14. Homeostasis

14.1 Homeostasis in Mammals

Paper 4

Marking Scheme

Q1.

(a)(i)	hypothalamus ;	1
(a)(ii)	(changes in) water potential (of blood) ; **A** ψ	1
(a)(iii)	posterior pituitary (gland) ;	1
(b)(i)	61.5(%) ;; 61.538461 *allow one mark for not rounding to one decimal place*	2
(b)(ii)	*any **three** from:* 1 (increase in ADH results in) aquaporins added to, cell surface membrane / luminal membrane / plasma membrane ; 2 more water leaves, filtrate / collecting duct **or** more water reabsorbed / more water enters blood or tissue fluid ; 3 so urine, **volume** decreases / **concentration** increases ; 4 AVP ; e.g. ADH binds to receptor / increase in permeability of (cell surface) membrane / *ref. to* water moving, down a water potential gradient or by osmosis **I** descriptions	3

Q2.

(a)	negative feedback ;	1
(b)	*any **three** from:* 1 (blood) glucose concentration decreases due to increased respiration **or** (blood) glucose concentration decreases due to glucose used to generate ATP for, muscle contraction / movement / exercise ; 2 glucagon released (from pancreas) ; 3 glucagon acts on liver cells ; 4 glycogenolysis occurs / description ; 5 glucose released into blood so (blood) glucose concentration, increases / returns to set point ; 6 AVP ; e.g. gluconeogenesis / ref. cell signalling	3
(c)(i)	**A** – gluconic acid / gluconolactone ; **B** – chromogen ;	2
(c)(ii)	*any **two** from:* 1 measures, current / direct, blood glucose concentration ; 2 accurate reading / quantitative / numerical / digital ; 3 reusable ; 4 AVP ; e.g. can use regularly / convenient digital store of data / connected to phone or surgery	2

Q3.

<table>
<tr><td>(a)(i)</td><td>A – podocyte ;

B – (capillary) endothelial cell ;</td><td>2</td></tr>
<tr><td>(a)(ii)</td><td>high(er), hydrostatic / blood, pressure ; Ignore ref. to water potential
basement membrane acts as a filter / only small molecules can pass through basement membrane ;</td><td>2</td></tr>
<tr><td>(b)</td><td><table>
<tr><th>component of blood plasma in glomerulus</th><th>component in newly formed glomerular filtrate</th><th>component in urine</th><th></th></tr>
<tr><td>glucose</td><td>same</td><td>not present</td><td>;</td></tr>
<tr><td>large proteins</td><td>not present</td><td>not present</td><td>;</td></tr>
<tr><td>urea</td><td>same</td><td>increased</td><td>;</td></tr>
</table></td><td>3</td></tr>
<tr><td>(c)</td><td>posterior pituitary gland – releases (more) ADH ; A secretes

kidney – reabsorbs more water / urine more concentrated / lower volume of urine ;
OR
(more) aquaporins added to membrane of collecting duct (cells) / membrane of collecting duct (cells) more permeable to water ;</td><td>2</td></tr>
</table>

Q4.

(a)	*any **four** from:* 1 changes in factor / stimulus, detected by receptor ; 2 *ref. to* CNS / brain / coordinator ; 3 impulses / (named) hormone, sent to, (named) effector / muscle / gland ; 4 (named) effector / muscle / gland, carries out response ; 5 factor **returns** to, set point / norm ; 6 negative feedback ; 7 AVP ; e.g. cell signalling	**4**

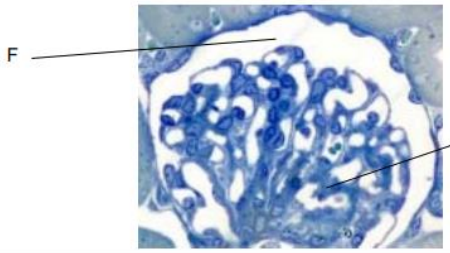
(b)	*any **three** from:* *cell signalling carries on* 1 / 2 two details ;; e.g. glucagon binds to receptors / adenylyl cyclase stimulated / G protein activated / cAMP formed / protein kinase A activated / enzyme cascade 3 no / less, (functioning) glycogen phosphorylase (produced) **OR** non-functioning glycogen phosphorylase (produced) **OR** no / less, glycogen phosphorylase activated ; 4 change in, tertiary structure / active site ; 5 (so) less / no, glycogen converted to glucose / glycogenolysis ;	**3**
(c)	*any **three** from:* 1 no / less, (functioning) glycogen synthase (produced) **or** non-functioning glycogen synthase (produced) **or** no / less, glycogen synthase activated ; 2 high / increase in, blood glucose <u>concentration</u> (following this meal) ; 3 (so) glucose (excreted) in urine ; 4 more lipid synthesis ; 5 inhibits release of glucagon ; 6 AVP ; e.g. affects blood water potential / dehydration / thirst / tiredness / coma / affects blood pressure	**3**

Q5.

(a)(i)	**1** (excess) amino acids, deaminated / have amino group removed ; **2** in the liver ;	**2**
(a)(ii)	*any **three** from:* **1** osmoreceptors in hypothalamus (detect change / are receptors) ; **2** effector(s): collecting duct / distal convoluted tubule / nephron ; **3** target cells: collecting duct (cells) ;	**3**

(b)	*any **three** from:* **1** ultrafiltration / forms glomerular filtrate ; **2** high, hydrostatic / blood, pressure in, glomerulus / capillaries ; **3** so, water / (named) solutes, move (out of glomerulus / into Bowman's capsule) ; **4** through *two of*: fenestrae / fenestrations basement membrane slit pores / filtration slits / between podocytes ; **5** AVP ;	**3**
(c)	*any **three** from:* **1** high(er / est), U:P / ratio → can tolerate water shortage ; **2** high(er / est), U:P / ratio → much water reabsorbed / small volume of urine produced ; **3** high(er / est), U:P / ratio → can, concentrate urine / conserve water **OR** high(er / est), U:P / ratio → (well) adapted to dry environment ; **4** AVP ;	**3**

Q6.

(a)		**2**
(b)(i)	$\frac{118-52}{60}$ **or** $\frac{118-52}{69}$ **or** $\frac{118-52}{51}$; 1.1 **or** 1.0 **or** 1.3 ; $cm^3\ min^{-1}\ y^{-1}$; **A** $cm^3\ min^{-1}$ / year **A** year(s) $^{-1}$ **R** yr or yrs or mins	**3**

(b)(ii)	*any **three** from:* 1 high(er), hydrostatic / blood, pressure causes higher GFR ; **ora** 2 water / solute, potential gradient between glomerulus and Bowman's capsule affects GFR ; 3 kidney disease / named, decreases GFR ; e.g. damage to nephron or basement membrane / cancer 4 dehydration / lower water potential of blood, decreases GFR ; **ora** 5 high altitude decreases GFR ; **ora** 6 drugs / named, affects GFR ; e.g. diuretics / beta blockers / vasodilators / NSAIDS / ACE inhibitors 7 larger difference between afferent arteriole lumen and efferent causes higher GFR ; **ora**	**3**

(c)	*any **seven** from:* 1 Na^+, actively transported / pumped, out of cells ; 2 Na^+ enter blood ; 3 Na^+ concentration in cells decreases **or** Na^+ concentration gradient (between pct lumen and cytoplasm) / described ; 4 Na^+ enter cells from, filtrate / lumen ; 5 by facilitated diffusion ; 6 cotransport of, glucose / amino acids ; **I** secondary active transport 7 water potential of cells decreases ; 8 water enters cells from (filtrate / lumen) by, osmosis / down the water potential gradient ; 9 glucose / amino acids, leave cells by, (facilitated) diffusion / described ; 10 glucose / amino acids, reabsorbed **or** move into , tissue fluid / blood ; 11 AVP ; e.g. other named ions reabsorbed	**7**

Q7.

(a)	glands ; cell surface membrane / plasma membrane ; **A** liver (cells) second messenger / cAMP ; **A** enzyme cascade / phosphorylation of enzymes / signalling cascade (striated) muscles ; collecting duct ; homeostasis ;	**6**
(b)(i)	1 insulin, produced / released ; 2 increase in uptake of glucose into cells ; 3 detail of uptake ; e.g. increase permeability of cell surface membrane (to glucose) / GLUT added to cell surface membrane 4 increase / stimulates, respiration of glucose (in cells) / phosphorylation of glucose ; 5 (stimulates) glycogenesis / conversion of glucose to lipids ;	**3**
(b)(ii)	*ref.* glucagon ;	**1**

Q8.

(a)(i)	**A** = glomerulus ; **B** = Bowman's capsule ;	**2**
(a)(ii)	*any **four** from:* **1** ultrafiltration ; **2** high(er) pressure due to afferent arteriole wider than efferent arteriole ; **3** capillary endothelium has, fenestrations / gaps / holes / pores ; **4** small molecules / (named) ions / glucose / amino acids / urea / water, **and** **EITHER** leave, blood / plasma / capillary / glomerulus **OR** enter, capsule / filtrate / tubule ; **5** basement membrane forms, (main) filtration / selective, barrier ; **6** (R)MM / M_r, limit of, 68 000 to 70 000 (Da) / 68–70 kDa ; **7** podocytes, form slit pores / support basement membrane ;	**4**
(b)(i)	**C** adenyl(yl) cyclase ; **D** c(yclic) AMP ;	**2**
(b)(ii)	*any **four** from*: **1** in both as Na^+ concentration increases ADH concentration increases (after a, certain / stated, point) ; **2** in, type C / SIAD, ADH rise occurs at a lower Na^+ concentration ; **3** comparative figures ; **4** (ADH →) more aquaporins / greater permeability to water, in collecting duct / DCT ; **5** (C / SIAD / ADH →) more water reabsorbed, at collecting duct / at DCT / into blood ; **6** (C / SIAD / ADH →) small(er) volume of / (more) concentrated, urine ; **7** type C / SIAD, causes, high blood water potential / low blood Na^+ concentration ;	**4**

Q9.

(a)(i)	**P**: receptor ; **Q**: adenyl(yl) cyclase ; **R**: G-protein ; **S**: cyclic AMP / cAMP ;	**4**

(a)(ii)	<table><tr><th>process</th><th>effect on rate of process when blood glucose concentration decreases</th></tr><tr><td>glycogenolysis</td><td>increase</td></tr><tr><td>glycogenesis</td><td>decrease</td></tr><tr><td>glycolysis</td><td>decrease</td></tr><tr><td>fatty acid synthesis</td><td>decrease</td></tr></table> ;;; 4 correct = 3 marks 3 correct = 2 marks 1/2 correct = 1 mark	**3**
(b)	*any **four** from:* 1 strip contains glucose oxidase and peroxidase ; 2 strip dipped into urine ; 3 glucose (and oxygen) reacts with glucose oxidase to produce hydrogen peroxide ; 4 hydrogen peroxide reacts with peroxidase to produce a colour change ; 5 colour is matched with a colour chart to give, reading / estimate, of glucose concentration ; *any **three** from:* 6 quick(er) ; 7 (more) sensitive / accurate / precise ; 8 gives immediate reading ; 9 results can be stored electronically / can be connected to smart phone / AW ; 10 numerical / digital / quantitative / objective ; 11 reusable ;	**7**

Q10.

(a)	*any **four** from:* 1 (drink of water causes) increase in blood water potential / AW ; 2 detected by, osmoreceptors / hypothalamus ; 3 causes decrease in release of ADH (into blood in first hour) ; 4 less water reabsorbed (from collecting ducts) ; 5 (so) decrease in blood water potential / blood water potential returns to set point ; 6 causes increase in release of ADH ; 7 negative feedback ;	**4**

Q11.

(b)	**A**: adenylyl cyclase ; **B**: protein kinase A ;	**2**

Q12.

(a)	**A** – distal convoluted tub(ul)e ; **B** – cortex ; **C** – loop of Henlé ;	**3**

(b)	*any **three** from:* 1 as ADH concentration increases urine concentration increases ; 2 as ADH concentration increases urine flow rate decreases ; 3 as urine flow rate decreases urine concentration increases ; 4 data quote with units ; 5 AVP ;	**3**
(c)	*any **five** from:* 1 ADH binds to cell, surface / membrane, receptor (of collecting duct cells) ; 2 *ref.* G protein / adenyl(ate) cyclase ; 3 second messenger / cAMP ; 4 protein kinase activated ; 5 vesicles, move towards / fuse with, cell (surface) membrane ; 6 *correct ref.* aquaporins ; 7 collecting duct / cells / membrane, (more) permeable to water ; 8 more water, leaves, lumen / nephron **or** more water enters, blood / medulla ;	**5**

Q13.

	1 internal ; 2 negative feedback ; 3 receptor(s) ; 4 endocrine / islets of Langerhans / α and β ; 5 glycogen ;	**5**

Q14.

(a)	homeostasis / negative feedback ;	1
(b)(i)	blood(stream) / circulation ;	1
(b)(ii)	**A** – adenyl,(-yl) / (-ate), cyclase ; **B** – cyclic AMP / cAMP ;	2
(b)(iii)	amplifies signal / expands message ;	1
(b)(iv)	break down glycogen / glycogen → glucose / glycogenolysis ;	1
(c)	*any **four** from:* **1** blood on, pad / strip, inserted into, biosensor / glucometer ; **2** glucose oxidase ; **3** (glucose) → gluconic acid and hydrogen peroxide ; **4** (electric) current / flow of electrons / voltage ; **5** (current) proportional to glucose, quantity / concentration ; **6** digital / numerical, reading (on screen) ;	4

Q15.

(a)	to generate a high, blood pressure / hydrostatic pressure ; **Ignore** to increase the blood pressure to force, plasma / fluid / water, through basement membrane / into the Bowman's capsule / into lumen ; **R** osmosis / diffuse **Ignore** named substance e.g. glucose	2
(b)(i)	**A** – basement membrane ; **B** – podocyte ;	2
(b)(ii)	*any **three** from:* **A** basement membrane 1 acts as a, filter / filtration barrier ; 2 only, named molecules / ions / molecules less than 68 000–70 000 (R)MM, can pass through **or** red blood cells / large proteins, cannot pass through ; **B** podocyte 3 has, gaps / slits / projections / pores ; 4 allows, fluid / water / filtrate, to pass into the, lumen / Bowman's capsule ; 5 produces, **A** / basement membrane ;	3

Q16.

(b)	glycogenolysis / described ; gluconeogenesis / described ; e.g. glucose from, amino acids / fatty acids	**2**

(d)	*any **three** from:* **1** change in a parameter ; **2** detected by receptor ; **3** coordination / described ; **4** (corrective) action taken by effector ; **5** return to, set point / norm / optimum ;	**3**

Q17.

(a)	<table><tr><th>response</th><th>explanation</th></tr><tr><td>blood vessels near the surface of the skin constrict (narrow)</td><td>less heat lost as, less / slower, blood (flow) at, skin / surface ;</td></tr><tr><td>shivering occurs</td><td>muscle contraction, creates / generates / produces, heat ;</td></tr><tr><td>hairs rise</td><td>trapped air, insulates / reduces thermal gradient ;</td></tr><tr><td>reduction in the production of sweat</td><td>to stop / decrease, heat loss by evaporation ;</td></tr></table>	**4**
(b)	decrease / less, surface area to, conserve / retain heat **or** decrease / less, surface area so less heat lost ;	**1**
(c)(i)	*any **three** from:* **1** Sitatunga's (core / body) temperature (fairly) constant ; **2** Nile monitor's / lizard's, (core / body) temperature rises as environmental temperature rises ; **3** figures for two animals at one temperature with units **or** one animal at two temperatures with units ; **4** AVP ;	**3**
(c)(ii)	problem with, catching prey / feeding / avoiding predation ;	**1**
(d)	**1** *ref. to* set point / norm(al) / ideal value ; **2** rise / fall / change / fluctuation ; **3** reversed / corrected / counter-acted ;	**3**

Q18.

(a)	idea of shortage of, glutamate / an amino acid, in diet ;	**1**

(c)	osmoreceptors in hypothalamus ;	**1**
(d)	*any **five** from:* 1 (ADH) secreted / released, into blood by posterior pituitary ; 2 binds to receptors on cell surface membranes ; 3 of collecting duct cells ; 4 enzyme cascade ; 5 vesicles with aquaporins move towards (cell surface) membrane ; 6 add aquaporins to (cell surface) membrane ; 7 water moves from collecting duct into blood, down a water potential gradient / by osmosis ; 8 water potential of blood rises ;	**5**

Q19.

(a) — **4**

feature	letter
glomerular filtrate	**E** ;
basement membrane	**C** ;
podocyte cells	**D** ;
capillary endothelial cell	**A** ;

(b) — **5**

*any **five** from:*

1 afferent arteriole, (lumen) wider / has larger diameter, than efferent ;

2 causes high, blood / hydrostatic, pressure in, glomerulus / capillaries ;

3 pores / gaps / fenestrations, in capillary endothelium ; **I** holes in cells

4 basement membrane acts as a filter / AW ;

5 detail of podocytes ; e.g. finger-like structures / folds / slit pores

6 correct *ref. to* passage of substances ; e.g. basement membrane stops, blood cells / large proteins / molecules above RMM 68 000–70 000 **or** allows urea / glucose / amino acids / ions / water

7 *idea of* network of capillaries ;

(c)(i) — **2**

*any **two** from:*

1 as (mean arterial blood) pressure increases the GFR increases, levels off and increases / AW ;

2 (plateau occurs) at 100 cm^3 min^{-1} / between 10 and 20 kPa ;

3 AVP ; e.g. plateau is normal or healthy value

(c)(ii) — **1**

*any **one** from:*

1 kidney, damage / disease / cancer ;

2 dehydration ;

3 low, blood / hydrostatic, pressure **or** blood loss ;

4 AVP ; e.g. other (relevant) disease

Q20.

(a)(i)	homeostatis / negative feedback ;	**1**
(a)(ii)	sarcoplasmic reticulum ;	**1**
(a)(iii)	*any **four** from:* 1 (Ca^{2+}) binds to troponin ; 2 troponin changes shape ; 3 troponin / tropomyosin, moves ; 4 binding sites on actin exposed ; 5 myosin heads, attach / form cross bridges ; 6 myosin head tilts and pulls actin ;	**4**
(a)(iv)	*any **two** from:* 1 activates protein kinase ; 2 acts as second messenger ; 3 AVP ; e.g. stimulates signaling cascade activates other (named) enzyme	**2**

(b)	*any **three** from:* 1 decreased uptake of glucose / decreased permeability to glucose ; 2 decreased glycogenesis ; 3 decreased glucose, oxidation / respiration ; 4 change in, fatty acids / fat, metabolism ; 5 AVP ; e.g. *ref. to* effect on glucagon	**3**

Q21.

(a)

description	letter
efferent blood vessel	**B ;**
part of nephron containing cells that respond to ADH	**F, G ;**
part of nephron where podocyte cells are located	**C ;**
part of nephron containing cells that are located in the medulla	**E, G ;**

4

(b)

*any **five** from:*

1 microvilli / basal membrane folds, increase / give large, surface area ;

2 for / many, (named) transport proteins ;

3 Na^+ / sodium ions, and, glucose / amino acids, move / co-transported, into cell (from filtrate / lumen) ;

4 Na^+ / sodium ions, pumped / move (out of cell) to, blood / tissue fluid ;

5 *ref. to* active transport ;

6 many mitochondria, give / for, energy / ATP ;

7 tight junctions and reason ;

5

(c)(i)

*any **two** from:*

1 as water potential (of blood) increases concentration of ADH (in the blood) decreases ;

2 two ADH figures related to two % change in water potential figures ;

3 between 0% and (+)10% change in water potential, ADH (concentration), does not change / is constant / stays the same / plateaus ;

2

(c)(ii)

blood, volume / pressure, decreases ;

1

Q22.

(a)	*any **five** from:* 1 (ACTH) binds to receptor on cell surface membrane (of adrenal gland cells) ; 2 G protein activated ; 3 adenylyl cyclase activated ; 4 cyclic AMP made from ATP ; 5 (cyclic AMP) second messenger ; 6 (cyclic AMP) binds to kinase (enzyme) ; 7 *ref. to* enzyme cascade / activation of enzymes by phosphorylation ; 8 amplifies signal ; 9 (amplification of signal) results in synthesis of cortisol ;	**5**
(b)	negative feedback ;	**1**

(d)	*any **one** from:* 1 decrease in water potential of the blood ; 2 eating food with high salt content ; 3 excessive panting (because of increased body temperature) ; 4 AVP ; e.g. diabetes	**1**

Q23.

(a)	cell surface membrane / plasma membrane ; glycoprotein / protein / polypeptide ; **R** channel protein	**2**
(b)(i)	$\frac{19-5}{5}\times 100$ **or** $\frac{14\times 100}{5}$; 280(%) ; *ecf – if candidate uses 18 instead of 19 then allow correct total of 260 for one mark*	**2**
(b)(ii)	(catalyses) glycogen production **or** decreases (blood glucose concentration) ;	**1**

Q24.

(a)(i)	*any **one** from:* 1 decrease in water potential (of the blood) ; **I** low water potential 2 lower blood volume ; 3 increase in, ion / salt, concentrations (of the blood) ;	**1**
(a)(ii)	posterior pituitary (gland) ;	**1**
(b)	**A** – receptor ; **I** G-protein **B** – vesicle ; **I** aquaporin	**2**
(c)	*any **four** from:* 1 (**B** / vesicles) moves towards / fuses with, cell surface membrane ; **Ignore** aquaporins 2 aquaporins added to cell surface membrane ; **A** water channels 3 cell surface membrane more permeable to water ; 4 water moves from, collecting duct / lumen / filtrate, into, cell / blood / tissue fluid ; 5 by osmosis / down water potential gradient ; 6 water potential of blood, rises / returns to set point ; 7 less water lost (in urine / from body) ; **A** urine, more concentrated / lower volume	**4**

Q25.

(a)(i)	correct lines ;;	**2**
(a)(ii)	basement membrane ;	**1**
(b)	<table><tr><th>afferent arteriole lumen diameter</th><th>efferent arteriole lumen diameter</th><th>GFR</th></tr><tr><td>normal</td><td>normal</td><td>normal</td></tr><tr><td>decreased</td><td>normal</td><td>decrease ;</td></tr><tr><td>normal</td><td>increased</td><td>decrease ;</td></tr></table>	**2**
(c)	*any **five** from:* 1 active transport / pumping, of Na+ (out of cells) into, blood / tissue fluid ; 2 sodium (potassium) pumps in basal membrane ; 3 Na^+ concentration decreases inside cells / Na^+ concentration gradient set up ; 4 (so) Na^+ enters (epithelial / tubule) cells from, lumen / filtrate ; 5 by facilitated diffusion ; 6 Na^+ co-transports glucose into cell ; 7 this is, secondary / indirect, active transport ; 8 (facilitated) diffusion of glucose (out of cells) into blood ; 9 GLUT proteins ;	**5**

(d)	*any **three** from:* 1 microvilli, has large surface area / for increased (re)absorption ; **I** increase surface to volume ratio 2 many mitochondria provide ATP for, sodium (potassium) pumps / active transport ; 3 tight junctions / closely packed cells, hold adjacent cells together / prevents leakage / fluid cannot pass between cells / substances must pass through cells ; 4 many transport proteins for movement of named substance ;	**3**

Q26.

(a)(i)	*any **three** from:* 1 blood glucose concentration rises in both with drink ; 2 diabetic, always / initially, has high**er** blood glucose concentration ; 3 diabetic has, high**er** peak / steep**er** rise, in blood glucose concentration ; 4 diabetic blood glucose concentration, has slower fall / does not return to normal in 3 hours / is still high after 3 hours ; 5 compare two data points with *x* and *y* figures and units ;	**3**

(a)(ii)	β cells / pancreas / islets of Langerhans / hypothalamus ;	**1**
(a)(iii)	negative feedback ;	**1**
(b)(i)	**A** – glucose oxidase ; **B** – (hydrogen) peroxidase ;	**2**
(b)(ii)	*biosensor* – rapid / immediate / 2 seconds, reading **or** (more), accurate / precise / quantitative / numerical / sensitive **or** shows current blood glucose / re-usable ; *dipstick* – non-invasive / painless / less risk of infection / easy to use / cheap ;	**2**
(c)	*any **five** from:* 1 (insulin) binds to receptors on, liver / muscle / adipose (cells / tissue / organ) ; 2 GLUT(4) added to membrane of, muscle / adipose, cells **or** (GLUT 4) increases , muscle / adipose, cell, permeability (to glucose) ; 3 glucokinase phosphorylates glucose in liver cells **or** increased (rate of) diffusion of glucose into liver cells ; 4 more / faster, respiration of glucose ; 5 activates glycogen synthase / causes glycogenesis / causes glycogen synthesis ; 6 causes, lipid / triglyceride / fatty acid, synthesis **or** decreases, glycogenolysis / lipolysis / gluconeogenesis ; 7 blood glucose concentration decreases ;	**5**