases re-absorption of **Na⁺ in the distal convoluted tubule and collecting duct**
- Therefore *increases* blood volume because water follows Na⁺ passively

When the body detects a low blood pressure, a system known as the RAAS (Renin-Angiotensin-Aldosterone-System) becomes activated. This is a series of biochemical/enzymatic reactions which results in the creation of aldosterone

1. Where is aldosterone produced

- a) Adrenal gland (Cortex)

2. Where does aldosterone function

- a) Distal convoluted tubule and collecting duct

3. What is the physiological effect of aldosterone

- a) Increases Na⁺ absorption by increasing # of ENaC apical end, increases NKA activity basolaterally; ENaC function potentials K-leak channels
- b) Absorption of Na⁺ from kidneys will result in an osmolar gradient, resulting in passive transcellular H₂O movement

Renal Physiology (or ?Pathophysiology)

The Kidney – Hormonal Control

Vasopressin (ADH)

- Produced by the hypothalamus in response to high solute concentration in the blood
- Increases re-absorption of **water** in the nephron collecting duct
- Therefore *increases* blood volume
- Alcohol inhibits its effect, caffeine inhibits its release

SIADH is a disorder in which ADH (Vasopressin) is inappropriately produced (hence named Syndrome of Inappropriate ADH).

1. Where is ADH produced

- a) Posterior pituitary

2. What is the stimulus to produce ADH

- a) Hypothalamic sampling of blood detects high serum osmolality (high solute concentration)

3. Where does ADH act

- a) Acts on the collecting duct

4. What does ADH do?

- a) Increases expression of AQP2 channels – results in the increased absorption of **PURE WATER** and increase the urine osmolality

Urine

Urea does not make urine yellow- urea is colourless

Urochrome- by-product of haemoglobin breakdown, originates in liver

1. **Blood recycles itself after 120 days and in the process it releases haemoglobin to be broken down into bilirubin. In this process, one of the intermediate products is water soluble and can be excreted by the kidneys. This product tends to make the urine coloured. What is the name of this product?**
 - a) Urochrome
 - b) Conjugated bilirubin can also be secreted but tends to occur when you have a jaundice (certain types) and isn't normally the compound causing most colouring of urine

Topic 8

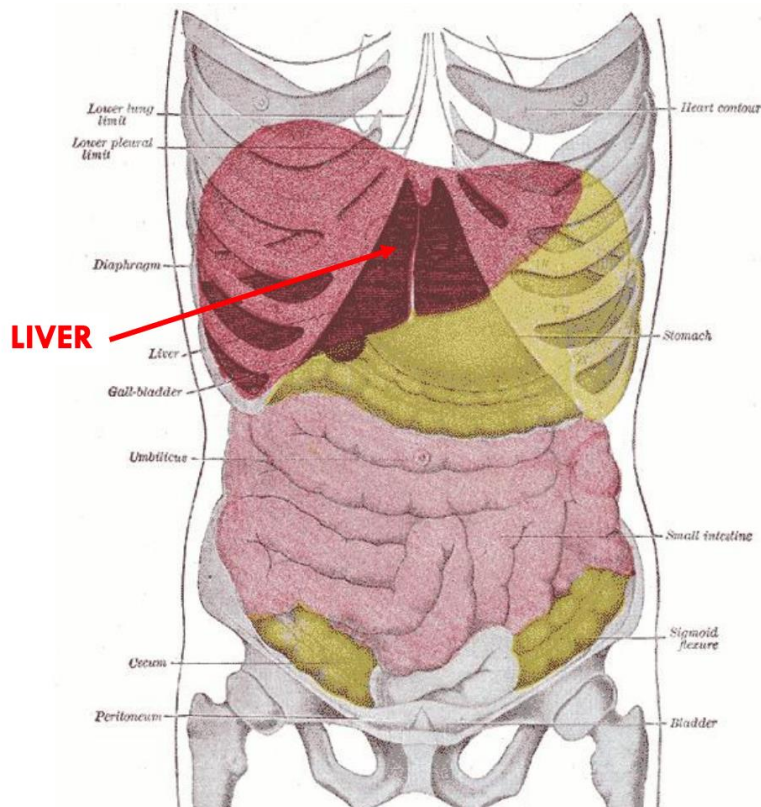
Detoxification

Function of the liver

1. What are the functions of the liver

- a) Maintains blood glucose
- b) Distributes cholesterol and triglycerides
- c) Manufactures plasma proteins
- d) Manufactures coagulation factors
- e) Produces proteins for iron and copper transport
- f) Acid-base balance
- g) Removes waste products
- h) Inactivates some neurotransmitters
- i) Synthesizes bile salts
- j) Filters/inactivates gut bacteria

Anatomy of the liver



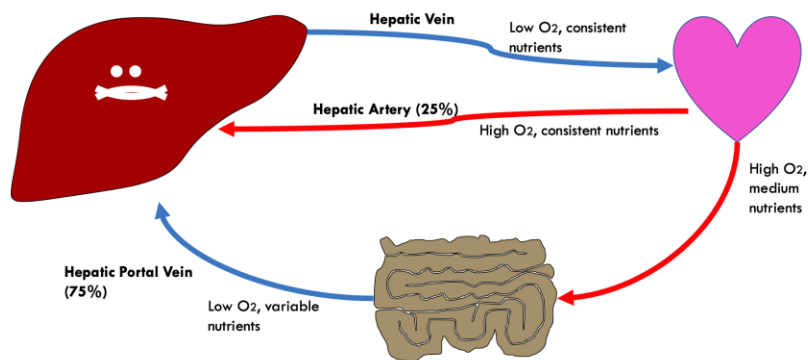
1. Is the liver a right-sided or left-sided organ predominantly?

1. Right sided

2. What muscular structure lies directly above the liver?

1. The diaphragm

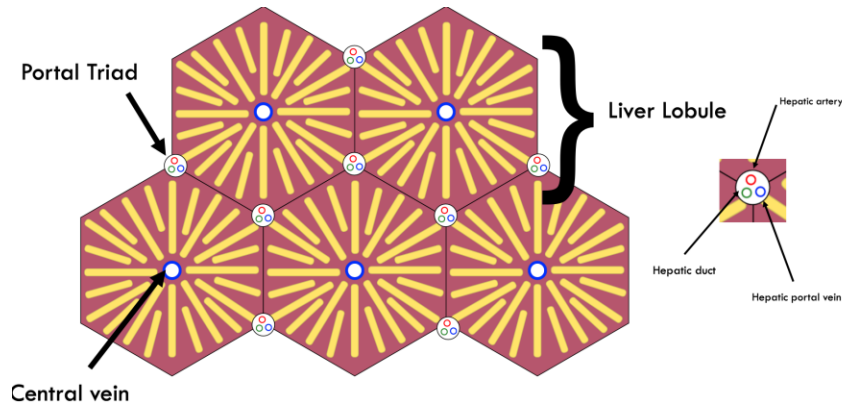
Anatomy of the liver



1. Describe the inputs and the outputs of the liver

1. Blood comes in (to supply the living tissue of the liver) via the Hepatic artery (25%)
2. Blood comes in (containing filterable material) via the Portal vein (75%)
3. Blood leaves the liver via the Hepatic veins (both cleared blood and depleted/used blood)
4. Obviously filtered toxins, etc. are excreted via the bile ducts (not in the figure as it is not a blood product)

Liver anatomy



1. Name the smallest functional unit of the liver

1. Hepatic lobule

2. What are the components of the portal triad?

1. Hepatic duct (connects to bile duct)
2. Hepatic artery
3. Hepatic portal vein

3. Which structure of the hepatic lobule connects to the hepatic vein?

1. Hepatic central vein

Liver physiology

- Albumin- blood protein mainly responsible for maintaining blood osmolarity
- Can also help transfer water-insoluble molecules



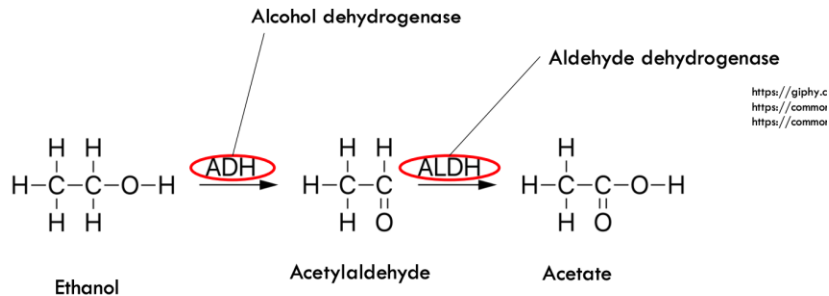
1. In situations of severe hepatic failure we see a process whereby patients become oedematous and ascitic due to reduced plasma oncotic pressure. Considering that hepatic failure is thought of when the 'liver fails' to do its job, what blood product do you think is mainly responsible for the ascites?
 1. Plasma albumin is produced by the liver – its depletion causes this.
2. Why do people with liver failure have a tendency to bleed?
 1. Reduced formation of coagulation factors

Liver physiology

1. Name 4 neurotransmitters which are inactivated by the liver

1. Serotonin
2. Oxytocin
3. Oestrogen
4. Testosterone

The liver and alcohol clearance



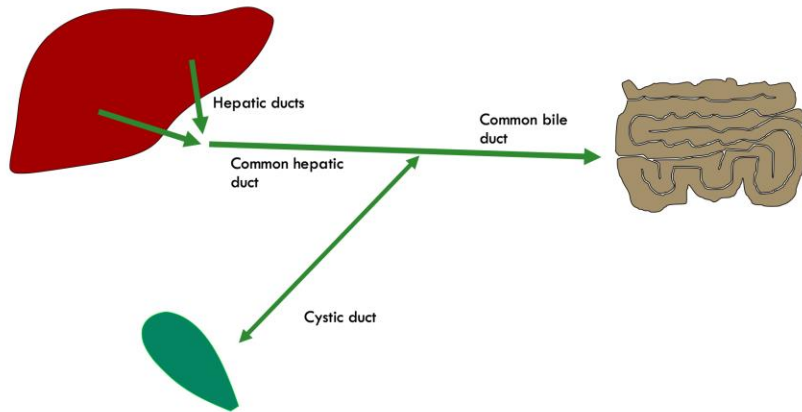
1. Which 2 enzymes are responsible for alcohol clearance?

- a) Alcohol dehydrogenase
- b) Aldehyde dehydrogenase

2. In the disorder commonly known as 'Asian flush' (otherwise known as a Disulfiram reaction) involves the buildup of a toxic metabolite of ethanol. What enzyme do you think is missing/underexpressed in Asians to cause this?

- a) Aldehyde dehydrogenase

Bile storage and function



1. Describe the flow of bile in the GIT

- Liver produces bile and it enters the hepatic ducts which join to the common hepatic duct
- This can be stored in the gallbladder (via cystic duct)
- Gallbladder contraction releases stored bile via cystic duct into common bile duct
- Common bile duct CAN join with the pancreatic duct (not in figure) and be secreted into the duodenum (small intestine) to be used in fat breakdown
- Bile can be recirculated and reabsorbed in the small intestine