## HL Paper 3

Cells on the surface of intestinal villi have microvilli, which provide a large surface area for absorption. State another structural characteristic of these villus cells that adapts them to the absorption of nutrients.

Explain the role of receptors in mediating the action of both steroid and protein hormones.

Outline the ways in which the liver regulates the chemical and cellular composition of the blood.

Explain the process of erythrocyte and hemoglobin breakdown in the liver.

Discuss high altitude training for athletes.

Outline how infection by Vibrio cholerae can lead to dehydration.

Describe a method that could be used to measure the energy content of a sample of food.

Explain how and why ventilation rate varies with exercise.

a (i)State one example of a steroid hormone.	[1]
a (iiState <b>one</b> example of a hormone that is a tyrosine derivative.	[1]
b. Outline the hormonal control of digestive juice secretion in the stomach.	[2]
c. Outline how exercise causes an increase in the ventilation rate.	[3]

Describe how the liver regulates nutrient levels.

a.i. Jaundice causes a yellow discolouration of the skin, mucous membranes and sclera of the eyes. State the bile pigment causing this	[1]
discolouration.	
a.ii.Explain how the normal production of bile pigments changes with the development of jaundice.	[4]
b. Distinguish between the structure of liver sinusoids and capillaries.	[2]

a. The diagram shows an ECG trace with the QRS complex indicated.



Outline the events of the cardiac cycle that are occurring during this QRS interval.

- b. Heart rate is affected by the hormone epinephrine. The action of epinephrine is mediated by a chemical called a second messenger. Explain the [3]
  mechanism of action of a second messenger.
- c. During cardiac arrest, the ventricles of the heart might begin to contract in an uncoordinated fashion. Outline the treatment used for this [1] condition.
- d. Explain the role of chemoreceptors in the regulation of ventilation rate.

[2]

[3]

a.i. Thyroxin is a hormone produced in the thyroid gland. State <b>one</b> function of thyroxin.	[1]
a.ii.The action of thyroxin is similar to steroid hormones. Describe the action of steroid hormones.	[3]
b. The World Health Organization recommends that the iodine intake should be supplemented in pregnant women due to their increased	[2]
requirements. Outline the need for iodine supplementation.	

Explain the oxygen dissociation curves of adult hemoglobin, fetal hemoglobin and myoglobin.

Describe how the liver helps to maintain human health.

The cholesterol-lowering effect of *Lactobacillus* bacteria was studied. Forty rats were divided into groups and fed either a normal or high cholesterol diet. Some rats fed the high cholesterol diet were also supplemented with *L. fermentum* or *L. plantarum*. After a six week feeding period, the concentration of cholesterol in liver tissue and the mass of bile salts in feces were measured.



[Source: adapted from Ning Xie, Yi Cui, Ya-Ni Yin, Xin Zhao, Jun-Wen Yang, Zheng-Gen Wang, Nian Fu, Yong Tang, Xue-Hong Wang, Xiao-Wei Liu, Chun-Lian Wang, Fang-Gen Lu (2011) Effects of two Lactobacillus strains on lipid metabolism and intestinal microflora in rats fed a high-cholesterol diet. BMC Complementary and Alternative Medicine, 11, pp. 53–64.]

Concentration of cholesterol:

Mass of bile salts:

- b. Calculate the percentage increase in the concentration of cholesterol in liver tissue, caused by feeding the rats a high cholesterol diet without [1]
  supplementing with bacteria. Show your workings.
- c. Deduce the effects of supplementing the diet with *Lactobacillus* on the concentration of cholesterol in liver tissue and on the mass of bile salts [2] in feces.
- d. Scientists hypothesized that *Lactobacillus* could be used in diets to reduce the incidence of coronary heart disease (CHD). Evaluate the [3] evidence for and against this hypothesis provided by the data.

Explain the role of the liver in regulating and storing nutrients.

a.	Distinguish between the mode of action of steroid and peptide hormones.	[2]
b.	Outline the control of gastric juice secretion.	[2]

a. A good marker of dietary intake of iodine is the urinary iodine level (UI). A study was carried out in the UK to establish urinary iodine levels and [2] milk intake in schoolgirls aged 14–15 years.



[Source: M Vanderpump (2014) *Clinical Medicine* 2014, Vol 14, No 6, Royal College of Physicians, pages 7–11. Reproduced with permission of ROYAL COLLEGE OF PHYSICIANS, via Copyright Clearance Center.]

Urinary iodine values from 50 to 99  $\mu$ g dm<sup>-3</sup> are considered to be mild iodine deficiency. Deduce the effect of milk intake on the iodine status of schoolgirls in the UK.

b.	Outline the need for iodine in the endocrine system.	[2]
c.	Growth hormones are examples of peptide hormones. Explain the mechanism of action of peptide hormones.	[3]

c. Outline how bile helps in lipid digestion.	[1]
d. Describe how bile pigment is formed.	[3]

Explain the mechanisms used by the ileum to absorb and transport food.

a. Samples from cardiac muscle were taken during autopsies from individuals who had coronary heart disease (CHD) and a control group. The [1] histogram shows the relationship between the quantity of cardiac muscle cells and their diameter in the left ventricle in the two groups.





Distinguish between the distribution of cardiac muscle cell diameters in the CHD and control groups.

- b. Describe how the structure of cardiac muscle cells allows them to transmit impulses.
- c. Explain the reason for the delay between contractions of the atria and of the ventricles.

a (i)Define hormones.

- a (ii\$tate one type of hormone, giving an example.
- b. Compare gastric juice and pancreatic juice.

Pancreatic juice

c. Outline the reason for one named substance found in food not being digested and absorbed by humans.

[3]

[2]

[1]

[1]

[3]

The graph shows the length of time that the content of a meal takes to pass through the gut as a function of digestible matter content. The more digestible matter present in the meal, the lower the dietary fibre content.



[Source: © International Baccalaureate Organization 2016]

- a. Estimate the mean residence time of a meal with 50 % digestible matter.
- b. Explain the relationship between percentage of digestible matter and mean residence time.

Explain how the liver stores and regulates levels of nutrients in the body, including details of the circulation of blood through the liver in your answer. You may use a diagram to illustrate your answer.

[1]

[3]

Researchers explored the effects of roadside traffic exposure in London on people with asthma. Each participant walked for two hours through Hyde Park, a large traffic-free park, and on a separate occasion along Oxford Street, where diesel-powered buses and taxicabs are permitted. The researchers measured the pH of the participants' exhaled breath two hours before each walk and three hours and six hours after the start of each walk. The level of an inflammation indicator, myeloperoxidase, was also measured the day after the experiment.





a. Calculate the percentage increase of myeloperoxidase between Hyde Park and Oxford Street for participants.	[1]
b (i)Compare the changes in exhaled breath pH caused by walking through Hyde Park and along Oxford Street.	[2]
b (i Explain the changes in exhaled breath pH caused by walking along Oxford Street in people with asthma.	[2]

Explain the events of the cardiac cycle, including the heart sounds.

The liver is a complex organ with a wide range of functions. Outline the functions of the liver.

a. A study was undertaken to determine the most effective method to delay the onset of type II diabetes in high-risk patients. Three groups were [2] given either a placebo (control), a medicine that suppresses glucose production by the liver (anti-diabetic drug) or a lifestyle-modification program (lifestyle). The results for four years are shown in the graph.



<sup>[</sup>Source: adapted from Berry, Colin, Jean-Claude Tardif, and Martial G. Bourassa. "Coronary Heart Disease in Patients With Diabetes." Journal of the American College of Cardiology 49.6 (2007): 631-642. Web. 19 Jan. 2017.]

Analyse the use of the anti-diabetic drug in delaying the onset of type II diabetes.

b. List features that would increase a person's risk of developing diabetes.

a. In healthy adults, there are heart sounds during the cardiac cycle. Outline the causes of **two** of these sounds.

b. State **two** products resulting from the breakdown of erythrocytes (red blood cells) in the liver.

1. .....

2. .....

c. Compare gastric juice and pancreatic juice.

	Gastric juice	Pancreatic juice
Acidity or alkalinity		
Enzymes		
Site of action		

d. List **one** material that is egested after human digestion.

[2]

[2]

[2]

[3]

In patients with coronary heart failure (CHF), the presence of anemia can increase the risk of mortality. Anemia is a shortage of red blood cells or a reduced concentration of hemoglobin in the blood. Hepcidin is a peptide that is synthesized in the liver to suppress iron absorption in the intestine. The blood hepcidin concentration in CHF patients with anemia and without anemia was measured. The control group did not have cardiac disease or anemia.



[Source: Matsumoto et. al, Iron Regulatory Hormone Hepcidin Decreases in Chronic Heart Failure Patients With Anemia, Circulation Journal, December 18, 2009. Reproduced with permission.]

a.	State which group has the greatest range of blood hepcidin concentration.	[1]
b.	Calculate the difference in median blood hepcidin concentration for CHF patients with anemia and without anemia, giving the units.	[1]
c.	Using the data, deduce whether the incidence of CHF or the incidence of anemia has a greater effect on the blood hepcidin concentration.	[3]
d.	Iron is necessary for hemoglobin to carry oxygen so low iron levels cause low levels of hemoglobin. Suggest reasons for the levels of hepcidin	[2]
	found in CHF patients with anemia.	

Explain the oxygen dissociation of **myoglobin**, completing the graph below to support your answer. Po<sub>2</sub> is the partial pressure of oxygen.



For children suffering from persistent asthma, budesonide may be used in inhalers to suppress airway inflammation. This therapy may continue for many years, so its long-term effect on growth was studied. One thousand children were randomly assigned to receive either budesonide or a placebo, a neutral substance used as the control, and were monitored until adulthood. The graph shows the difference in height between the group who received the drug and others who received the placebo (the control group). The same treatment group was measured at the start of the treatment period, four times during the treatment period and then once again about eight years later.



[Source: H Kelly et al., (2012), New England Journal of Medicine, 367 (10), pages 904-908]

a. State the mean height difference between the budesonide group and the placebo group at the start of the study.

b. The mean age for starting the treatment was nine years. Suggest a reason for the choice of this age.

[1]

[1]

- c. Describe the effect of budesonide on the mean difference in height, during the period of treatment.
- d. Evaluate the long-term after-effect of budesonide treatment on height.
- e. Suggest one significant shortcoming in the data.

## The electrocardiogram (ECG) of a normal patient after exercise is shown.



[Source: © International Baccalaureate Organization 2016]

.....bpm

a. Using the R-R interval in this ECG, calculate the heart beats per minute (bpm) of this patient. Show your working.

b. Describe the electrical activity that occurs in the heart during the P wave.

c. Explain why the QRS wave has a larger amplitude than a P wave.

The graph below shows the oxygen dissociation curve at a low  $\text{CO}_2$  concentration.

[1]

[1]



a.i. Outline the main changes in the lungs that occur in patients with emphysema.



intense exercise when the  $\mbox{CO}_2$  concentration of the blood is high.

b.iiExplain how the increase in CO<sub>2</sub> concentration affects the release of oxygen to respiring cells.



a (i)State one mechanism the ileum uses to absorb digested food into the bloodstream.

[2]

[2]

b (i)Label the line that represents the ventricle.	[1]
b (i∉stimate the total time the atrioventricular valves are open.	[1]
c (i)Although some $CO_2$ entering the blood simply dissolves in the plasma, most enters the erythrocytes (red blood cells).	
Outline how CO <sub>2</sub> interacts with hemoglobin once it enters erythrocytes.	
c (ii)Describe the formation of $HCO_3^-$ in erythrocytes.	[2]

Explain, using an oxygen dissociation curve, how hemoglobin supplies oxygen to respiring tissues and how the Bohr shift increases the supply.

In control subjects, blood potassium levels are maintained, through homeostasis, between 3.5 and 4.5 mmol litre<sup>-1</sup>. In patients with anorexia, blood potassium canfall below this level. This is known as hypokalemia. In patients with kidney failure, levels can rise above this range, causing hyperkalemia. The traces show the electrocardiograms (ECGs) of a patient with hypokalemia, a normal subject and a patient with hyperkalemia.





b.i.Distinguish between the ECG trace of the patient with hypokalemia and the patient with hyperkalemia.	[2]
b.ii.Outline the events that occur within the heart that correspond to the QRS complex.	[3]
b.iiSevere hypokalemia can lead to ventricular fibrillation. Describe the medical response to ventricular fibrillation.	[3]
b.ivSometimes hyperkalemia occurs as a body tries to respond to low blood pH. State the normal range of blood pH in the human body.	[1]
b.vExplain how low blood pH causes hyperventilation (rapid breathing).	[3]

Helicobacter pylori infection is a cause of stomach ulcers. It affects SLC26A9, which is a membrane protein present in the epithelial lining of the

stomach. SLC26A9 takes part in the reversible transport of chloride and hydrogen carbonate ions into and out of the epithelial cells in order to raise

the pH at the membrane to neutral levels. Entry of chloride ions into epithelial cells and removal of hydrogen carbonate ions both cause extracellular

pH to increase.

To assess the function of SLC26A9, this process was reversed by artificially raising the external pH. The rate of change of extracellular pH was measured with normal epithelial cells and with modified cells with extra SLC26A9. The tests were also performed in the presence of DIDS, an inhibitor of SLC26A9.



Reproduced with permission of the American Physiological Society from American Journal of Physiology. Cell Physiology, J. Xu et al., 289, pp. 493–505, 2005.

a. Calculate the difference in the rate of decrease of pH between the control cells and the modified cells without DIDS.

..... pH min<sup>-1</sup>

b. State the effect of DIDS on the rate of decrease of the extracellular pH.

c. Scientists hypothesized that *Helicobacter pylori* alters the ability to maintain neutral pH at the epithelial cell surface by inhibition of SLC26A9. [2]
 Evaluate this hypothesis.

[1]

[1]

- d. In further experiments, scientists observed that the levels of mRNA of SLC26A9 increased in epithelial cells when infected by *Helicobacter* [1]
  *pylori.* Suggest a possible explanation for this increase.
- e. Predict, with a reason, the effect of DIDS on stomach pH if given to an experimental subject.

The human body suffers significant physiological changes at extreme altitudes. Extensive scientific information has been obtained from medical research expeditions to Mount Everest (8848 m above sea level). The figure below shows the relationship between the partial pressures of oxygen (Po<sub>2</sub>) and carbon dioxide (Pco<sub>2</sub>) in the alveoli as altitude increases from sea level (at top right) to the summit of Mt. Everest (at bottom left).



[Source: adapted from JB West, (2006), Integrative and comparative Biology, 46 (1), pages 25-34]

The table below shows the data from the field study on the alveolar gas and arterial blood values for a climber at sea level and on the summit of Mt. Everest.

Lverest.

Altitude / meters	Inspired Pco <sub>2</sub> / mm Hg	Arterial Pco <sub>2</sub> / mm Hg	Arterial pH
Sea level (0)	2.50	40.0	7.40
Summit (8848)	0.83	7.5	>7.70

[Source: adapted from JB West, (2006), Integrative and comparative Biology, 46 (1), pages 25-34]

a. Outline the changes in the partial pressures of carbon dioxide and oxygen as altitude increases.

b. Predict, with a reason, how the ventilation rate will change as a climber ascends from sea level to the summit of Mt. Everest.

c (i)Calculate the percentage change in the arterial partial pressure of carbon dioxide (Pco<sub>2</sub>) at the summit compared with that at sea level. [1]

[2]

[2]

[2]

d. State one adaptation of people who live permanently in high altitude areas.

The effects of normal and hypoxic (lower than normal) oxygen concentrations on the oxygen levels in blood and muscles of athletes were investigated in a study. Healthy male non-athletes and athletes performed 30 seconds of intense maximal exertion exercise on a stationary bicycle. The data displayed below show the arterial oxygen saturation levels before, during and after the exercise.



[Source: K. Oguri et al. (2008), "Pronounced muscle deoxygenation during supramaximal exercise under simulated hypoxia in sprint athletes", Journal of Sports Science and Medicine, 7 (4), 512-519: Figure 3. Reprinted with permission from the Journal of Sports Science and Medicine.]

a. Estimate the change in the arterial oxygen saturation between 30 and 60 seconds in non-athletes under hypoxic conditions.

.....%

b (i)Compare the effect of hypoxic concentrations on athletes and non-athletes during exercise.

b (ilsuggest a reason for the differences.

c. Explain how the body prevents oxygen saturation levels from falling by more than a small amount during maximal exertion exercise. [2]

d. Hypoxic concentrations also occur at high altitudes. Explain one effect of high altitude on oxygen transport by blood.

[1]

[1]

[2]

[1]

[1]

Coronary heart disease (CHD) is common in some families, with men being more susceptible to the disease than women. Researchers in Finland carried out an investigation to determine whether the pattern within families was the same for women as for men. The graph shows how the risk of developing CHD in men and women of certain ages depends on whether they had a brother or sister with the disease.



[Source: adapted from S Pohjola-Sintonen, et al., (1998), European Heart Journal, 19, pages 235-239]

- a. State the risk of a man developing CHD between the ages of 55–59 if his brother had CHD.
- b. Calculate the increase in risk over the control group for a woman of 60–64 of developing CHD if her sister had the disease.

[1]

[1]

[3]

[2]

- c. Compare the results for the men and the women.
- d. Suggest **two** reasons why a man is more likely to develop CHD if his brother had the disease.

Helicobacter pylori is able to live inside the stomach wall of humans. This bacterium can cause inflammation of the stomach wall (gastritis). There may

be a link between *H. pylori* and the development of stomach cancer.

The graph below shows the blood levels of antibodies resulting from *H. pylori* infection for a control group without stomach cancer and a group with stomach cancer. The solid lines show the median concentrations for the control group and the group with stomach cancer. Antibody concentrations above 10  $\mu$ g ml<sup>-1</sup> indicate that there has been infection with *H. pylori*.



[Source: Reproduced from D Forman, D G Newell, F Fullerton et al., "Association between infection with Helicobacter pylori and risk of gastric cancer: evidence from a prospective investigation", *Bristish Modical Journal*, Volume 302, Number 6788, (1991) with permission of BMJ Publishing Group Ltd.]

- a. 47 % of the control group had been infected with *H. pylori*. Calculate the percentage of the group with stomach cancer that had been infected. [2]
  Show your working.
- b. Using all of the data, evaluate the hypothesis that *H. pylori* causes stomach cancer.
- c. A study in gerbils indicated that infection with *H. pylori* leads to a decrease in the secretion of hydrochloric acid. Discuss the consequences of [2] this finding for the digestion of proteins in the stomach in humans.
- a. The table shows the death rate due to coronary heart disease (CHD) in two different countries.

Country	Deaths / 10 <sup>-5</sup> individuals
USA	97.6
Japan	32.1

[© International Baccalaureate Organization, 2013]

Using the table below, outline three named factors that could be responsible for the differences between the two populations.

## [3]

[3]

Factor	Outline

b (i)State four glands secreting digestive juices into the alimentary canal.

- 1. ..... 2. ..... 3. .....
- 4. ....

Alcohol is known to increase the risk of cardiovascular disease (CVD). An investigation was undertaken to look at the effects of drinking different

amounts of alcohol in men and women.

C-reactive protein (CRP), fibrinogen and total white blood cell count (WBC) were measured. These are markers that can be used to measure the risk of cardiovascular disease (CVD).

Samples were taken from populations in three different countries and their drinking habits were determined and their blood was analysed.



[Overall alcohol intake, beer, wine, and systemic markers of inflammation in western Europe: results from three MONICA samples (Augsburg, Glasgow, Lille), A. Imhof, M. Woodward, A. Doering, N. Helbecque, H. Loewel, P. Amouyel, G.D.O. Lowe, W. Koenig, European Heart Journal, December 1, 2004, Oxford University Press]

a.	State the overall trend for CRP for men and women over the range of alcohol consumption.	[1]
b.	Evaluate, using all the data, whether drinking small amounts of alcohol reduces the risk of CVD.	[3]
c.	Deduce which is the best marker to measure the risk of CVD.	[1]
d.	Outline atherosclerosis and the causes of CVD.	[2]

The graph shows the oxygen dissociation curve for adult haemoglobin.



a.	State the pathway by which hormones travel from the hypothalamus to the anterior pituitary gland.	[1]
b.	State the condition of the blood that would stimulate the release of ADH (vasopressin).	[1]
d(i).	Using the graph, draw a line to show how the oxygen dissociation curve changes with the Bohr shift.	[1]
d(ii)	Explain the role of the Bohr shift during vigorous exercise.	[2]

The oxygen dissociation curve is a graph that shows the percentage saturation of hemoglobin at various partial pressures of oxygen. Curve A shows the dissociation at a pH of 7 and curve B shows the dissociation at a different pH.



a. Outline how coronary thrombosis can be caused.	[2]
b (i)State the possible cause of the curve shifting from A to B.	[1]
b (i枊n the graph, draw the curve for myoglobin.	[2]
c. Describe the breakdown of hemoglobin in the liver.	[2]

## The diagram demonstrates the action of steroid and peptide hormones in a section of cell and adjacent capillary.



[Source: © International Baccalaureate Organization 2016]

a. On the diagram, label a

(i) second messenger.

(ii) gene regulatory protein.

- b. Outline one characteristic of steroid hormones that allows them to readily diffuse through cell membranes
- c. Compare and contrast the mechanisms of action of peptide and steroid hormones.

The table summarizes the relative content of essential amino acids in different foods. Cysteine and tyrosine are classified as being "conditionally

essential". The quantity of each amino acid in a hen egg is set as 1.0 and all other values are relative to the hen egg standard.

	Hen egg	Human milk	Cow milk
Isoleucine	1.0	1.1	1.1
Leucine	1.0	1.4	1.3
Valine	1.0	1.0	1.0
Threonine	1.0	1.0	0.9
Methionine and Cysteine	1.0	1.1	0.7
Tryptophan	1.0	1.6	1.3
Lysine	1.0	1.0	1.3
Phenylalanine and Tyrosine	1.0	1.0	0.9
Histidine	1.0	0.9	1.1

[Source: Data obtained from Robert McGilvery, Biochemistry: A Functional Approach, 1970, W. B. Saunders.]

- a. Outline what is meant by the term essential amino acid.
- b. Phenylalanine is converted to tyrosine by the enzyme phenylalanine hydroxylase.



Phenylalanine

Tyrosine

(i) Deduce the reason that tyrosine is considered to be a conditionally essential amino acid.

(ii) When infants with the condition phenylketonuria (PKU) are left untreated, they have a build-up of phenylalanine in the blood and high levels of phenylalanine in the urine. State the cause of this condition.

c.	Evaluate human milk as an overall source of essential amino acids.	[2]
d.	Outline the control of milk secretion by oxytocin and prolactin.	[3]
e.	The diagram represents a lobule from a mammary gland. The mammary gland is an example of an exocrine gland.	[2]

[2]

[2]



[Source: Luis A Bate, Professor of Physiology and Ethology, University of Prince Edward Island. Used with permission.]

Identify **two** features of an exocrine gland visible in the diagram.

The electron micrograph shows the epithelial cells of the villus.



[Source: Courtesy of Dr John McNulty and the Loyola University Medical Center, Chicago http://www.dartmouth.edu/~anatomy/Histo/lab\_1/epithelium/DMS028/microvilli.jpg]

Identify the parts labelled I and II.

I:										•				•			•																	•											•												
II:	•	•	•	•		•	•	•	•			•	•	•	•	•			•		•		•	•		•	•		•	•		•	•					•	•			•	•	•			•	•		•	•			•	•		

The diagram below shows a section through the ileum.



Roland Soper, Nigel P. O. Green, G. Wilfred Stout and Dennis J. Taylor, *Biological Science*, 1990, p. 316, Cambridge University Press. Used with permission.

a (iiQutline <b>two</b> i	mportant structural features of cell X.	[2]
b. Explain the r	ble of bile in lipid digestion.	[2]
c. Explain why	rypsin is initially synthesized as an inactive precursor and how it is activated.	[3]

The electron micrograph below shows cells from the intestine.



[Source: C Candalh, Inserm, magnification ×10 000]

а	In the electron	micrograph	ahove	state	the name	of the
a.		mucrograph	above,	Slale	line name	or the

(i) structure labelled X.

(ii) type of cells labelled Y.

- b. Define hormone.
- c. Outline the circulation of blood through liver tissue.
- a. Label the section of healthy liver tissue below.



[P. Billiet et al. (2000) Further Investigations in Biology, 4, p. 64, IBID Press. Reproduced with permission.]

[2]

[3]

[3]

II.

III.

b.	Outline two roles of the liver.	[2]
c.	List <b>two</b> materials that are not absorbed but are egested by the body.	[1]
d.	State an example of a protein hormone.	[1]

The micrograph shows a section of cardiac muscle.



[Source: Musculocardiaco by Goyitrina (https://commons.wikimedia.org/wiki/File:Musculocardiaco.jpg)]

a.	Identify the structure labelled X.	[1]
b.	Describe the unique properties of cardiac muscle cells.	[4]
c.	State an early invention that led to improved knowledge of the heart.	[1]

The diagram below shows a section through the ileum.



Roland Soper, Nigel P. O. Green, G. Wilfred Stout and Dennis J. Taylor, *Biological Science*, 1990, p. 316, Cambridge University Press. Used with permission.

a (i)The diagram below shows the structure of the retina. Label I and II.



C. J. Clegg, Introduction to Advanced Biology, 2000, p. 285. Reproduced by permission of Hodder Education.

a (i)Label I and II.	[1]
a (iiDistinguish between rods and cones.	[2]
b. Outline the pupil reflex.	[2]
c. Discuss the use of the pupil reflex in testing for brain death.	[3]