OCR (B) Biology A-level

5.3.3 - Kidney function

Flashcards

What is excretion?

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Process of removing metabolic wastes (e.g. carbon dioxide & nitrogen-based by-products) to maintain metabolism.

Enables organisms to maintain pH balance & regulate osmotic pressure.

What happens to excess amino acids in the liver?

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Deamination forms ammonia & organic acids. Important because acids can be respired or converted into glycogen whereas excess amino acids cannot be stored.

Ammonia is detoxified and converted into urea by the addition of CO_2 in the ornithine cycle.

Describe the gross structure of the mammalian urinary system.

Describe the gross structure of the mammalian urinary system.

A: kidney

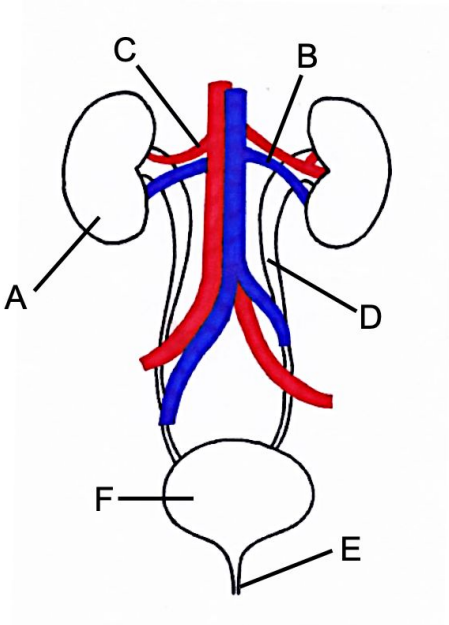
B: renal vein

C: renal artery

D: ureter

E: urethra

F: bladder



Describe the gross structure of a mammalian kidney.

Describe the gross structure of a mammalian kidney.

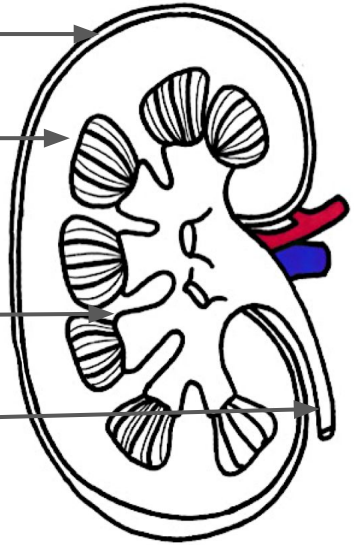
fibrous capsule: protects kidney

cortex: outer region consists of Bowman's capsules, convoluted tubules, blood vessels

renal pyramids: cone-shaped subdivisions

renal pelvis: funnel-shaped dilated section of ureter

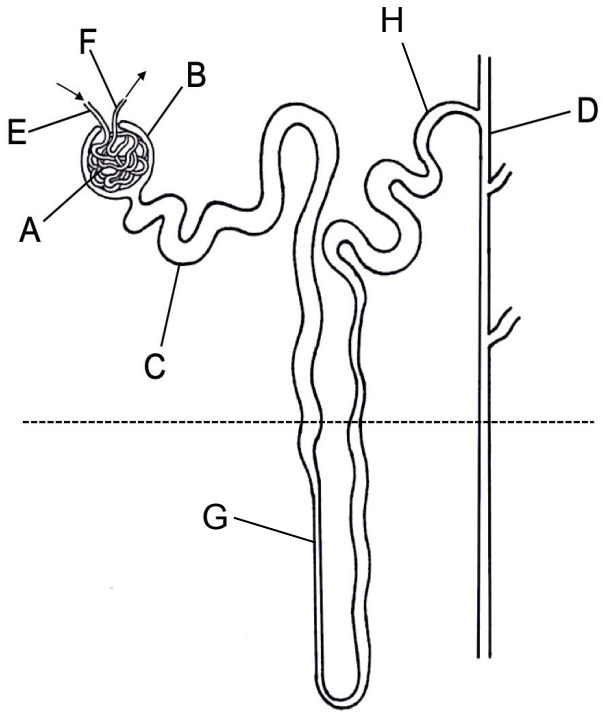
medulla: inner region consists of collecting ducts, loops of Henle, blood vessels



Describe the structure of a nephron.

Describe the structure of a nephron.

A: glomerulus
B: Bowman's capsule
C: proximal convoluted tubule
D: collecting duct
E: afferent arteriole
F: efferent arteriole
G: loop of Henle
H: distal convoluted tubule



Describe the blood vessels associated with a nephron.

Describe the blood vessels associated with a nephron.

Wide afferent arteriole from **renal artery** enters renal capsule & forms the **glomerulus**, a branched knot of capillaries which combine to form **narrow efferent arteriole**.

Efferent arteriole branches to form **capillary network** that surrounds tubules.

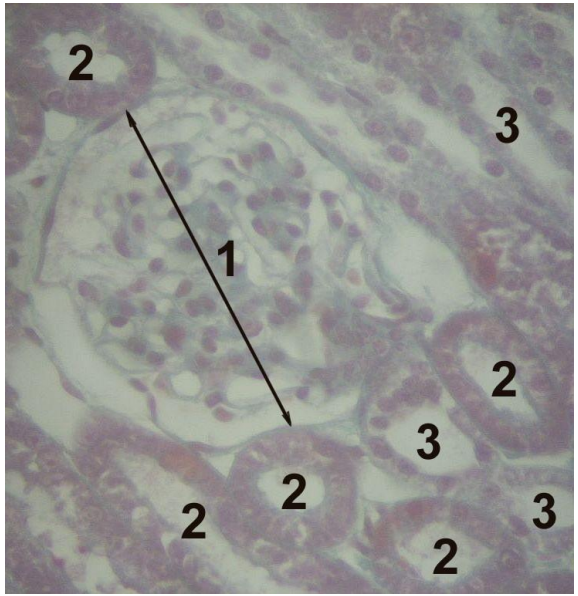
Describe the histology of the kidney.

Describe the histology of the kidney.

1: glomerulus

2: proximal tubule

3: distal tubule



Describe the sections of a nephron.

Describe the sections of a nephron.

Bowman's capsule at start of nephron: cup-shaped, surrounds glomerulus, inner layer of podocytes

Proximal convoluted tubule (PCT): series of loops surrounded by capillaries, walls made of epithelial cells with microvilli

Loop of Henle: hairpin loop extends from cortex into medulla

Distal convoluted tubule (DCT): similar to PCT but fewer capillaries

Collecting duct: DCT from several nephrons empty into collecting duct, which leads into pelvis of kidney

Describe the process of ultrafiltration.

Describe the process of ultrafiltration.

Occurs in **Bowman's capsule.**

High **hydrostatic pressure in glomerulus** (due to large lumen of afferent arteriole & smaller lumen of the efferent arteriole) forces small molecules (urea, water, glucose, ions) out of capillary fenestrations AGAINST osmotic gradient.

Basement membrane acts as filter. Blood cells & large molecules (e.g. proteins) remain in capillary.

How are cells of the Bowman's capsule adapted for ultrafiltration?

How are cells of the Bowman's capsule adapted for ultrafiltration?

- fenestrations between epithelial cells of capillaries
- fluid can pass between & under folded membrane of podocytes

State what happens during selective reabsorption and where it occurs.

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Useful molecules from glomerular filtrate (e.g. glucose) are reabsorbed into the blood.

Occurs in proximal convoluted tubule.

Outline the transport processes involved in selective reabsorption.

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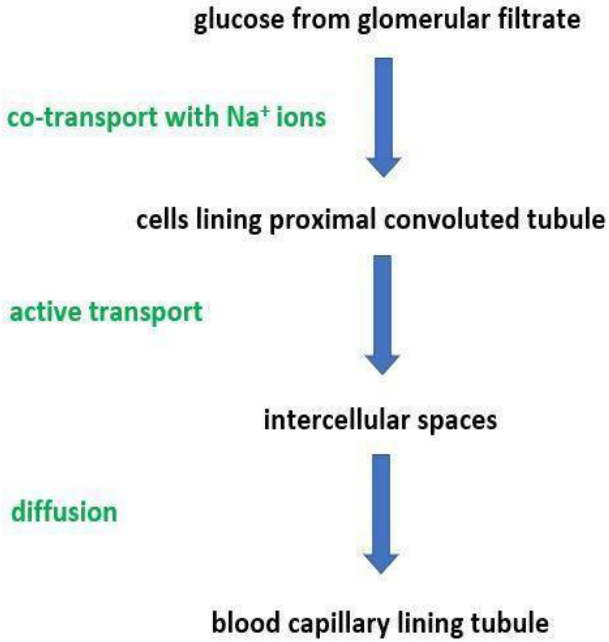

How are cells in the proximal convoluted tubule adapted for selective reabsorption?

How are cells in the proximal convoluted tubule adapted for selective reabsorption?

- **microvilli**: large surface area for co-transporter proteins
- many **mitochondria**: ATP for active transport of glucose into intercellular spaces
- **folded basal membrane**: large surface area

How does the kidney produce urine?

How does the kidney produce urine?

After selective reabsorption, filtrate passes through Loop of Henle, which acts as countercurrent multiplier & then through distal convoluted tubule, where water & mineral ions are reabsorbed.

More water is reabsorbed in collecting duct. Remaining fluid (urine) contains only waste materials & water.

What happens in the Loop of Henle?

What happens in the Loop of Henle?

1. Active transport of Na^+ & Cl^- out of **ascending limb**
2. Water potential of **interstitial fluid** decreases
3. Movement of water out of **descending limb** via osmosis (ascending limb is impermeable to water)
4. Water potential of **filtrate** decreases going down descending limb: lowest in **medullary region**, highest at top of ascending limb

Describe the biochemical composition of renal artery plasma and renal vein plasma.

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Renal artery plasma contains more oxygen (from heart), urea, excess hormones, dissolved waste gases, water, bile salts, excess inorganic ions, alcohol & drugs/ metabolic by-products of drugs than the renal vein plasma.

Describe the biochemical composition of urine and glomerular filtrate.

Describe the biochemical composition of urine and glomerular filtrate.

Glomerular filtrate contains more water and inorganic ions.

Urine contains no glucose, but filtrate does.

Both contain equal amounts of urea since none is reabsorbed.

Define osmoregulation.

Define osmoregulation.

Control of plasma water potential via negative feedback homeostatic mechanisms.

Explain the role of the hypothalamus in osmoregulation.

Explain the role of the hypothalamus in osmoregulation.

1. Osmosis of water out of **osmoreceptors** in hypothalamus causes them to shrink.
2. This triggers hypothalamus to produce more **antidiuretic hormone** (**ADH**).

Explain the role of the posterior pituitary gland in osmoregulation.

Explain the role of the posterior pituitary gland in osmoregulation.

Stores and secretes the ADH produced by the hypothalamus.

Explain the role of ADH in osmoregulation.

Explain the role of ADH in osmoregulation.

Forms hormone-receptor complex on surface membrane of cells in collecting duct. Triggers activation of cAMP as secondary messenger.

Triggers cellular processes that increase reabsorption of water. Urine becomes more concentrated.

How does ADH increase reabsorption of water?

How does ADH increase reabsorption of water?

1. Makes cells lining collecting duct more permeable to water: Binds to cell-surface membrane receptors → concentration of cAMP increases → aquaporins inserted into membrane of cells in collecting duct wall → increased permeability → more water reabsorbed
2. Makes cells lining collecting duct more permeable to urea: water potential in interstitial fluid decreases

Outline the function of erythropoietin (EPO).

Outline the function of erythropoietin (EPO).

When receptors detect cellular hypoxia, they trigger the release of EPO from the kidneys, which stimulates bone marrow to produce red blood cells. Homeostatic mechanism replaces the exact number of blood cells lost.

What is the renin-angiotensin system?

What is the renin-angiotensin system?

Multi-step pathway that results in production of aldosterone. Reduces excretion of salts & water in response to glomerular blood pressure. Regulates arterial blood pressure.

The enzyme renin, produced & secreted by cells around the renal afferent arteriole, converts the precursor peptide angiotensinogen into its active form, angiotensin.

What is the role of angiotensin?

What is the role of angiotensin?

Increases blood pressure by constricting blood vessels. This stimulates the secretion of more ADH.

What can cause kidney failure?

What can cause kidney failure?

- Kidney infections cause inflammatory damage = change in glomerular filtration rate (rate at which filtrate flows through kidney)
- Kidney stones
- Uncontrolled diabetes
- High blood pressure damages capillaries of glomeruli = larger molecules pass into urine

Describe the effects of kidney failure.

Describe the effects of kidney failure.

- Unregulated levels of EPO & renin can change blood pressure & result in cardiovascular disease.
- Build-up of toxic waste products (e.g. urea) causes symptoms such as vomiting.
- Fluid accumulation leads to swelling.
- Disruption to electrolyte balance can make bones more brittle.

How can kidney failure be diagnosed?

How can kidney failure be diagnosed?

- Blood test for the waste product creatinine
- Urine test for albumin & calculation of albumin:creatinine ratio
- Calculation of glomerular filtration rate (healthy kidneys filter more than 90 ml/min)
- Test for blood/ protein in urine

What are the potential treatments for kidney failure?

What are the potential treatments for kidney failure?

- **renal dialysis**: haemodialysis/ peritoneal dialysis (short-term solution repeated several times a week so toxic waste products do not accumulate)
- **kidney transplant** (long-term solution, but difficult to find suitable donor with same blood/ tissue type & patient requires immunosuppressants)

Suggest how transplant surgery may develop in the future.

Suggest how transplant surgery may develop in the future.

Development of techniques that prevent organ rejection & minimise the need for donors:

- therapeutic cloning of somatic cells produces healthy cells to replace diseased tissues
- reproductive cloning
- stem cell technology can produce new organ cells

Describe haemodialysis.

Describe haemodialysis.

Removes blood from vein & pumps it through a machine.

Blood runs countercurrent to dialysis fluid. Artificial membrane separates fluids = diffusion gradient enables molecules to move.

Add blood thinning agent to avoid clotting outside body.

Suggest the advantages and disadvantages of haemodialysis.

Suggest the advantages and disadvantages of haemodialysis.

+ 4 days per week without dialysis
+ Carried out by trained professionals
- Often takes place in a dialysis clinic, so patients may need to travel often
- Diet & fluid intake are restricted

Describe peritoneal dialysis.

Describe peritoneal dialysis.

Dialysis fluid is put into peritoneum.

Exchange of molecules happens across the body's own peritoneal membrane.

Fluid must be drained and replaced.

Suggest the advantages and disadvantages of peritoneal dialysis.

Suggest the advantages and disadvantages of peritoneal dialysis.

+ No need for regular visits to dialysis unit
+ Can be conducted at home
+ Fewer diet & fluid intake restrictions
- Needs to be done daily
- Self-administered - hygiene problems
- Risk of peritonitis (abdomen infection)
- Dialysis fluid used can reduce in protein levels