

# Chapter 11 - Animal Physiology [274 marks]

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1. A skeletal muscle contains bundles of elongated muscle fibre cells. What is the longest structure within each fibre? [1 mark]
- A. A myosin filament
  - B. The sarcomere
  - C. A myofibril
  - D. The Z line

## Markscheme

C

2. What is a function of synovial fluid in the elbow joint? [1 mark]
- A. Joins the humerus to the radius and ulna
  - B. Grows red blood cells
  - C. Protects the biceps
  - D. Allows easy movement

## Markscheme

D

3. Where are microvilli located in the nephron? [1 mark]
- A. Glomerulus
  - B. Proximal convoluted tubule
  - C. Loop of Henle
  - D. Collecting duct

## Markscheme

B

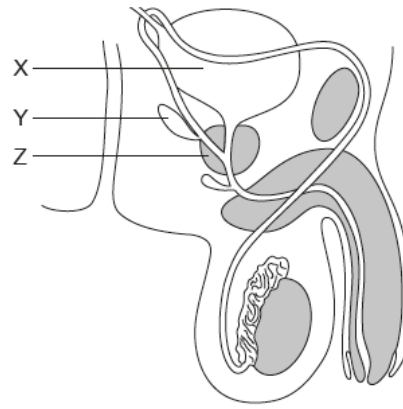
4. Through what process does a spermatid become a functioning spermatozoan? [1 mark]
- A. Mitosis
  - B. Differentiation
  - C. Fertilization
  - D. Meiosis

## Markscheme

B

5. The image shows the male reproduction system.

[1 mark]



[Source: © International Baccalaureate Organization 2015]

Where is prostate cancer likely to start developing?

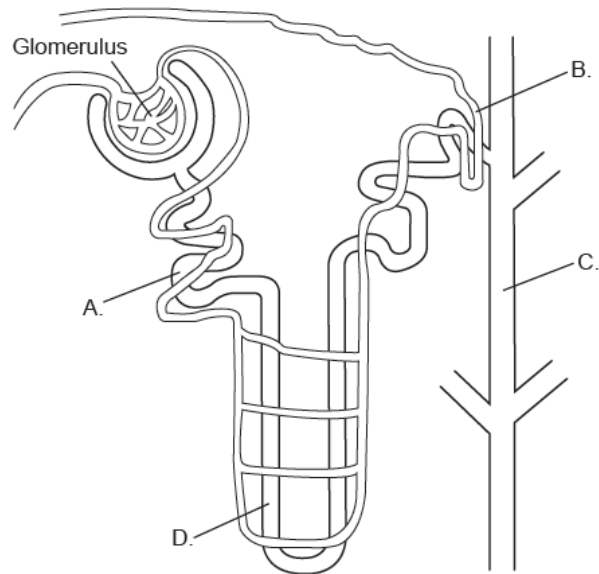
- A. In X only
- B. In Y and Z only
- C. In Z only
- D. In X, Y and Z

## Markscheme

C

6. The diagram shows a nephron from a human kidney. In what part of the nephron would most glucose be reabsorbed?

[1 mark]



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## Markscheme

A

7. In which region of the kidney is the glomerulus found?

[1 mark]

- A. Cortex only
- B. Medulla only
- C. Cortex and medulla
- D. Pelvis

## Markscheme

A

8. What is an example of active immunity?

[1 mark]

- A. Antibodies passed from the mother to fetus across the placenta
- B. Antibodies produced by another organism and injected to protect against a disease
- C. Antibodies passed from the mother in colostrum during breastfeeding
- D. Antibodies produced after the defence mechanisms have been stimulated by antigens

## Markscheme

D

9. What is the function of the epididymis in the male reproduction system?

[1 mark]

- A. To stimulate sperm production by secreting testosterone
- B. To store the sperm in the final stages of maturation
- C. To provide fluids to nourish the sperm
- D. To transport the sperm from the testes to the urethra

## Markscheme

B

10. From where is human chorionic gonadotropin (HCG) secreted in early pregnancy?

[1 mark]

- A. Embryo
- B. Corpus luteum
- C. Ovary
- D. Pituitary gland

## Markscheme

A

11. What results from the fusion of tumour cells with B-cells?

[1 mark]

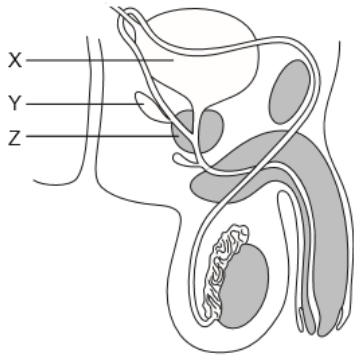
- A. The inability of B-cells to divide
- B. The production of monoclonal antibodies
- C. The production of antigens
- D. The activation of helper T-cells

## Markscheme

B

12. The image shows the male reproduction system.

[1 mark]



[Source: © International Baccalaureate Organization 2015]

Where is prostate cancer likely to start developing?

- A. In X only
- B. In Y and Z only
- C. In Z only
- D. In X, Y and Z

## Markscheme

C

13. What is the main role of nerves in human movement?

[1 mark]

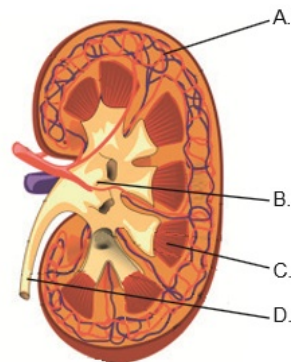
- A. To cause muscles to stretch
- B. To move joints
- C. To transport pain signals that indicate muscle injuries
- D. To stimulate muscle contraction

## Markscheme

D

14. Which letter correctly identifies the medulla?

[1 mark]



[Source: "KidneyStructures PioM" by Piotr Michał Jaworski; PioM EN DE PL – Own work.  
Licensed under CC BY-SA 3.0 via Wikimedia Commons –  
[https://commons.wikimedia.org/wiki/File:KidneyStructures\\_PioM.svg#/media/File:KidneyStructures\\_PioM.svg](https://commons.wikimedia.org/wiki/File:KidneyStructures_PioM.svg#/media/File:KidneyStructures_PioM.svg)]

## Markscheme

C

15. Which event takes place during normal fertilization?

[1 mark]

- A. The acrosome fuses with the egg membrane.
- B. The entire sperm cell enters the egg cytoplasm.
- C. The egg divides to form a blastocyst.
- D. The cortical granules fuse with the egg membrane.

## Markscheme

D

16. What is the correct order of events in fertilization?

[1 mark]

- A. fusion of gametes, acrosome reaction and then cortical reaction
- B. cortical reaction, fusion of gametes and then acrosome reaction
- C. acrosome reaction, fusion of gametes and then cortical reaction
- D. fusion of gametes, cortical reaction and then acrosome reaction

## Markscheme

C

17. What is secreted after implantation of the blastocyst in the uterine wall?

[1 mark]

- A. Estrogen which stimulates the degeneration of the corpus luteum
- B. HCG which prevents the degeneration of the corpus luteum
- C. Estrogen which prevents the degeneration of the corpus luteum
- D. HCG which stimulates the degeneration of the corpus luteum

## Markscheme

B

18. Which ions are released from the sarcoplasmic reticulum when a skeletal muscle fibre contracts?

[1 mark]

- A. Sodium
- B. Potassium
- C. Calcium
- D. Chloride

## Markscheme

C

19. What is the role of ATP during contraction of a skeletal muscle fibre?

[1 mark]

- A. To uncover the myosin binding sites on actin filaments
- B. To make cross-bridges between actin and myosin filaments
- C. To break cross-bridges and re-set myosin heads
- D. To cover the myosin binding sites on actin filaments

## Markscheme

C

20. In a healthy kidney which of these substances would you expect to find in the tubular fluid entering the loop of Henle? [1 mark]
- I. Glucose
  - II. Sodium ions
  - III. Proteins
- A. I only
  - B. I and II only
  - C. II only
  - D. II and III only

## Markscheme

C

21. In a mammal that had just ingested a large volume of water, what would be secreted into the bloodstream? [1 mark]
- A. More ADH (vasopressin)
  - B. Less epinephrine (adrenaline)
  - C. More epinephrine (adrenaline)
  - D. Less ADH (vasopressin)

## Markscheme

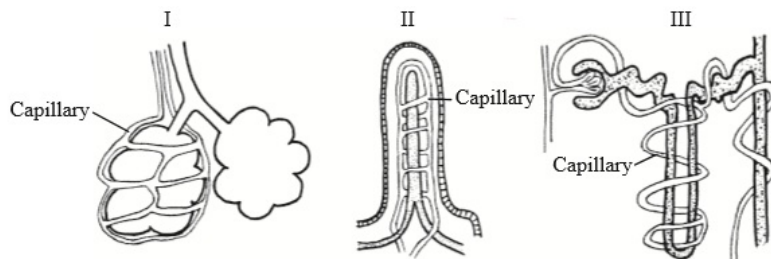
D

22. What is the role of HCG (human chorionic gonadotrophin) in early pregnancy? [1 mark]
- A. It stimulates the release of FSH (follicle stimulating hormone).
  - B. It maintains the corpus luteum.
  - C. It inhibits the release of progesterone.
  - D. It stimulates implantation of the blastocyst.

## Markscheme

B

23. Where are structures I, II and III found in the human body? [1 mark]



	I	II	III
A.	kidney	large intestine	brain
B.	lungs	small intestine	kidney
C.	lungs	large intestine	kidney
D.	kidney	small intestine	brain

## Markscheme

B

24. The images below show muscle tissue.

[1 mark]

Image I



Image II



[Source: (Figure) from *Biology Course Companion* by Andrew Allott and David Mindorff (OUP, 2007), copyright © 2007, reprinted by permission of Oxford University Press.]

Which image shows contracted muscle tissue?

- A. I because the dark band is narrower.
- B. II because the Z lines are closer together.
- C. II because there is less overlap between actin and myosin.
- D. I because the dark bands are darker.

## Markscheme

B

25. Which of the following events form the basis of immunity upon which the principle of vaccination is based?

[1 mark]

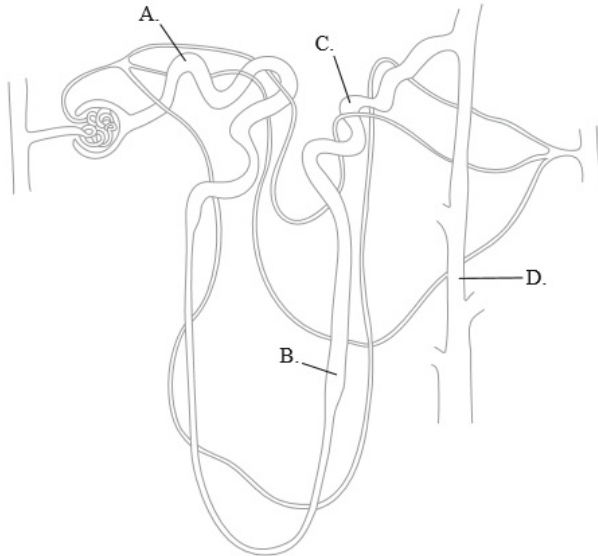
	<b>Clonal selection</b>	<b>Production of memory cells</b>	<b>Production of monoclonal antibodies</b>	<b>Challenge and response</b>
A.	no	yes	yes	yes
B.	no	yes	no	yes
C.	yes	yes	yes	yes
D.	yes	yes	no	yes

## Markscheme

D

26. In which part of the nephron is salt secreted from the tubule to increase osmotic potential?

[1 mark]



## Markscheme

B

27. Where is human chorionic gonadotrophin (HCG) produced?

[1 mark]

- A. Ovary
- B. Anterior pituitary
- C. Embryo
- D. Posterior pituitary

## Markscheme

C

28. During muscle contraction, what is the role of calcium ions ( $\text{Ca}^{2+}$ ) which are released from the sarcoplasmic reticulum?

[1 mark]

- A. To cause ATP hydrolysis on myosin filaments
- B. To bind to both actin and myosin filaments forming a cross-bridge
- C. To cause the cross-bridge to detach itself and start a new cycle
- D. To cause binding sites on the actin filaments to be uncovered

## Markscheme

D

29. What is the function of the knee joint?

[1 mark]

- A. It permits movement in one plane.
- B. It allows bones to glide over each other.
- C. It facilitates movement in all planes.
- D. It allows a wide range of movement.



## Markscheme

A

30. What is a difference between spermatogenesis and oogenesis?

[1 mark]

	<b>Spermatogenesis</b>	<b>Oogenesis</b>
A.	begins at puberty	begins at birth
B.	takes approximately 70 days	takes approximately 28 days
C.	does not require FSH	requires FSH
D.	produces four gametes per meiosis	produces one gamete per meiosis

## Markscheme

D

31. Which types of immunity are acquired by each of the following actions?

[1 mark]

	<b>Antigens injected into a child by vaccination</b>	<b>Antibodies crossing the placenta to the fetus</b>	<b>Antibodies received by baby from breastfeeding</b>
A.	passive	passive	active
B.	passive	active	passive
C.	active	active	active
D.	active	passive	passive

## Markscheme

D

32. What is a blastocyst?

[1 mark]

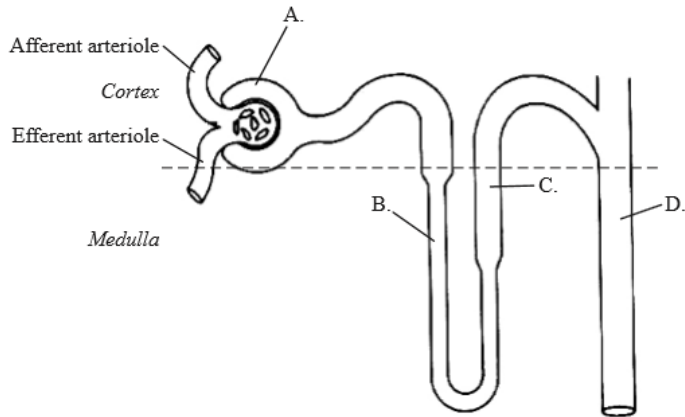
- A. An unfertilized egg surrounded by follicle cells
- B. An unfertilized egg cell expelled by menstruation
- C. The follicle when it has swelled up with fluid
- D. The embryo when it has become a hollow ball of cells

## Markscheme

D

33. The diagram shows the nephron in a kidney. Which labelled part is permeable to sodium and not to water?

[1 mark]



[Source: [www.medcyclopaedia.com/upload/book%20of%20radiology/chapter25/nic\\_k251\\_295.jpg](http://www.medcyclopaedia.com/upload/book%20of%20radiology/chapter25/nic_k251_295.jpg)]

## Markscheme

C

34. What occurs in the body after the injection of a vaccine containing antigens?

[1 mark]

- A. Activated B-cells divide to form memory cells.
- B. The receiver of the vaccine develops passive immunity.
- C. Helper T-cells produce specific antibodies.
- D. Macrophages are cloned and destroy the antigen.

## Markscheme

A

35. Which of the following statements is **incorrect**?

[1 mark]

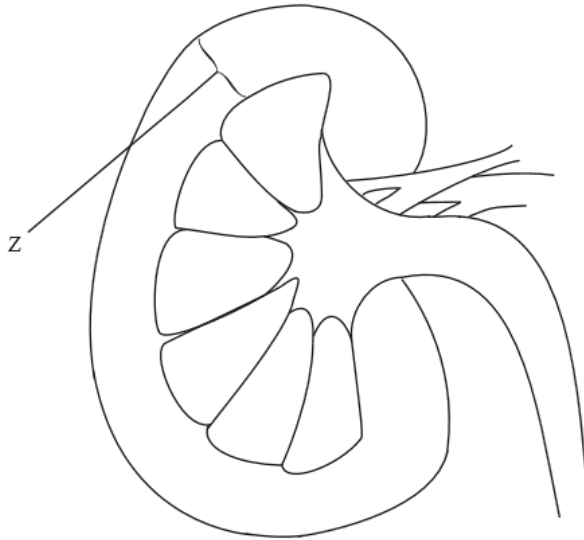
- A. Active immunity is the stimulation of the immune system to produce antigen-specific antibodies.
- B. Vaccines produce immunological memory similar to that acquired by having the natural disease.
- C. The most common way to acquire passive immunity is to have the natural disease.
- D. Killed forms of a microorganism can act as an antigen.

## Markscheme

C

36. The diagram below shows a longitudinal section through a kidney. What is the structure labelled Z and what is its function?

[1 mark]



	Structure Z	Function
A.	cortex	osmoregulation
B.	medulla	ultrafiltration
C.	cortex	ultrafiltration
D.	pelvis	osmoregulation

## Markscheme

C

37. Which of these statements about the human placenta is **incorrect**?

[1 mark]

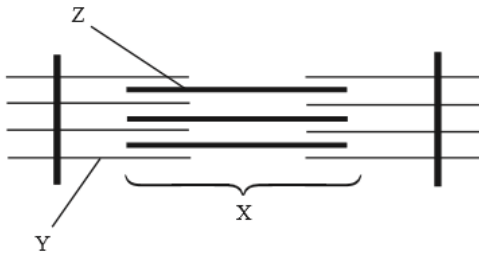
- A. The placenta is the site of nutrient and gas exchange between the mother and fetus.
- B. The placenta produces hormones, such as estrogen.
- C. The placenta begins to develop after implantation of the blastocyst.
- D. The mother's blood and the baby's blood mix in the placenta.

## Markscheme

D

38. What is indicated by the letters X, Y and Z?

[1 mark]



	X	Y	Z
A.	sarcomere	myosin filaments	actin filaments
B.	sarcomere	actin filaments	myosin filaments
C.	dark band	myosin filaments	actin filaments
D.	dark band	actin filaments	myosin filaments

## Markscheme

D

39. What are the roles of the following structures in the production of semen?

[1 mark]

	Epididymis	Seminal vesicle	Prostate gland
A.	production of a fluid containing alkaline minerals	production of fructose	maturation of sperm
B.	maturation of sperm	production of a fluid containing citric acid	production of fructose
C.	maturation of sperm	production of fructose	production of a fluid containing alkaline minerals
D.	production of a fluid containing alkaline minerals	maturation of sperm	production of fructose

## Markscheme

C

40. Which of the following best describes what happens in the glomerulus?

[1 mark]

- A. Selective reabsorption of water and molecules by active transport
- B. Ultrafiltration introduces water and other molecules into the capillaries
- C. Regulation of salt balance leading to the production of urine
- D. High blood pressure forces water and other molecules into the tubule lumen

## Markscheme

D

41a. Draw a labelled diagram to show the structure of a sarcomere.

[4 marks]

## Markscheme

*Award [1] for each structure clearly drawn and correctly labelled.*

Sarcomere – clearly indicated between Z lines;

Z lines;

actin filaments attached to Z line;

myosin filaments with heads;

(two) light bands;

dark band;

41b. Outline how skeletal muscle contracts.

[5 marks]

## Markscheme

calcium ions are released from the sarcoplasmic reticulum;

they expose the myosin binding sites (on actin) / cause movement of blocking molecules/troponin;

cross-bridges form between actin and myosin molecules;

ATP provides energy;

for actin filaments to slide over the myosin filaments / for myosin to push actin;

ATP provides energy to release myosin from binding site;

action can be repeated further along the molecule;

41c. Explain how nerve impulses are transmitted along and between neurons.

[9 marks]

## Markscheme

the resting potential of cell is negative inside compared with outside;

stimulation causes depolarization/reversal of charge on each side;

due to  $\text{Na}^+$  channels opening /  $\text{Na}^+$  flowing into the cell;

which causes an action potential;

$\text{K}^+$  channels open /  $\text{K}^+$  flows out of the cell;

sodium potassium pump restores resting potential;

transmitted between neurons across a synapse;

neurotransmitter released into synaptic cleft;

diffuse across cleft to postsynaptic membrane;

where they bind to receptors;

influx of  $\text{Na}^+$  into cell;

which may initiate action potential;

42. When a pathogen is ingested by a phagocyte, which event occurs first?

[1 mark]

- A. T-cell activation
- B. Memory cell proliferation
- C. Antigen presentation by the phagocyte
- D. B-cell activation

## Markscheme

C

43. Which of the following is a term for muscle cell?

[1 mark]

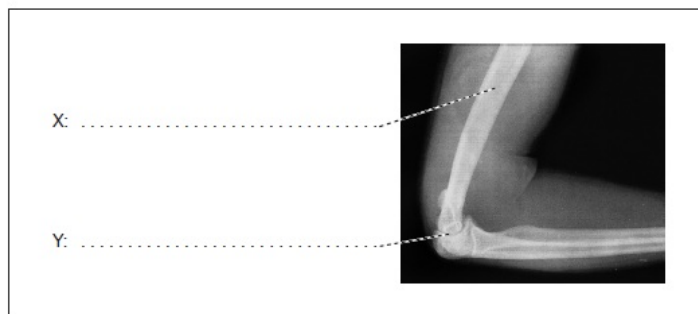
- A. Muscle bundle
- B. Muscle fibre
- C. Myofibril
- D. Sarcomere

## Markscheme

B

44a. Label the structures indicated on the X-ray of a human elbow.

[2 marks]



## Markscheme

X: humerus;

Y: synovial fluid / cartilage / joint capsule / elbow joint;

44b. Explain the role of calcium in muscle contraction.

[3 marks]

## Markscheme

action potential/nerve impulse/motor neuron causes release of calcium;

calcium released from sarcoplasmic reticulum;

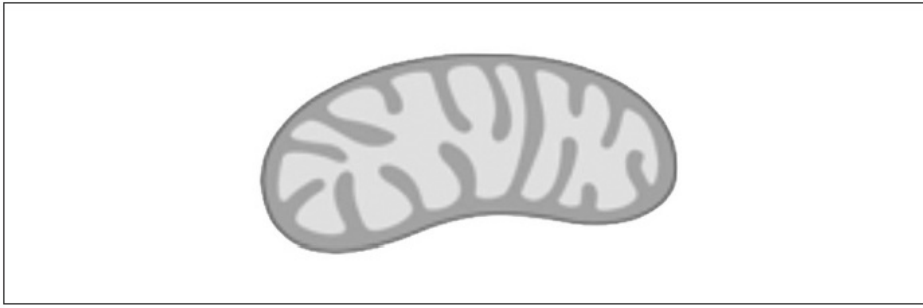
calcium causes binding sites on actin to be exposed;

myosin heads bind to binding sites/to actin and push actin (inwards);

44c. One of the stages of aerobic respiration is called the link reaction.

[1 mark]

Label the diagram to indicate where the link reaction occurs.



## Markscheme



Accept a line or arrow pointing to any part of the matrix, or a circle in it. It is not necessary to state link reaction unless more than one area is indicated.

44d. Outline the role of coenzyme A in aerobic respiration.

[2 marks]

## Markscheme

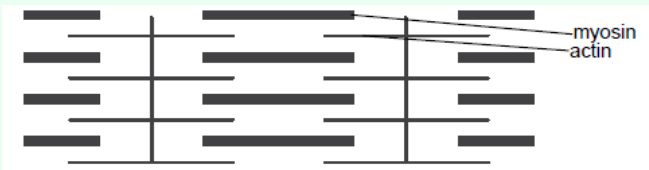
accept/bind acetyl group/acetate / acetyl coenzyme A/acetyl CoA formed;  
passes acetyl group/acetate to Krebs cycle;

45. Draw a labelled diagram showing the arrangement of proteins in a sarcomere.

[3 marks]

## Markscheme

- actin filaments – drawn as thin lines;
- myosin filaments (with heads) – drawn as thick lines;
- regions of overlap between fibres should follow diagram of sarcomere;
- correct labelling of the A or H band/Z line;



46a. Outline the function of myosin and actin in muscle contraction.

[3 marks]

## Markscheme

- a. formation of cross-bridges/myosin binds to the thin filament/actin;
- b. Z-bands pulled towards each other;
- c. sliding of actin and myosin filaments/shortening the sarcomere/I-band;
- d. use of ATP to break cross-bridges / myosin releases actin when binding to ATP;
- e. myosin heads re-set;
- f. contraction ceases when myosin head detaches from the thin filament;

46b. State the function of the following structures in the human elbow.

[1 mark]

Synovial fluid

## Markscheme

synovial fluid: avoids friction/lubricates / absorbs shock (at the elbow joint)

46c. State the function of the following structures in the human elbow.

[1 mark]

Biceps

## Markscheme

biceps: flexes arm/raises lower arm

47a. State the ethnic group with the lowest frequency of kidney failure.

[1 mark]

## Markscheme

Asian

47b. State the frequency of both kidney failure and greater than normal albumin levels in patients of European ancestry with type II diabetes.

[1 mark]

..... %

## Markscheme

11.5(%) (allow answers in the range of 11(%) to 12(%))

(NOTE: question is worded awkwardly but if students give both 24.5% and 11.5% do not give credit)

47c. Compare the levels of albumin in urine of patients with kidney failure in the different ethnic groups.

[3 marks]



## Markscheme

all ethnic groups show range (very high, high and normal) of albumin levels;

greatest frequency of very high levels of albumin found in Pacific Islander patients/ European ancestry patients have lowest frequency of very high levels of albumin;

greatest frequency of high levels of albumin in Indigenous Australian/European ancestry patients / lowest frequency of high levels of albumin in Pacific Islander patients;

European ancestry patients have highest frequency of normal levels of albumin / Indigenous Australian/Pacific Islander patients have lowest frequency of normal levels of albumin;

- 47d. The usual method of screening for chronic kidney disease is to test for kidney failure. Using the data in the bar chart, suggest why [2 marks] this method leads to more cases missed in patients of indigenous Australian ancestry than in patients with European ancestry.

## Markscheme

European ancestry patients have highest/higher frequency of kidney failure but more than half/a large percentage have a normal level of albumin;

Indigenous Australian patients have lower frequency of kidney failure but higher levels of albumin;

it would be better to test for both kidney failure and albumin levels;

- 48a. Analyse the electron micrograph for the state of contraction of the muscle fibre. [2 marks]



Z line

Z line

[Source: <http://click4biology.info/c4b/11/hum11.2.htm>  
Used with permission.]

## Markscheme

- muscle fibre is (partially) contracted;
- thick and thin filaments show considerable overlapping;
- narrow/reduced light bands between Z lines / *OWTTE*;

- 48b. Outline ATP production in muscle fibres during intense exercise. [2 marks]

## Markscheme

- for 8–10 seconds creatine phosphate regenerates ATP;
- anaerobic respiration produces ATP until lactate too high/for about 2 minutes/ 800 m of running;

- 48c. Explain the role of ATP in muscle contraction. [2 marks]

## Markscheme

- ATP breaks cross-bridges (between myosin and actin);
- ATP resets/activates/changes position of/cocks myosin heads;
- ATP provides energy to move actin/causes sliding of filaments;

49. List **two** structural features of a joint that reduce friction between bones.

[2 marks]

1. ....
2. ....

## Markscheme

- a. cartilage;
- b. synovial fluid;
- c. joint capsule (prevents fluid from leaking);

50a. Label I and II.

[1 mark]

## Markscheme

- I: glomerulus;
- II: (descending limb of) loop of Henle;  
(both needed)

50b. Outline the function of III.

[1 mark]

## Markscheme

- III: selective re-absorption of glucose/minerals/amino acids/water/ useful substances;  
absorption by active transport/using ATP of glucose/minerals/ amino acids/useful substances;

50c. Estimate the content of glomerular filtrate and urine of a healthy person by completing the following table.

[2 marks]

	Plasma proteins / mg 100 ml <sup>-1</sup>	Glucose / mg 100 ml <sup>-1</sup>	Urea / mg 100 ml <sup>-1</sup>
Blood plasma in renal artery	740	90	30
Glomerular filtrate		90	
Urine			

## Markscheme

	<i>plasma proteins / mg 100 ml<sup>-1</sup></i>	<i>glucose / mg 100 ml<sup>-1</sup></i>	<i>urea / mg 100 ml<sup>-1</sup></i>
<i>blood plasma in renal artery</i>	(740)	(90)	(30)
<i>glomerular filtrate</i>	0	(90)	30 (or slightly less);
<i>urine</i>	0	0	(much) greater than 30;

Award [1] for each correct row.

- 50d. Explain the role of the medulla and the collecting duct of the kidney in the maintenance of the water balance in blood. [3 marks]

## Markscheme

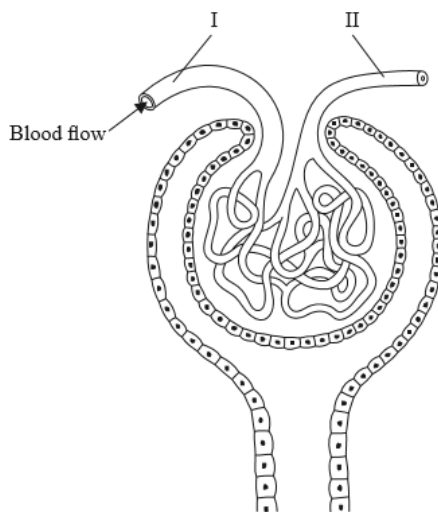
collecting duct has water channels/aquaporins/is permeable to water;  
 high solute concentration of medulla / medulla is hypertonic;  
 reabsorption of water allows excretion of concentrated urine (antidiuresis);  
 secretion of ADH/vasopressin increases permeability of collecting duct to water / *vice versa*;

- 51a. Explain the process of ultrafiltration. [2 marks]

## Markscheme

blood (in the glomerulus) under high pressure caused by difference in diameter of (afferent and efferent) arterioles;  
 fluid plasma and small molecules forced into kidney tubule/Bowman's capsule/ through fenestrations/basal membrane;  
 which prevent larger molecules/blood cells from passing through;

- 51b. The diagram below shows part of the human kidney. The arrow shows the direction of blood flow. [2 marks]



Compare the composition of the fluids found in the regions labelled I and II by giving **one** difference and **one** similarity.

Difference: .....

Similarity: .....

## Markscheme

*difference:* fluid at II has less urea/glucose/oxygen/salts/ions/water;  
*similarity:* fluid at II has same (amount of) proteins/blood cells as fluid at I;  
*Accept converse for both marking points.*

52a. Draw a labelled diagram of a mature sperm cell.

[4 marks]

## Markscheme

*Award [1] for each of the following clearly drawn and correctly labelled.*

- head and midpiece/mid-section/body;
- tail/flagellum; (*at least four times length of the head and containing fibres*)
- acrosome; (*shown as distinct structure near front of head*)
- nucleus; (*occupying more than half the width or length of head*)
- mitochondria; (*as repetitive structures inside membrane of mid piece*)
- centriole; (*between head and midpiece*)
- (plasma) membrane; (*shown as single line covering whole cell*)
- microtubules; (*in 9 plus 2 array*)

52b. Outline the role of hormones in the menstrual cycle.

[6 marks]

## Markscheme

- FSH promotes development of a new follicle;
- also leads to the production of estrogen;
- estrogen brings about repair and growth of uterine wall;
- estrogen causes negative feedback of FSH;
- estrogen brings about LH production;
- LH stimulates follicle growth;
- LH triggers ovulation;
- estrogen contributes to the proliferative phase of the uterine cycle / triggers LH surge;
- progesterone contributes to the secretory phase of the uterine cycle/maintains uterus wall;
- lowered level of progesterone (due to degeneration of corpus luteum) leads to menstruation;

52c. Discuss the cause, transmission and social implications of AIDS.

[8 marks]

## Markscheme

cause: [4 max]

- a. AIDS caused by HIV;
- b. penetrates (T) lymphocytes;
- c. (envelope) (glyco)protein and cell receptors involved;
- d. reverse transcriptase enables DNA to be produced from viral RNA; (*reject DNA transformed into RNA*)
- e. number of lymphocytes reduced over years;
- f. results in lower immunity;
- g. other illnesses develop (as result of lower immunity);
- h. AIDS is the observed syndrome when final stages of infection develop / *OWTTE*;

transmission: [3 max]

- i. HIV transmitted through blood/sexual contact/body fluids/placenta/childbirth/ breastfeeding;
- j. distribution/transmission uneven around the world;
- k. transmission risk increased depending on society's traditions/beliefs/behaviour;
- l. (rare minority of) individuals do not have cell receptors and do not develop AIDS;
- m. condoms/latex barriers only protection against transmission through sexual contact;

social implications: [3 max]

- n. treatment expensive;
- o. discrimination against victims;
- p. moral obligation of wealthy countries to help poorer countries;
- q. economic consequences / loss of wage earners etc.;
- r. increase in the number of orphans;
- s. comment on traditions/beliefs/behaviour; (*if not already awarded in transmission*) [8 max]

53a. Outline the thermal, cohesive and solvent properties of water.

[5 marks]

## Markscheme

water has a high specific heat capacity;  
a large amount of heat causes a small increase in temperature;  
water has a high latent heat of vaporization;  
a large amount of heat energy is needed to vaporize/evaporate water;  
hydrogen bonds between water molecules make them cohesive/stick together;  
this gives water a high surface tension / explains how water rises up xylem;  
water molecules are polar;  
this makes water a good solvent;

Award [4 max] if thermal, cohesive and solvent properties are not all mentioned.

53b. Explain the role of the kidney in maintaining water balance in humans.

[9 marks]

## Markscheme

process of water balance is called osmoregulation;  
water passes into the kidney tubules by ultrafiltration;  
water is reabsorbed in the proximal convoluted tubule;  
water reabsorbed into blood from the (descending limb) of the loop of Henle;  
process by osmosis;  
transport of salts into the medulla of kidney;  
changes salt concentration so water is reabsorbed;  
ADH released into blood when water is required;  
ADH causes concentrated urine / no/low ADH causes dilute urine;  
this causes more reabsorption of water from the collecting duct;  
excess water is released as urine;  
urine concentration depends on the body's need for water;  
drinking a lot gives dilute urine;

54a. Draw a labelled diagram of a mature human egg.

[5 marks]

## Markscheme

Award [1] for each structure accurately drawn and correctly labelled.

- haploid nucleus;
- cytoplasm – with nucleus-to-membrane distance >4 times nucleus diameter;
- centrioles – two must be shown but only one needs to be labelled;
- cortical granules – needs to be drawn in vicinity of plasma membrane;
- plasma membrane – shown as a single line and approximately circular overall;
- polar cell / (first) polar body – needs to be drawn outside the egg cell;
- zona pellucida / layer of gel (outside the cell membrane);
- follicle cells / corona radiata (outside the cell membrane);
- size shown as 100  $\mu\text{m}$ /0.1mm; (accept 90  $\mu\text{m}$  to 120  $\mu\text{m}$ )

54b. Outline a technique used for gene transfer.

[5 marks]

## Markscheme

- plasmid used for gene transfer/removed from bacteria;
- plasmid is a small/extra circle of DNA;
- restriction enzymes/endonucleases cut/cleave DNA (of plasmid);
- each restriction enzyme cuts at specific base sequence/creates sticky ends;
- same (restriction) enzyme used to cut DNA with (desired) gene;
- DNA/gene can be added to the open plasmid/sticky ends join gene and plasmid;
- (DNA) ligase used to splice/join together/seal nicks;
- recombinant DNA/plasmids inserted into host cell/bacterium/yeast;

54c. Explain how evolution may happen in response to environmental change with evidence from examples.

[8 marks]

## Markscheme

- a. variation in population;
- b. (variation is) due to mutation/sexual reproduction;
- c. valid example of variation in a specific population;
- d. more offspring are produced than can survive / populations over-populate;
- e. competition / struggle for resources/survival;
- f. example of competition/struggle for resources;
- g. survival of fittest/best adapted (to the changed environment)/those with beneficial adaptations / converse;
- h. example of changed environment and adaptation to it;
- i. favourable genes/alleles passed on / best adapted reproduce (more) /converse;
- j. example of reproduction of individuals better adapted to changed environment;
- k. alleles for adaptations to the changed environment increase in the population;
- l. example of genes/alleles for adaptations increasing in a population;
- m. evolution by natural selection;
- n. evolution is (cumulative) change in population/species over time / change in allele frequency;

*Suitable examples are antibiotic resistance and the peppered moth but any genuine evidence-based example of adaptation to environmental change can be credited.*

55a. Draw a labelled diagram to show the structure of the heart.

[5 marks]

## Markscheme

*Award [1] for each of the following structures clearly drawn and labelled correctly in a diagram of the heart.*

- a. left ventricle/right ventricle – both left and right ventricles must be shown but the mark can be awarded if either is correctly labelled. The left must be thicker walled than right and both must be larger than the atria;
- b. left atrium/right atrium – both left and right atria must be shown with thinner walls than ventricles, but the mark can be awarded if either atrium is correctly labelled;
- c. atrio-ventricular valves/tricuspid and bicuspid valves – positioned between atria and ventricles, with both labelled and tri/bicuspid correct if these names are used;
- d. semi-lunar valves – shown at the start of the aorta and pulmonary artery, with the cusps facing in the right direction;

*Award [1] for any two blood vessels clearly drawn and correctly labelled.*

aorta – shown connected to the left ventricle;

pulmonary artery – shown connected to the right ventricle;

pulmonary vein – shown connected to the left atrium;

vena cava – shown connected to the right atrium;

55b. Outline how the human body responds to high blood glucose levels.

[5 marks]

## Markscheme

- a. (high blood glucose levels) detected by pancreas islet cells/beta cells;
- b. insulin secreted in response (to high blood glucose/glucose above threshold level);
- c. insulin stimulates cells to absorb glucose;
- d. glucose used in cell respiration (rather than lipids);
- e. glucose converted to glycogen (in liver/muscle cells);
- f. glucose converted to fatty acids/triglycerides/fat;
- g. negative feedback process;

55c. Explain the role of the nephron in maintaining the water balance of the blood in the human body.

[8 marks]

## Markscheme

- a. ultrafiltration in the glomerulus produces (large volumes of) filtrate;
- b. 80%/most of water in filtrate is (always) (re)absorbed in proximal convoluted tubule;
- c. water reabsorbed from filtrate in descending loop of Henle;
- d. pituitary gland secretes ADH if blood solute concentration is too high;
- e. ADH makes the collecting duct/distal convoluted tubule more permeable to water;
- f. ADH moves aquaporins into the membranes (of cells in the tubule wall);
- g. more water reabsorbed from filtrate/into blood due to ADH;
- h. blood becomes more dilute / small volume of urine with high solute concentration;
- i. with low/no ADH less water is reabsorbed in the collecting duct;
- j. blood becomes more concentrated / large volume of dilute urine;
- k. water reabsorption in collecting duct due to high solute concentration of medulla;
- l. active transport of  $\text{Na}^+$  ions from filtrate in ascending limb of loop of Henle;

56a. Draw a labelled diagram of the human adult male reproductive system.

[5 marks]

## Markscheme

- a. scrotum – *shown around testes*;
  - b. testis/testis/testicle – *shown inside scrotum*;
  - c. epididymis – *shown adjacent to testis and connected to sperm duct*;
  - d. sperm duct/vas deferens – *double line connecting testis/epididymis to urethra*;
  - e. seminal vesicles – *sac shown branched off sperm duct (not off the urethra)*;
  - f. prostate gland – *shown positioned where sperm duct connects with urethra*;
  - g. urethra – *shown as double line linking bladder to end of penis*;
  - h. penis – *with urethra passing through it*;
- Award [1] for each structure clearly drawn and labelled that conforms to the italicized guidelines given.*

56b. Describe the application of DNA profiling to determine paternity.

[5 marks]

## Markscheme

- a. DNA from child, mother and possible father(s) used to establish paternity;
- b. (DNA profiling is done) for legal reasons / divorce / inheritance;
- c. (DNA profiling is done) for personal reasons / self-esteem issues for children/fathers/parents;
- d. DNA copied/amplified using PCR;
- e. DNA cut using restriction enzymes;
- f. (gel) electrophoresis used to separate DNA fragments;
- g. pattern of bands is produced (in gel);
- h. analysed for matches between child with mother and possible father;
- i. (about) half the child's bands will match the father (while the other half will match the mother);

56c. Explain the inheritance of colour blindness.

[8 marks]



## Markscheme

- a. colour blindness caused by recessive allele / colour blindness is recessive;
- b. gene located on X chromosome/sex-linked;
- c.  $X^b$  is allele for colour blindness and  $X^B$  is allele for normal colour vision/dominant allele;
- d. male has one X and one Y chromosome;
- e. male has only one copy of gene(s) located on X chromosome;
- f. X chromosome (in males) comes from female parent;
- g. any male receiving allele from mother will express the trait;
- h.  $X^bY$  is genotype for colour blind male;
- i. many more males have colour blindness than females;
- j. female will express colour blindness only if is homozygous recessive/ $X^b X^b$ ;
- k. heterozygous/ $X^B X^b$  female is a carrier;
- l. colour blind female could be born to colour blind father and carrier mother;

Marks may be earned for use of **annotated** diagram/Punnett square to show points given above.

Accept use of letters other than B and b as long as capital letter is used for dominant and lower case letter for recessive alleles. For using other improper notation (not showing X or Y), award **[0]** for the first misuse and then apply ECF to additional notation as long as usage is consistent.

(Plus up to **[2]** for quality)

57a. Explain how skeletal muscle contracts.

[8 marks]

## Markscheme

Remember, up to **TWO** “quality of construction” marks per essay.

- a. sliding filament model / filaments/actin and myosin slide past each other;
  - b. action potential/depolarisation/nerve impulse arrives at end of motor neurone;
  - c. neurotransmitter/acetylcholine released causing action potential (in muscle fibre);
  - d. sarcoplasmic reticulum releases calcium ions;
  - e. calcium ions cause binding sites on actin/for myosin to be exposed;
  - f. myosin heads bind to sites on actin/form cross-bridges;
  - g. myosin (head) moves actin filament using energy from ATP;
  - h. actin moved towards the centre of sarcomere/M line/M band;
  - i. sarcomeres shortened;
  - j. (binding of) ATP causes release of myosin head from actin;
  - k. conversion of ATP to ADP and Pi causes myosin heads to change angle;
  - l. cycle (of events) repeated (during muscle contraction);
- Accept the above points in annotated diagrams.

57b. Active skeletal muscle requires a good supply of oxygen. Outline the mechanism of ventilation in the lungs.

[6 marks]

## Markscheme

Remember, up to TWO “quality of construction” marks per essay.

during inhalation:

- external intercostal muscles contract moving rib cage up and out;
- diaphragm contracts becoming lower/flatter;
- increase in volume and decrease in pressure (of thorax);
- air flows into lungs as atmospheric pressure is higher;

during exhalation:

- internal intercostal muscles contract so ribs move in and down;
- diaphragm relaxes and returns to domed shape;
- decrease in volume and (therefore) increase in pressure (of thorax);
- air moves out until pressure in lungs falls/is equal to atmospheric pressure;
- abdominal muscles can be used to make a stronger/forced exhalation;

58a. Outline what is meant by homeostasis.

[4 marks]

## Markscheme

maintaining (stable) internal environment/conditions;  
within (narrow) limits;  
example (e.g. body temperature / blood pH / blood glucose / water / CO<sub>2</sub> concentration);  
levels of these variables are monitored (internally);  
negative feedback mechanisms / *OWTTE*; (*reject if positive feedback included*)  
involves hormonal / nervous control;

58b. Describe how body temperature is maintained in humans.

[6 marks]

## Markscheme

maintained close to 36.7/37°C/98.6°F ;  
heat is transferred/distributed in body by blood;  
hypothalamus contains thermoreceptors;  
hypothalamus monitors temperature/sends message to effectors/causes response;  
(vaso) dilation of skin arterioles warms skin/cool body;  
(vaso) constriction of skin arterioles retains body heat;  
skin/sweat glands produce sweat to cool the body when overheated;  
removal of heat through evaporation of sweat;  
shivering generates heat / increased metabolism / hair erection to retain heat;  
example of behavioural change to warm/cool the body to thermoregulate;

58c. Explain the processes occurring in the kidney that contribute to osmoregulation.

[8 marks]

## Markscheme

osmoregulation is maintenance of water balance of blood/tissues;  
loop of Henle creates hypertonic conditions in the medulla;  
water reabsorbed as filtrate passes through collecting duct;  
hypothalamus monitors/controls water balance/content of blood;  
controls secretion of ADH by (posterior) pituitary gland;  
ADH is released when blood too concentrated/too little water/hypertonic;  
ADH makes the collecting duct more permeable to water;  
due to more aquaporins;  
more water reabsorbed (in response to ADH);  
less water in urine/urine more concentrated/urine hypertonic;  
no/less ADH when blood too dilute/too much water/hypotonic;  
collecting duct less permeable/less water reabsorption/more water in urine;

59a. Draw a labelled diagram of the digestive system.

[4 marks]

## Markscheme

Award [1] each for the following structures clearly drawn and correctly labelled.

esophagus – connected to top of stomach;

stomach – connected to small intestine;

small and large intestines – connected to each other;

liver shown as larger than the stomach with gall bladder shown under/embedded in liver;

gall bladder – connected to the small intestine (via bile duct);

pancreas – connected to small intestine (via pancreatic duct);

59b. Many people cannot digest lactose and benefit from a diet containing no lactose. Outline the production of lactose-free milk.

[6 marks]

## Markscheme

milk contains lactose / lactose is milk sugar;

lactose is broken down to glucose and galactose;

by (the enzyme) lactase;

which is lacking in people with lactose intolerance;

lactose-free milk is sweeter than milk containing lactose;

lactase produced by small intestine / produced by yeast sometimes found in milk;

can be added directly to milk;

immobilized in beads / biotechnological techniques;

ultrafiltration of milk to remove lactose;

59c. Explain how the kidney helps to retain useful substances in the blood and eliminate substances which the body does not need.

[8 marks]

## Markscheme

ultrafiltration occurs in the glomerulus;

basement membrane acts as a filter;

preventing proteins/cells from passing;

(filtered) substances pass to the Bowman's capsule;

to proximal convoluted tubule (PCT);

(where there is) selective reabsorption;

(in PCT) all glucose/amino acids are reabsorbed;

(in PCT) most) water reabsorbed;

surrounding the loop of Henle, is an area of high solute concentration;

in distal convoluted tubule, ions are exchanged between filtrate and blood;

collecting duct has role in osmoregulation;

ADH regulates the amount of water reabsorbed;

substances not reabsorbed are eliminated as urine;

60a. Describe the production of semen.

[6 marks]

## Markscheme

sperm produced by meiosis;

in testis/seminiferous tubules;

sperm are stored/mature in the epididymis;

sperm able to swim;

seminal vesicles add fluid;

(seminal) fluid rich in fructose;

prostate gland adds fluids;

fluid rich in proteolytic enzymes/citric acid/acid phosphatase/lipids/minerals;

(semen) contains basic amines/alkaline substances;

which neutralizes acid/hostile environment of the vagina;

60b. Explain the structure and function of the placenta.

[8 marks]

## Markscheme

disc-shaped structure;  
connected to the fetus by an umbilical cord;  
placenta is embryonic and maternal tissue;  
placental villi increase the surface area (for exchange);  
fetal capillaries in placenta/placental villi;  
inter-villous spaces/sinuses through which mother's blood flows;  
fetal and mother's blood do not mix / small distance between fetal and mother's blood;  
transfer of foods/nutrients/glucose from mother to fetus;  
fetal gas exchange/transfer of oxygen from mother to fetus;  
transfer of excretory/waste products/CO<sub>2</sub> from fetus to mother;  
transfer of antibodies/hormones from mother to fetus;  
secretion of estrogen/progesterone/HCG;  
*Allow reference to embryo instead of fetus throughout.*

60c. Outline the hormonal control of birth.

[4 marks]

## Markscheme

at about 38 to 40 weeks pregnancy/end of pregnancy/progesterone levels decrease;  
removes inhibition of oxytocin secretion;  
(oxytocin) released from (posterior) pituitary;  
oxytocin stimulates uterus contraction;  
cervix widens/dilates;  
increase in oxytocin increases rate and intensity of contractions;  
positive feedback;

61a. Blood is a liquid tissue containing glucose, urea, plasma proteins and other components. List the other components of blood.

[5 marks]

## Markscheme

plasma/water;  
dissolved gases / CO<sub>2</sub> / O<sub>2</sub>;  
erythrocytes / red blood cells;  
leucocytes / white blood cells;  
lymphocytes and phagocytes;  
platelets;  
hormones / named hormone(s);  
amino acids / albumin / antibodies;  
salts / minerals / ions other named solute in plasma apart from glucose, urea and plasma proteins;

61b. Outline how the human body prevents blood glucose concentration from rising excessively.

[5 marks]

## Markscheme

blood glucose concentration monitored by pancreas/islets/beta cells;  
(more) insulin secreted in response to high blood glucose / glucose above threshold level;  
insulin stimulates cells to absorb glucose;  
glucose used in cell respiration (rather than lipids);  
glucose converted to glycogen;  
by liver/muscle cells;  
glucose converted to fatty acids / triglycerides / fat;  
negative feedback process;  
*Accept these points if clearly made in an annotated diagram.*

- 61c. Blood plasma, glomerular filtrate and urine have different concentrations of solutes, such as glucose, protein and urea. Explain the [8 marks] processes occurring in the kidney that cause differences in the concentrations of these solutes between blood plasma, glomerular filtrate and urine.

## Markscheme

(filtrate formed by) ultrafiltration;  
glucose / amino acids / soluble components enter Bowman's capsule;  
proteins in blood plasma but not in filtrate / proteins not filtered out (of blood);  
glucose not in urine (normally);  
(selective) reabsorption (of glucose);  
in the proximal convoluted tubule;  
by active transport / microvilli increase the surface area;  
little/no urea reabsorbed  
concentration increases / urea more concentrated in urine than in blood plasma;  
water reabsorbed from filtrate;  
by osmosis;  
in descending limb of nephron / in proximal convoluted tubule;  
salts actively transported into the medulla (from filtrate);  
creating concentration gradient/hypertonic medulla;  
collecting duct permeability altered depending on blood solute concentration;