Q9 Outline the functions of the kidney (March 2013)

Functions of the kidney:

1. Excretion of metabolic waste and foreign substances
    - Filtration of metabolic waste products at the glomerulus for excretion in urine (including urea from protein, uric acid from nucleic acids, creatinine from muscle creatine, and the metabolites of various hormones)
    - Filtration of drugs and other foreign substances
    - Hepatic metabolism often works synergistically with the kidney to metabolise organic molecules to a water soluble form, aiding renal excretion

2. Regulation of water and electrolyte balance
    - The kidneys vary their excretion of water and electrolytes to maintain homeostasis
    - Kidneys filter approx. 180L of fluid and other substances per day, with 99% reabsorbed along the tubule
    - 65% of filtered sodium is reabsorbed at the proximal tubule with water following it. 25% occurs at the LOH and 5% at the early distal tubule, where there is no water movement. The remaining 2-4% is reabsorbed at the cortical collecting duct. Water reabsorption here is governed by ADH, which stimulates the movement of aquaporins (water channels) to the cell membrane
    - The kidneys can concentrate urine via the countercurrent mechanism up to 1400mOsm to reduce renal water loss – the obligatory solute load requiring excretion is 600mOsm/day, requiring a minimal urine output of approx. 430ml/day
    - The renal tubules also reabsorb K, Ca, Mg and Cl either passively or actively

3. Regulation of plasma osmolality
    - Plasma osmolality is altered whenever the inputs and outputs of water and solutes changes disproportionately. The kidney must excrete water and solutes to match input to output whilst keeping the ratio of solutes and water constant. Input from the hypothalamic osmoreceptors contributes.

4. Regulation of acid base balance
    - Excretion of H+ ions, fixed acids, phosphate and ammonium, and resorption of HCO3- to maintain plasma neutrality

5. Regulation of blood pressure
    - Production of angiotension 2 via the RAAS in response to a reduction in GFR system leads to peripheral vasoconstriction, reabsorption of sodium, secretion of aldosterone, and consequently a rise in MAP
    - Changes in blood volume regulated by the kidney (as mentioned above) will also influence BP
    - High BP may stimulate the secretion of ANP which opposes the effects of renin and produces a loss in body water and sodium

6. Endocrine function
    - Production of the hormone vitamin D (7-dehydroxycholecalciferol in skin activated by UV light to cholecalciferol, which is converted in the liver to 25-hydroxycholecalciferol, and by 1alpha hydroxylase in the kidney to 1,25-dihydroxycholecalciferol)
    - Secretion of EPO to stimulate RBC production (released in response to a reduction in pO2 in the local environment of the secretory cells which lie in between the cortex and medulla)
    - Production of aldosterone and angiotensin II as regulated by the RAAS will contribute to BP management
    - Production of prostaglandins esp PGE2 and prostacyclin – potent renal vasodilators
    - Production of bradykinin – potent renal vasodilator

7. Gluconeogenesis
    - The renal cortex contains glucose-6-phosphatase and thus the ability to release glucose in times of need