8823 – 6015M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2023

Biology

Higher level

Paper 3

38 pages

Subject Details: Biology HL Paper 3 Markscheme

Candidates are required to answer **all** questions in Section A and **all** of the questions from **one** option in Section B. Maximum total = **45 marks**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a semicolon (;) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column.
The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (/). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

9. Words that are underlined are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

Section A

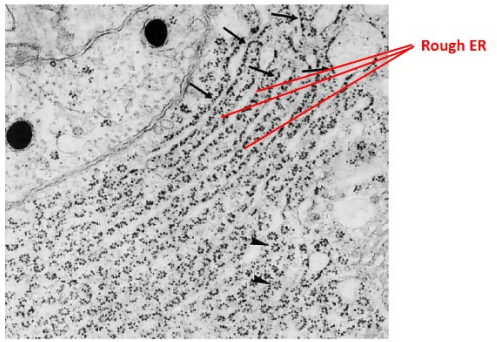
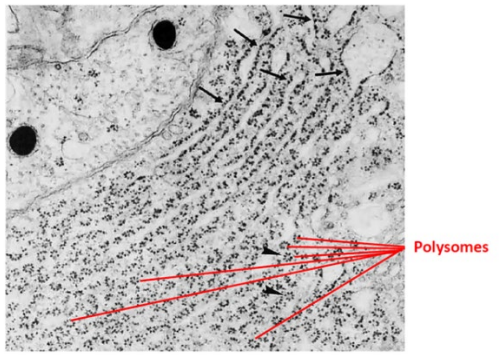
Question			Answers	Notes	Mark
1.	a		8;		1
1.	b		smaller than DNA because it is further away from well;		1
1.	c		a. (heat/94 °C) separates/denatures the DNA strands / breaks hydrogen bonds; b. (cooling/55 °C) allows primers to bind to the DNA strand / annealing (of primers); c. (heating/72 °C) allows for DNA elongation ***OR*** (heating/72 °C) allows <u>Taq</u> polymerase to synthesize new strands;	*Mp a. do not accept denaturing of enzymes or proteins, they must say DNA* *Mp a,b and c* ***OWTTE***	**2 max**
1.	d		a. bands of DNA much lighter/thinner ***OR*** no bands of DNA visible; b. fewer copies of DNA;	Mp b. ***OWTTE***	**1 max**

Question			Answers	Notes	Total
2.	**a**	**i**	4mm;	*Accept values between 3.5 and 4.6 mm.* *Accept a correct value within the answer box OR a correct bar drawn on the graph.*	**1**
2.	**a**	**ii**	a. only one measurement taken; b. a mean cannot be calculated; c. many measurements needed to calculate a standard deviation/show a range;		**2 max**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**b**		a. temperature; b. water/humidity; c. growth medium (in plate); d. nutrients; e. light f. CO_2 (concentration);	*Do not accept salt concentration as it is the independent variable.*	**1 max**
2.	**c**		*Strengths* *a.* if only one gene is mutated (m1 or m2) the plant grows the same as the control (with salt)/***OWTTE***; *b.* each protein compensates for the lack of the other (protein); *Limitations* *c.* all plants grow less in salt conditions (including the control); *d.* if both genes are mutated (m1+ 2), the plant shows minimal growth;	*Accept answers referring to salt tolerance instead of growth.*	**2 max**

Question			Answers	Notes	Mark
3.	a	i	any label close to the linear polysomes;	*Accept lines, arrows or circles along with the name as an annotation.*  [Source: Christensen, A.K., Kahn, L.E. and Bourne, C.M., 1987. *The American Journal of Anatomy*, 178, pp.1–10 © 1987 Wiley-Liss, Inc.]	1
3.	a	ii	any small circle labelled (similar to those indicated by the triangles or the lines on the diagram);	*Accept lines, arrows or circles along with the name as an annotation.*  [Source: Christensen, A.K., Kahn, L.E. and Bourne, C.M., 1987. *The American Journal of Anatomy*, 178, pp.1–10 © 1987 Wiley-Liss, Inc.]	1

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	**b**		x 16 000	*Allow a range (+/- 2000) Scale bar is 8mm for 0.5 µm, so magnification is x 16 000.* *8mm ÷ 0.5µm* *= 0.008m ÷ 0.0000005m* *= 16 000*	**1**
3.	**c**		Y is the start codon because translation goes from 5' to 3' ***OR*** Y is the start codon because it is in the 5' end of the mRNA ***OR*** Y is the start codon because it is the first to enter the ribosomes;		**1**

Section B

Option A – Neurobiology and behaviour

Question			Answers	*Notes*	Total
4.	**a**		a. Broca's area controls speech; b. neurons in the Broca's area die; c. the patient will not be able speak/reduced speech;	*Mp c: do not accept lack of understanding or communication instead of inability to speak.*	**2 max**
4.	**b**		a. neuroplasticity/plasticity ***OR*** the brain's ability to reorganize itself; b. formation of new (neural) connections/synapses/pathways; c. (new neural connections/synapses) in response to new experiences/speech therapy/stimulation;		**2 max**

Question			Answers	Notes	Total
5.	**a**		label on any part of the cerebellum;		**1**
5.	**b**		a. there appears to be some correlation ***OR*** cerebellum volume increases with body mass/vice versa; b. there are some exceptions/outliers (rhesus monkey and humans/orangutan) / ***OWTTE***; c. the values of the body mass are not shown so the relationship is subjective ***/OWTTE***;		**2 max**
5.	**c**		a. measures whether the cerebellum/brain is active/being used; b. by detecting higher blood flow; c. oxygenated blood (flow) is detected;	*Award both mp b+c if the student writes "detecting higher* oxygenated *blood flow".*	**2 max**

Question			Answers	*Notes*	Total
6.	**a**	**i**	any neurotransmitter receptor labelled;		**1**
6.	**a**	**ii**	any part of the presynaptic membrane labelled;	*Do not accept if labelled too high or if labelling is within the synaptic cleft and not touching the membrane.*	**1**

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
6.	**b**		dopamine/serotonin/norepinephrine/noradrenaline/acetylcholine;	*Do not award a mark for GABA or glutamate since they are fast-acting.*	**1**
6.	**c**		a. slow-acting neurotransmitters modulate/control fast synaptic transmission; b. can persist/continue to have effects for days; c. cause changes in neurons ***OR*** help to establish memory; d. memory is an (important) part of learning; e. greater synaptic transmission enhances learning ***OR*** learning occurs because we have new connections/reinforcement of connections;		**2 max**

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
6.	**d**		a. enhances/increases release of neurotransmitters; b. blocks re-uptake/recycling of neurotransmitters (in presynaptic neuron); c. more serotonin is released than dopamine; d. brain can become depleted of serotonin;	*Mp a+b: Accept the following named neurotransmitters: serotonin /dopamine /norepinephrine /noradrenaline.*	**2 max**

Question			Answers	Notes	Total
7.			a. innate behaviour is independent from the environment ***OR*** innate behaviour is inherited in the genes; b. learned behaviour is acquired by experience/taught by parents; *Supports innate behaviour* c. as most kept the same migration pattern without parental contact; *Does not support innate behaviour* d. range/outliers observed for both directions; e. overlap between the two directions; f. no comparison to those who were not isolated;	*mp f:* ***OWTTE***	**3 max**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>8.</td><td>a</td><td></td><td>a. cilia give a faster response / vice versa;
b. cilia have greater change in cell membrane/current potential / vice versa;
c. cilia current/potential is restored slower / vice versa;</td><td>mp c: Accept long lasting/short lasting instead of slower/faster.</td><td>2 max</td></tr>
<tr><td>8.</td><td>b</td><td></td><td><table>
<tr><td>Feature of receptor</td><td>Olfactory</td><td>Rod</td></tr>
<tr><td>connection to nerve</td><td>no intermediate cells</td><td>bipolar cells
OR
ganglion cells;</td></tr>
<tr><td>type of stimulus perceived</td><td>chemicals</td><td>light/photo;</td></tr>
</table></td><td>Award [1] for each correct row.</td><td>2</td></tr>
<tr><td>8.</td><td>c</td><td></td><td>cochlea/organ of Corti/basilar membrane;</td><td>Do not accept hair cell in semi-circular canal as they are not auditory.</td><td>1</td></tr>
</table>

Question			Answers	Notes	Total
9.			*Neurulation* a. neural plate formed from ectoderm of embryo; b. the neural plate folds inwards forming the neural groove; c. closing (of the neural groove) forms the neural tube; d. incomplete closure (of neural tube) causes *spina bifida*; e. formation of neural plate, folding and closing is called neurulation; *Elongation* f. the neural tube elongates as the embryo grows; g. the spinal cord forms from the lower part of the neural tube; h. the brain/cerebrum develops in the upper area; i. cells from the neural tube differentiate into neurons; j. neurons travel from their origin to their final position in the brain / neuronal migration;	*Accept answer in an annotated diagram.* *Mp e: is for the definition of neurulation, whereas mps a to d are for the processes involved.* *Mp g: do not accept confusion between spinal cord and spine.*	**6 max**

Option B – Biotechnology and bioinformatics

Question			Answers	Notes	Total
10.	**a**		A6/6A;		**1**
10.	**b**		to provide optimum temperature for bacterial growth/enzymes ***OR*** because the bacteria cannot be seen until they have multiplied ***OR*** for safety reasons;	*Lower incubation temperature recommended by IB safety guidelines*	**1**
10.	**c**		a. grows at all concentrations of antibiotic (while other colonies do not); b. resistant to antibiotic ***OR*** antibiotic does not act as a bactericide; c. (resistance due to) presence of plasmid; d. (plasmid) containing antibiotic resistance gene;		**2 max**

(continued…)

(Question 10 continued)

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>10.</td><td>d</td><td></td><td>
<table>
<tr><th>Feature</th><th>This experiment</th><th>Zone of inhibition</th></tr>
<tr><td>Location of antibiotic</td><td>spread throughout agar</td><td>in a disc/well;</td></tr>
<tr><td>How the effect of antibiotic is evaluated</td><td>presence or absence of colony/strain</td><td>width of the zone of inhibition (surrounding the disc/well);</td></tr>
</table>
</td><td>Award one mark for each correct row.</td><td>2</td></tr>
<tr><td>10.</td><td>e</td><td></td><td>a. test is named Gram staining;
b. cells are stained violet/with crystal violet dye;
c. add iodine;
d. then washed with alcohol/acetone;
e. Gram-negative are decolourized (because there is no peptidoglycan in their outer layer);
f. a pink counterstain/safranin/fuchsine is added;
g. Gram-negative bacteria are pink colour (from counterstain);</td><td></td><td>4 max</td></tr>
</table>

Question			Answers	Notes	Total
11.	**a**		direct relationship ***OR*** positive correlation ***OR*** the greater the divergence time, the greater the substitutions;	*Do not accept "linear relationship" on its own.*	**1 max**
11.	**b**		a. using BLASTn/Clustal W; b. sequences in FASTA ***OR*** sequences are pasted into program; c. program aligns the nucleotides (according to similarities) ***OR*** the outcome shows the sequences aligned and the differences shown (as lines);	*Mp a: "n" must be written in BLASTn.*	**2 max**

Question			Answers	Notes	Total
12.	**a**	**i**	antigen/surface protein/glycoprotein;		**1**
12.	**a**	**ii**	colour change/different absorbance;		**1**
12.	**b**		PCR ***OR*** Microarray ***OR*** DNA hybridization;	*Accept other valid method.*	**1 max**

Question			Answers	Notes	Total
13.	**a**		a. *(hypothesis supported as)* smooth surface (stainless steel) has no biofilm whereas rougher surface (shrimp/crab) has more biofilm ***OR*** slightly rough surface (shrimp) has less biofilm than the very rough surface (crab) ***OR*** the rougher the surface the greater the biofilm; b. *(hypothesis not supported as)* more surfaces should be tested before valid conclusion can be made ***OR*** same species/material with different degrees of roughness should be tested for valid conclusions ***OR*** since different species/material were used the differences may be due to other factors;		**2**
13.	**b**	**i**	a. formation of EPS (extracellular polymeric substance/exopolysaccharide); b. cooperation/quorum sensing; c. antibiotic resistance;	*Accept other valid property.*	**1 max**

(continued…)

(Question 13 continued)

Question			Answers	Notes	Total
13.	**b**	**ii**	*Either* a. sewage treatment; b. bacteria (in trickle beds) digest/break down sewage; *Either* c. bioremediation of oil spills; d. *Pseudomonas* break down oil/use oil as energy source; *Either* e. bioremediation of methyl mercury; f. *Pseudomonas* convert (methyl mercury) to less harmful form/mercury ions used by other bacteria; *Either* g. *another named valid example;* h. *brief account of method of another example;*	*Brief account must match method for 2 marks* *Mp b: Also accept aerobic or anaerobic bacteria.*	**2 max**

14.			a. antithrombin is directly purified from the milk of goats; b. production in goats yields larger amounts; c. production in goats is faster/cheaper; d. no need to handle human blood; e. less chances of contamination by disease-causing organisms/HIV/hepatitis;	*Only benefits are expected*	**3 max**

Question			Answers	Notes	Total
15.			a. genetically modified crop plants produce new proteins; b. target gene identified; c. target gene linked to other sequences/promoter that control its expression; d. recombinant DNA introduced into whole plants/leaf discs/protoplasts; e. marker genes used to identify/indicate successful uptake; f. by physical method ***OR*** chemical method ***OR*** using a vector; g. description of method e.g., calcium chloride used to open membrane pores; h. description of mode of testing the uptake e.g., use of antibiotic to detect plasmid with resistance has been taken up; i. DNA must be taken up by plant/chloroplast/chromosomal DNA; j. description of why change in recombinant plant increases yield e.g., resistance to salty environment;	*Accept valid examples for any of the marking points.* *Mp b+c refer to the gene to be manipulated.* *Mp e is for stating need/purpose of marker gene, whereas mp h is for the description of the marker gene.* *Mp f is for naming a type of method, whereas mp g is for its description.*	**6 max**

Option C – Ecology and Conservation

Question			Answers	Notes	Total
16.	**a**		acorn barnacles;		**1**
16.	**b**		primary consumers/second trophic level/herbivores;		**1**

(continued…)

(Question 16 continued)

Question			Answers	Notes	Total
16.	**c**	**i**	no change/not much change ***OR*** *Pisaster* population wouldn't change much;		**1**
16.	**c**	**ii**	a. *Thais* population decreases (from lack of main food); b. *Thais* will feed more on bivalves reducing number of bivalves; ***OR*** Fewer *Thais* means bivalves might increase in number; c. *Pisaster* decreases (slightly) in numbers (from lack of *Thais* and acorn barnacles);		**2 max**
16.	**d**		a. (*Pisaster*) has a disproportionate effect (on the community); b. it feeds on all the organisms in the community; c. it maintains/regulates populations of other species/autotrophs; d. it maintains species diversity/biodiversity ***OR*** if eliminated species diversity/biodiversity is decreased;	*Mp b and c: Accept named examples.*	**2 max**

Question			Answers	Notes	Total
17.	a		species 1 ***OR*** hatched line identified;		**1**
17.	b		a. high numbers/reproduce in favourable conditions /***OWTTE***; b. are very sensitive/highly intolerant species; c. over time changes in numbers indicate changes in environmental conditions/pollution/oxygen level/***OWTTE***; d. indicator species are used to calculate Lincoln/biotic index;	*Mp a is about the relation with conditions whereas mp c is about changes.* *Mp b: "intolerant" applies to Stoneflies, as it is specified in the question.* *Mp d: Do not accept the Simpson's index.*	**3 max**
17.	c		a. eutrophication results in algal bloom/the excess of producers; b. biological oxygen demand/BOD is the amount of dissolved oxygen needed by aerobic organisms/bacteria; c. the higher the BOD, the less oxygen in the water; d. decomposition carried out by aerobic organisms/bacteria, lowering oxygen; e. eutrophication leads to an increased BOD because bacteria decompose algae;		**3 max**

Question			Answers	Notes	Total
18.	**a**		a. anywhere between 0–6: lag; b. anywhere between 6–18: exponential/log/growth/rapid reproduction/increase; c. anywhere between 18–24: decelerating/transitional; d. above 24 / between 24–30: plateau/stationary growth/stable;	*Award marks for any two correct labels within the correct range.* *Phase names in marking points are expected. Do not accept phase 1, phase 2, etc., as labels.*	**2 max**

(continued…)

(Question 18 continued)

Question			Answers	Notes	Total
18.	**b**		a. both are sigmoid ***OR*** both have a similar pattern; b. both start exponential growth at day 6/same time ***OR*** both reach plateau/carrying capacity/maximum biomass at day 24/same time; c. error bars are similar in both curves;	*Mp a: Do not accept "both experience growth/plateau" as it doesn't mean the same pattern.* *Do not accept contrasting statements since "compare" is only for similarities.*	**2 max**
18.	**c**		a. light; b. space/surface area; c. food/nutrients/minerals/resources; d. pH; e. temperature; f. oxygen/carbon dioxide; g. disease; h. predation (by herbivores);		**2 max**

Question			Answers	Notes	Total
19.	**a**		a. leaching; b. run-off; c. flooding/weathering; d. (small particle) erosion;	.	**1 max**
19.	**b**		a. the rate of turnover in the phosphorus cycle is low/non-renewable ***OR*** phosphorous cycle takes many years to complete; b. consumption faster than production; c. most of the input is lost (to rivers and lakes); d. most P comes from mines ***OR*** a constant input from mined P is required; e. eventually the P reserves/mines will be depleted;		**3 max**

Question			Answers	Notes	Total
20.			a. introduction of an alien species disrupts natural relationships; b. absence of natural predators increases population of alien species ***OR*** alien species can become invasive in absence of natural predators; c. niches might overlap; d. species must compete for (limited) resources available; e. alien species may have selective advantages that allow them to out-compete indigenous species / ***OWTTE*** ***OR*** competitive exclusion; f. reduction/extinction of endemic/indigenous species; g. named example of alien species e.g., introduction of cane toad to limit cane beetle; h. specific effect on the environment of introduction of alien species e.g., death of native species due to toxin present in cane toad;	*Mps g+h must match.* *Mp g: Named example includes specific name and/or type/purpose of introduction. Do not accept vague examples, i.e., "frog", "rat", "beetle", etc. Verify any unfamiliar examples.*	**6 max**

Option D – Human physiology

Question			Answers	Notes	Total
21.	**a**		they ate raw meat/berries that contained vitamin C/ascorbic acid ***OR*** their diet contained vitamin C/ascorbic acid;		**1**
21.	**b**		a. most animals can produce vitamin C; b. only animals that require vitamin C can be used ***OR*** animals that can produce their own vitamin C cannot be used; c. (animals that can produce vitamin C) have the enzyme / gene;		**2 max**

Question			Answers	Notes	Total
22.	**a**	**i**	labelled arrow from arteriole to sinusoid and any hepatocyte ***OR*** labelled arrow directly from sinusoid to any hepatocyte;	*Do not accept a direct arrow from the arteriole to hepatocytes.*	**1**
22.	**a**	**ii**	labelled arrow from any hepatocyte to sinusoid then towards central vein ***OR*** labelled arrow from any hepatocyte to sinusoid;	*Do not accept a direct arrow from the hepatocyte to the central vein.*	**1**
22.	**b**		a. amino acids broken down; b. glucose can be stored as / released from glycogen; c. vitamin A/B_{12}/D/K can be stored; d. plasma proteins / named plasma protein produced; e. synthesis of cholesterol ***OR*** surplus cholesterol converted to bile salts; f. iron is stored; g. fatty acids stored as lipids/fats;	*Mp c: Do not accept unspecified vitamin.* *Do not accept produce/secrete bile, detoxify alcohol as these are not nutrients.*	**2 max**
22.	**c**	**i**	cancer / cirrhosis / hepatitis / (non-alcoholic) fatty liver disease / jaundice;	*Accept other verified chronic liver disease.* *Do not accept alcoholism.*	**1 max**
22.	**c**	**ii**	a. they engulf erythrocytes/RBCs/foreign matter/phagocytosis/***OWTTE***; b. breakdown of erythrocytes;	*Do not accept breaking down of hemoglobin.*	**1 max**

Question			Answers	Notes	Total
23.	**a**		direct relation/positive correlation ***OR*** the higher the osmolarity, the higher the ADH concentration;		**1**
23.	**b**		a. peptide hormones bind to <u>plasma membrane</u> receptors (of the target cell); b. activating a cascade mediated by second messengers inside the cell/cytoplast; c. (second messengers) trigger synthesis of enzymes/other proteins; d. peptide hormones do not enter the target cell;	*Accept named peptide hormones (other than ADH).*	**3 max**
23.	**c**		it secretes hormones directly into the blood;		**1**

Question			Answers	Notes	Total
24.	**a**		a. genetic differences between males and females; b. differences in hormones; c. differences in diet ***OR*** males eat more saturated fats than women; d. difference in lifestyle;	*Mp d: lifestyle includes smoking, obesity, sedentary, lack of exercise, stress and other accepted risk factors.*	**1 max**
24.	**b**		a. excessive salt/fat in diet; b. lack of flexibility in arteries ***OR*** presence of (arterial) plaque/cholesterol/LDL; c. lifestyle; d. age/genetics;	*Mp c: include smoking, obesity, sedentary, lack of exercise, stress and other accepted risk factors.*	**2 max**

(continued…)

(Question 24 continued)

Question			Answers	Notes	Total
24.	**c**		a. ECG measures the electrical activity of the heart/***OWTTE***; b. even R-R interval shows a regular heart rate ***OR*** equal distance between each cycle shows normal/rhythmic heartbeat ***OR*** the pattern on the ECG should be regular; c. regular P-wave shows normal sinoatrial node/SAN electrical/atrial activity; d. QRS wave/rhythm/complex/ventricular depolarization is triggered by signals from the AV node ***OR*** QRS wave/rhythm/complex is regular; e. unsynchronized contractions/fibrillations (of atria or ventricles) show abnormal activity ***OR*** irregular ST/QT/T waves could indicate health abnormalities;	*Do not accept descriptions of the contraction cycles or blood pressure.* *Answers must relate to the ECG pattern/waves.*	**3 max**

Question			Answers	Notes	Total
25.	**a**		the higher the altitude, the lower the partial pressure ***OR*** inverse relationship;	*Do not accept linear relationship*.	**1**

(continued…)

(Question 25 continued)

Question			Answers	Notes	Total
25.	**b**		a. lower oxygen partial pressure reduces oxygen availability (for the blood); b. less oxygen diffuses/is exchanged with the blood ***OR*** less oxygen diffuses across the alveolar membrane/alveoli; c. less saturation of hemoglobin with oxygen; d. more CO_2 remains in the blood ***OR*** less CO_2 is exhaled; e. breathing rate/depth is increased (in the short term); f. (to compensate for the lack of oxygen) the body will produce more erythrocytes/RBCs/hemoglobin;	*Mp a: Do not accept lower oxygen concentration at high altitude. Partial pressure must be mentioned.* *Mp c: Do not accept increased hemoglobin affinity for oxygen instead of saturation.* *Mp d: Allow higher CO_2 decreasing hemoglobin affinity for oxygen.*	**3 max**

Question			Answers	Notes	Total
26.			*Secretion of acid* a. hydrochloric acid/HCl is produced by parietal cells of the stomach; b. controlled by nervous/(vagus) nerve/hypothalamus stimulation; c. stomach wall produces hormones/gastrin; d. release of hydrogen ions/H^+ occurs through protein carriers/pumps; e. exchange of ions (H^+/K^+) occurs through proton pump/ATPase pump; *Control by medication* f. proton pump inhibitors/PPIs <u>irreversibly</u> block the proton pump; g. PPIs decrease of hydrogen ions/H+ into the lumen of the stomach ***OR*** PPIs reduce the amount of hydrochloric acid/HCl produced; h. PPIs make the stomach less acidic; i. antacids neutralize the acid in the stomach (in the short term, as long term this increases acid secretion);	*Mp a: accept lining/wall/epithelial cells.* *Mp a: do not accept stomach alone.* *Mp d: Do not accept channels instead of pumps. If channels used more than once, do not award the mark for the first occurrence, and allow ECF for the others.*	**6 max**