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**COURSE TITLE: RENAL PHYSIOLOGY, BODY FLUID AND TEMPERATURE REGULATION**

**COURSE CODE: PHS 303**

**Question 1: Discuss the role of kidney in glucose homeostasis?**

The human kidney is involved in the regulation of glucose homeostasis and in abnormalities found in diabetes mellitus via three different mechanisms: (i) release of glucose into the circulation via gluconeogenesis; (ii) uptake of glucose from the circulation to satisfy its energy needs; and (iii) reabsorption into the circulation of glucose from glomerular filtrate to conserve glucose carbon.

* **RENAL GLUCONEOGENESIS**

After a 14-16h overnight fast, glucose is released into the circulation at a rate of approximately 10 μmol/(kg min). Approximately 50% of this is the result of the breakdown of glycogen (glycogenolysis) stored in the liver and the other half is because of the production of new glucose molecules from precursors such as lactate, glycerol, alanine and other amino acids (gluconeogenesis) by liver and kidneys. The renal cortex (like the liver) contains gluconeogenic enzymes and it can synthesize glucose-6-phosphate from precursors (lactate, glutamine, glycerol and alanine). Because it contains glucose-6-phosphatase, it is able to release glucose into the blood stream and the human liver and kidneys are the only organs that can perform gluconeogenesis. Therefore, after an overnight fast, the liver produces 75–80% of glucose released into the circulation and the remaining 20–25% is derived from the kidneys.

* **RENAL GLUCOSE REABSORPTION**

In addition to releasing glucose into the circulation by synthesizing new glucose molecules via gluconeogenesis and its utilization of glucose, the kidney can also influence glucose homeostasis by returning glucose to the circulation via the reabsorption of glucose from glomerular filtrate. Normally, approximately 180L of plasma are filtered by the kidneys each day. As the average plasma glucose concentration throughout a 24-h period is ∼5.5 mmol/l (100 mg/dl), ∼180 g of glucose is filtered by the kidneys each day. In healthy individuals, virtually all of this is reabsorbed into the circulation and the urine is essentially free from glucose. To put this into perspective, in a given day, the kidneys produce 15–55 g glucose via gluconeogenesis and metabolize 25–35 g glucose. Therefore, in terms of glucose economy, it is clear that renal reabsorption is the primary mechanism by which the kidney influences glucose homeostasis.

**Question 2:  Discuss the process of micturition?**

Micturition or urination is the process of expelling urine from the bladder. This act is also known as voiding of the bladder. The [excretory system](https://www.toppr.com/guides/biology/excretory-products/human-excretory-system/) in humans includes a pair of kidneys, two ureters, a urinary bladder and a urethra. The kidneys filter the urine and it is transported to the urinary bladder via the ureters where it is stored till its expulsion. The process of micturition is regulated by the [nervous system](https://www.toppr.com/guides/biology/control-and-coordination/nervous-system/) and the [muscles](https://www.toppr.com/guides/biology/locomotion-and-movement/muscle/) of the bladder and urethra. The urinary bladder can store around 350-400ml of urine before it expels it out.

**Stages of Micturition**

The urinary bladder has two distinct stages or phases:

1. Resting or filling stage
2. Voiding stage

**Resting or Filling Stage**

It is in this phase of the bladder that the urine is transported from the kidneys via the ureters into the bladder. The ureters are thin muscular tubes that arise from each of the kidneys and extend downwards where they enter the bladder obliquely.

The oblique placement of the ureters in the bladder wall serves a very important [function](https://www.toppr.com/guides/maths/relations-and-functions/functions/). The opening of the ureter into the urinary bladder is not guarded by any sphincter or muscle. Therefore, this oblique [nature](https://www.toppr.com/guides/business-studies/business-services/nature-and-types-of-services/) of opening prevents the urine from re-entering the ureters. At the same time, the main muscle of the urinary bladder, the detrusor muscle, is relaxing allowing the bladder to distend and accommodate more urine.

**Voiding Stage**

During this stage, both the urinary bladder and the urethra come into play together. The detrusor muscle of the urinary bladder which was relaxing so far starts to contract once the bladder’s storage capacity is reached.

The urethra is controlled by two sets of muscles: The internal and external urethral sphincters. The internal sphincter is a smooth muscle whereas the external one is [skeletal](https://www.toppr.com/guides/biology/locomotion-and-movement/skeletal-system/). Both these sphincters are in a contracted state during the filling stage.

**Question 3: Explain juxtaglomerular apparatus?**

The juxtaglomerular apparatus (also known as the juxtaglomerular complex) is a structure in the kidney that regulates the function of each nephron, the functional units of the kidney. It is a specialized structure formed by the distal convoluted tubule and the glomerular afferent arteriole. It is located near the vascular pole of the glomerulus and its main function is to regulate blood pressure and the filtration rate of the glomerulus.

**Question 4: Discuss the role of kidney in regulation of blood pressure?**

Renal regulation of blood pressure occurs:

* PHYSICALLY: By variation of glomerular filtration pressure to variation in urine formation
* HORMONALLY: By secretion of Renin.

When blood volume increases and B.P is increased, kidneys excrete excess fluid by

* PRESSURE DIURESIS: Increased urine formation as a result of increased glomerular filtration due to raised renal perfusion pressure
* PRESSURE NATRIURESIS: Increased urinary excretion of sodium as a result of increased glomerular filtration of sodium due to raised renal perfusion pressure

When blood volume and BP is decreased there is (i) Decreased glomerular capillary H.P (ii) Decreased glomerular filtration

Thus kidneys conserve ECF volume

**Question 5: Discuss the role of Kidney in Calcium homeostasis?**

 Kidneys are major regulations of calcium homeostasis. This is illustrated by the profound and complex deregulation of mineral metabolism appearing during chronic kidney disease (CKD) recognized as mineral and bone disorders in chronic kidney disease (MBD-CKD).

Fluxes of calcium between the small intestine (the place for calcium absorption), the bone (the main storage place for calcium), and the kidney (the main place of elimination of the absorbed calcium) are highly controlled by numerous transport mechanisms, hormones, and interconnected feedback loops. This is an absolute requirement to prevent unwanted bio mineralization in tissues. Indeed, calcium is a highly reactive ion which has high propensity to form microcrystals in fluids and tissues. In mammals, the complex process of bio mineralization takes place in a controlled manner in teeth and bones, in which the matrix is calcified with hydroxyapatite, a calcium-phosphate salt. As the calcification process necessitates interactions between matrix proteins and high local calcium and phosphate concentrations at a specific pH, keeping calcium in solution also demands significant effort. With plasma concentrations of ∼2.4 mmol/l for calcium and 1 mmol/l for phosphate, crystallization would spontaneously occur, if inhibitors of calcification, such as magnesium, fetuin A, osteoprotegerin, or matrix protein were not present in plasma. Thus the control of calcification in bone on the one hand and the preserved solubility of calcium salts in plasma on the other hand are both dependent on the tight control of plasma levels of calcium and phosphate and on the presence/absence of strong inhibitors.

The same reasoning can be applied to urine in which calcium has a concentration of ∼3 mmol/l and phosphate 10 mmol/l. Inhibitors and promoters of urine crystallization and stone formation have been extensively described (for a review, see Ref. [177](https://journals.physiology.org/doi/full/10.1152/ajprenal.00273.2015#B177)), and calciuria appears to be a major promoter of crystallization and stone formation. Hypercalciuria, as defined either as excretion rate or as concentration, is contributing to Randall's plaque formation and to kidney stone formation ([99](https://journals.physiology.org/doi/full/10.1152/ajprenal.00273.2015#B99)). Thus control of calciuria is instrumental in reducing the risk of intrarenal bio mineralization and kidney stone formation.

In plasma, only ∼50% of calcium is freely available, the rest being bound to proteins or forming complexed salts. The concentration of free ionized calcium depends on plasma pH and plasma protein content and constitutes the calcium that is sensed and defended by the organism. It can be measured as ionized calcium.

In the kidney, the only source of calcium reaching the tubules is ultra-filtrated calcium, consisting of ionized calcium and other calcium-containing salts filtered through the glomerulus. It represents ∼50% of the total plasma calcium, but it is impossible to be precisely measured in a clinical setting. This constitutes a major caveat when it comes to evaluating the fractional excretion of calcium. No secretion or back leak of calcium contributes to the calcium delivered to the tubular system and, consequently, the load of calcium filtered is the unique and major contributor of calcium reaching the proximal tubule (PT). Along the tubular system, complex trans epithelial transport mechanisms allow a highly regulated reabsorption of ∼98% of filtrated calcium ([Fig. 1](https://journals.physiology.org/doi/full/10.1152/ajprenal.00273.2015#F1)). In certain circumstances though, the tubular reabsorption system may be overwhelmed by the filtrated load, as seen in primary hyperparathyroidism or in vitamin D intoxication. In these two conditions, the calcium reabsorption machinery of the kidney is maximally stimulated but cannot counterbalance the filtered calcium load, leading to hypercalciuria.