1. Define Glomerular Filtration Rate (GFR).

Solution:

Glomerular Filtration rate (GFR) is the amount of filtrate formed by both the kidneys (nephrons) every minute. The GFR of a healthy person is approximately 125ml per minute. The GFR consists majorly of water and other constituents such as amino acids, glucose, potassium, sodium, urea, uric acid and ketone bodies.

2. Explain the autoregulatory mechanism of GFR.

Solution:

Kidneys regulate the glomerular filtration rate through a mechanism which is auto-regulatory. It involves the action of the juxtaglomerular apparatus, which is a microscopic structure present between the returning distal convoluted tubule and vascular pole of the renal corpuscle of the same nephron. It regulates the glomerular filtration rate and renal blood flow. When the glomerular filtration rate declines, the juxtaglomerular cells are activated for the release of renin. This triggers the glomerular blood flow causing the GFR to revert to normal. Renin causes GFR to revert to normalcy by activating the renin-angiotensin mechanism.

3. Indicate whether the following statements are true or false.

(a) Micturition is carried out by a reflex.

(b) ADH helps in water elimination, making the urine hypotonic.

(c) Protein-free fluid is filtered from blood plasma into the Bowman's capsule.

(d) Henle's loop plays an important role in concentrating urine.

(e) Glucose is actively reabsorbed in the proximal convoluted tubule.

Solution:

(a) Micturition is carried out by a reflex. – True

(b) ADH helps in water elimination, making the urine hypotonic. – False

ADH helps in the reabsorption of water, causing the urine to be hypotonic.

(c) Protein-free fluid is filtered from blood plasma into the Bowman's capsule. – True

(d) Henle's loop plays an important role in concentrating urine. – True

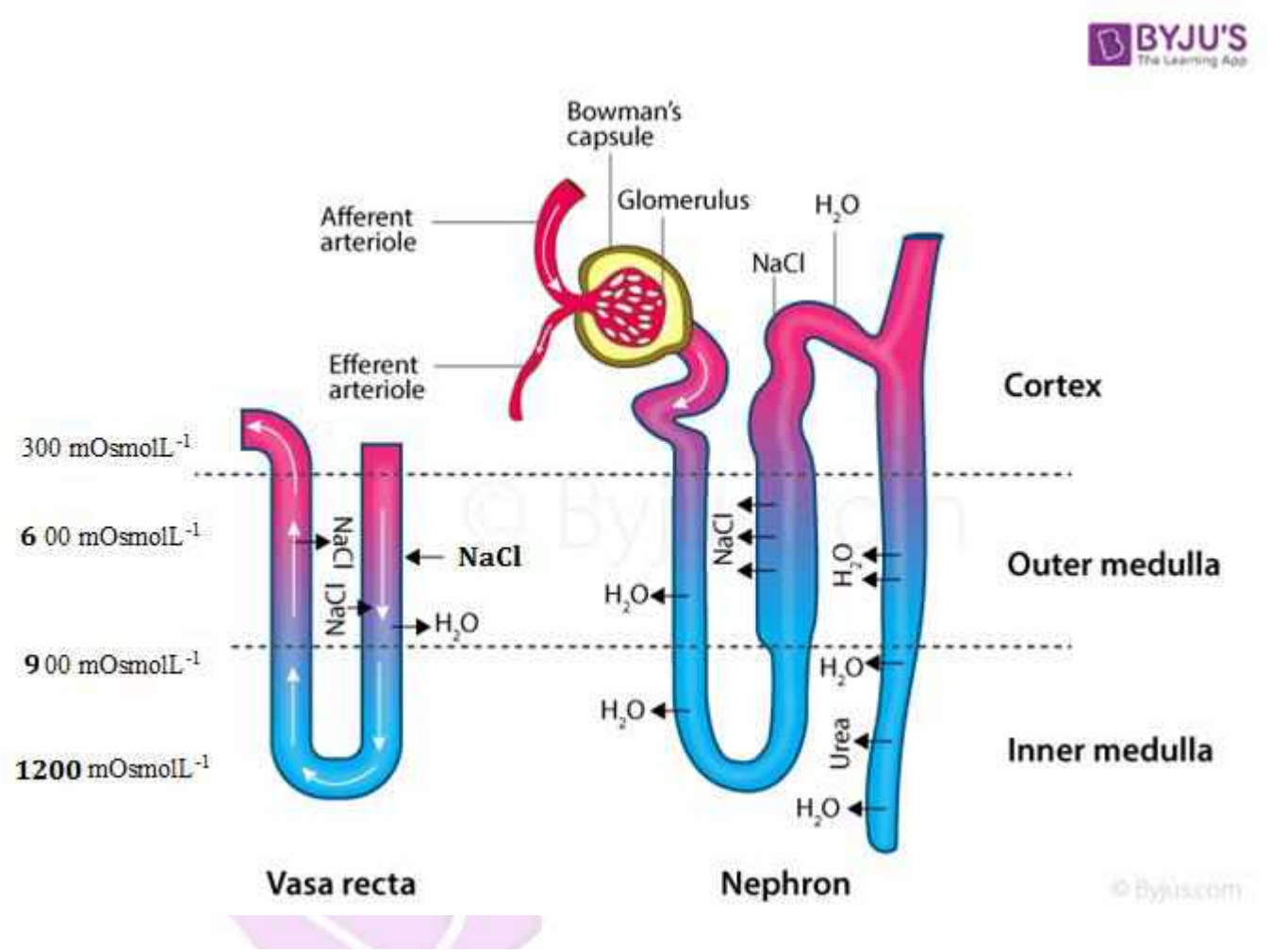
(e) Glucose is actively reabsorbed in the proximal convoluted tubule. – True

4. Give a brief account of the counter-current mechanism.

Solution:

The chief adaptation for the conservation of water is the counter-current mechanism that is functional inside the kidney. In the kidney, there are two counter-current mechanisms, namely

1. Henle's loop
2. Vasa recta



- Henle's loop is a U-shaped part of the nephron. The flow of blood in the two branches of the tube is in the opposite direction, which gives rise to the counter currents.
- Vasa recta, on the other hand, is an efferent arteriole that forms a capillary network around the tubules in the renal medulla, which tracks parallel to the Henle's loop. Vasa recta are also U-shaped. The flow of blood is in opposite directions in the two limbs of the vasa recta. Hence, the blood that enters the renal medulla in the descending limb comes in close proximity with the outgoing blood in the ascending limb

- Through the countercurrent mechanism, the osmolarity increases in the cortex from 300 mOsmolL^{-1} to about 1200 mOsmolL^{-1} in the inner medulla, which helps in sustaining the concentration gradient. This, in turn, aids in the easy movement of water from the collecting tubules. The concentration gradient is due to the movement of urea and NaCl.

5. Describe the role of the liver, lungs and skin in excretion.

Solution:

The role of the liver, lungs and skin in the process of excretion is as follows:

Liver

- It is the chief site for the removal of inactivated products of steroid hormones, cholesterol, drugs and vitamins.
- Dead erythrocytes possess haemoglobin. This haemoglobin is also disintegrated into bile pigments – biliverdin and bilirubin, which are treated wastes.
- Bile carries substances to the intestine, which along with the wastes, are eliminated.

Lungs

- Carbon dioxide is expelled from the body by the lungs.
- Approximately it eliminates 200ml of carbon dioxide every minute.
- Water in the form of water vapour is also eliminated.
- Loss of water increases in colder conditions and declines in humid, hot conditions.
- During the process of expiration, several volatile materials are also ejected.

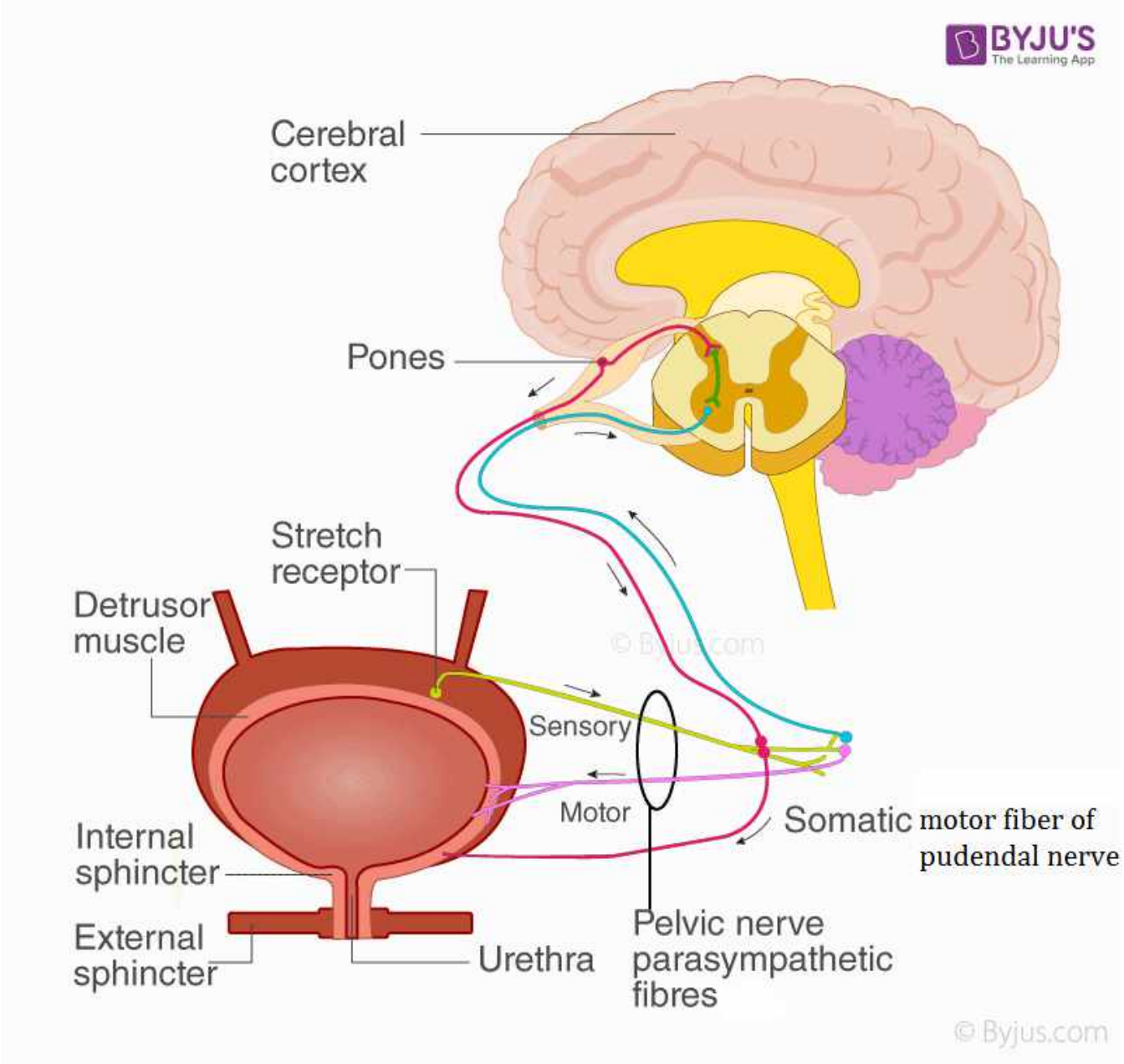
Skin

- It is chiefly responsible for the thermoregulation (cooling) of the body.
- Sweat is excreted by the skin. It contains nitrogenous wastes. Sweat is excreted only when necessary, such as to cool the body.
- Sweat is excreted by the sweat glands and constitutes urea, NaCl and lactic acid.
- Through the sebum, the sebaceous glands remove hydrocarbons, sterols and waxes.
- A protective oily covering is provided to the skin by the sebum.

6. Explain micturition.

Solution:

Micturition is the process of releasing urine. Micturition is caused by a neural mechanism known as the micturition reflex.



The urinary bladder temporarily stores the urine that is formed. The bladder tends to stretch when the urinary bladder gets filled with urine. This stretching causes to initiate a signal, and responding to this signal, the receptors located in the walls of the bladder send out signals to the central nervous system (CNS). The CNS conveys motor messages that originate the relaxation of the urethral sphincters and the contraction of the smooth muscles of the urinary bladder, thereby resulting in micturition (passing of urine).

7. Match the items of column I with those of column II.

Column I	Column II

(a) Ammonotelism	**(i) Birds**
(b) Bowman's capsule	**(ii) Water reabsorption**
(c) Micturition	**(iii) Bony fish**
(d) Uricotelism	**(iv) Urinary bladder**
(d) ADH	**(v) Renal tubule**

Solution:

Column I	Column II
(a) Ammonotelism	(iii) Bony fish
(b) Bowman's capsule	(v) Renal tubule
(c) Micturition	(iv) Urinary bladder
(d) Uricotelism	(i) Birds
(d) ADH	(ii) Water reabsorption

8. What is meant by the term osmoregulation?

Solution:

Osmoregulation is the process of regulating the osmotic concentration in the cells of the body by checking the quantity of water and salts.

9. Terrestrial animals are generally either ureotelic or uricotelic, not ammonotelic. Why?

Solution:

Ammonia is an extremely toxic nitrogenous waste. In order to reduce the toxicity of ammonia in the body, a very large amount of water is necessary. To dilute ammonia, the bodies of terrestrial animals do not possess an adequate quantity of water. If the body of terrestrial animals stores this excess ammonia, it may turn extremely poisonous for them. Hence, in such animals, ammonia is always converted to less toxic uric acid and urea. This is the reason why terrestrial animals are generally either uricotelic or ureotelic.

10. What is the significance of the juxtaglomerular apparatus (JGA) in kidney function?

Solution:

The juxtaglomerular apparatus is a specialised sensitive region that is formed by the cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact.

Significance

- Its mechanism is via the renin-angiotensin-aldosterone system (RAAS).
- When the glomerular filtration rate dips, the juxtaglomerular apparatus stimulates, causing the secretion of renin.
- This renin converts a protein into a peptide, i.e., angiotensinogen, to angiotensin.
- Angiotensin is a hormone that elevates the GFR and the flow of blood in these three ways:
    1. Narrowing the efferent arterioles causes an increase in glomerular pressure.
    2. Triggering the walls of the PCT in order to reabsorb more water and NaCl.
    3. Triggers the adrenal gland to secrete aldosterone that facilitates reabsorption of water and NaCl in the DCT.
- The volume of blood and blood pressure thereby increases. The hypertonic urine and urine volume decreases.

11. Name the following.

(a) A chordate animal having flame cells as excretory structures.

(b) Cortical portions projecting between the medullary pyramids in the human kidney.

(c) A loop of capillary running parallel to Henle's loop.

Solution:

(a) A chordate animal having flame cells as excretory structures. – Amphioxus

Flame cells or protonephridia are the excretory structures found in some animals.

(b) Cortical portions projecting between the medullary pyramids in the human kidney. – Columns of

Bertini

The medulla is divided into several conical masses (medulla pyramids) that project into the calyces. The cortex extends in between the medullary pyramids as renal columns known as Columns of Bertini.

(c) A loop of capillary running parallel to Henle's loop. – Vasa recta

A minute vessel of the network that runs parallel to the Henle's loop forms a 'U' shaped vasa recta. Vasa recta are highly reduced in the cortical nephrons.

12. Fill in the gaps.

(a) Ascending limb of Henle's loop is _____ to water, whereas the descending limb is _____ to it.

(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone _____.

(c) Dialysis fluid contain all the constituents as in plasma except _____.

(d) A healthy adult human excretes (on an average) _____ gm of urea/day

Solution:

1. Impermeable, permeable
2. Vasopressin (anti-diuretic hormone)
3. Nitrogenous waste
4. 25-30