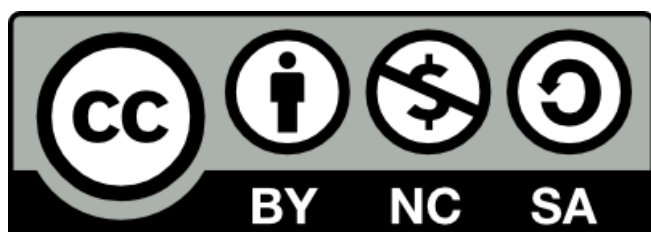




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COMPETITOR #: _____



15th International Biology Olympiad

Brisbane, 2004

THEORY EXAMINATION # 2

Total time available: 2½ hours (150 minutes)

Total points available: ~80

GENERAL INSTRUCTIONS

Please check that you have the appropriate examination papers and answer sheets.

It is recommended that you manage your time in proportion to the points allotted for each question.

IMPORTANT

Use the answer sheets provided to record your answers.

Ensure your name and three digit code number is written on the top of each page of the answers.

Using the pencil provided, fill in the appropriate circle on the answer sheet.

Unless otherwise indicated, there is only **ONE** correct answer for each question.

Part marks are given and no marks are deducted for incorrect answers.

Good luck.

Questions 81-85. **A 14 year old teenager presents to the family doctor with numerous facial pimples. The doctor diagnoses a moderate case of acne.**

~~Question 81).~~ Which factor predisposes towards acne? (1 point)

- ~~_____ A. _____ Chocolate~~
- ~~_____ B. _____ Greasy foods~~
- ~~_____ C. _____ Puberty~~
- ~~_____ D. _____ Dry skin~~
- ~~_____ E. _____ Eczema~~

Question 82). Acne is characterized by inflamed skin. Which of the following is NOT one of the principal signs of inflammation? (1 point)

- A. Calor (heat)
- B. Rubor (redness)
- C. Pallor (paleness)
- D. Dolor (pain)
- E. Tumor (swelling)

Question 83). Acne is caused by infection of the sebaceous glands by *Propionibacterium acne*. It is a Gram-positive bacterium which means its cell wall is composed of which of the following?

(1 point)

- A. Thick lipopolysaccharide layer
- B. Thick peptidoglycan layer
- C. Thin lipopolysaccharide layer over a thick peptidoglycan layer
- D. Thick lipopolysaccharide layer over a thin peptidoglycan layer
- E. Thick lipopolysaccharide layer over a thick peptidoglycan layer

Question 84). Which immune cells are delivered to the site of infection to phagocytose invading bacteria? (1 point)

- A. Lymphocytes
- B. Neutrophils
- C. Eosinophils
- D. Basophils
- E. Plasma cells

Question 85). Treatment with antibiotic drugs helps overcome many bacterial infections. Why is penicillin toxic to many bacteria? (1 point)

- A. It interferes with DNA replication
- B. It inhibits transcription
- C. It disrupts translation
- D. It blocks protein synthesis
- E. It inhibits cell wall formation

Questions 86-90. **One of the most controversial issues in modern-day biology is the genetic modification of agricultural crop plants that supply food products for human consumption. Biologists should be aware of the underlying science of genetic modification.**

Question 86). Indicate whether each statement concerning genetically modified (GM) crops in 2004 is True (T) or False (F): (1 point)

	Answer [T/F]
1. Products from GM crops are now commonly consumed by humans	
2. Crops genetically modified to resist attacks by insect larvae are now produced commercially	
3. The consumption of food from GM crops must be dangerous because transgenic DNA is consumed	
4. Many crop plants have been genetically modified to express genes of Calvin cycle enzymes at higher than normal levels so that these plants photosynthesise faster	
5. Researchers have genetically modified rice to express in developing grains genes for enzymes that synthesise β -carotene (the natural precursor of vitamin A)	

Question 87). Indicate which of the following major crops have been genetically modified and are now widely grown commercially by answering Yes (Y) or No (N). (1 point)

	Answer [Y/N]
1. Maize	
2. Wheat	
3. Soybean	
4. Potato	
5. Canola	

Question 88). Transgenic plants, like transgenic animals, are genetically-engineered varieties containing one or more artificially inserted genes. Which of the following methods are used to introduce genes into crop plants? (1 point)

1. *Agrobacterium tumefaciens* infection
2. Electroporation
3. Retroviral infection of stem cells
4. Plant tissue culture
5. Microinjection

- A. 1,3
- B. 1,2,5
- C. 2,4,5
- D. 4,5
- E. all five

Question 89). Genetic engineers construct recombinant DNA molecules using two enzymes: restriction endonuclease and DNA ligase. What do these two enzymes do? (1 point)

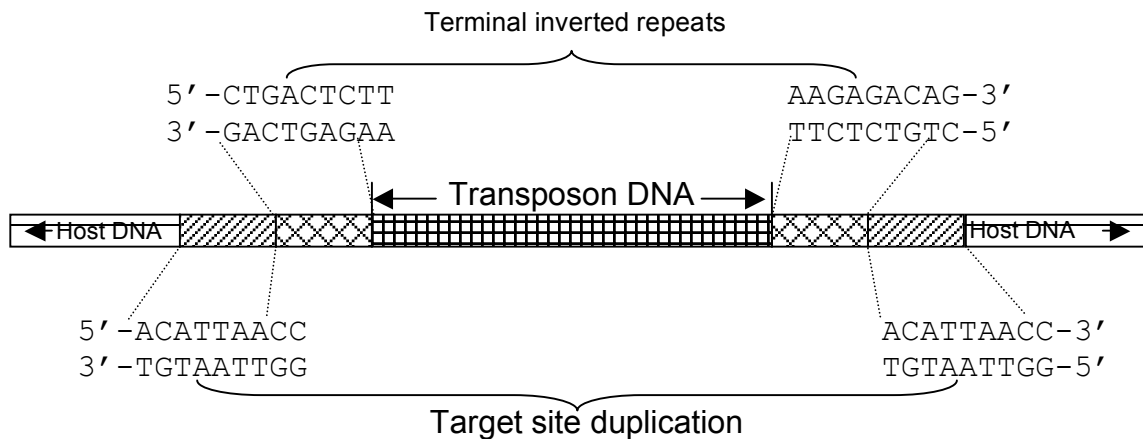
- A. They catalyse different reactions: restriction endonuclease joins fragments into larger molecules; DNA ligase hydrolyses DNA into smaller fragments
- B. They catalyse different reactions: restriction endonuclease hydrolyses DNA into smaller fragments; DNA ligase joins fragments into larger molecules
- C. They both hydrolyse DNA into smaller fragments
- D. They both join fragments of DNA into larger molecules
- E. They catalyse different hydrolysis reactions: restriction endonuclease hydrolyses bacterial plasmid DNA; DNA ligase hydrolyses DNA from eukaryotic cells

Question 90). Scientists coax transformed cells to grow into whole plants by using tissue culture techniques in which various plant hormones are included in culture media. Match the hormones listed in the left hand column with the actions listed in the right hand column. (1 point)

1. the auxin indoleacetic acid (IAA)	A. promotes growth of —excised apical meristems
2. the auxin 2,4-dichlorophenoxy- —acetic acid (2,4-D)	B. promotes organogenesis —of roots
3. the cytokinin zeatin	C. promotes organogenesis —of shoots
4. gibberellin e.g. GA ₃	D. maintains valuable tissue samples —in culture for long periods of time
5. abscisic acid (ABA)	E. promotes the growth of a callus —of undifferentiated cells

1	2	3	4	5

Questions 91-95. A transposon has 3 functional requirements: a DNA “recognition sequence” where it will integrate into the host genome; DNA sequences called “terminal inverted repeats” that occur once the transposon has integrated into the genome; and transposon DNA that encodes for the protein “transposase” which regulates movement into and out of the host genome. A simple transposon is shown in the following diagram.



Consider the following ten statements and use them to answer Questions 91 to 95

1. — The genome would be returned to its original state
2. — One transposon would remain in the genome
3. — The two transposons and the host DNA, encoding gene "X" between the two integrated transposons could be lost from the host genome
4. — The genome will lose its integrity and will disintegrate
5. — There will be a duplication of gene X on one chromosome
6. — Gene X will be inverted
7. — Gene X will be moved to another chromosome
8. — Gene X will remain in its original position but will also be incorporated into another chromosome.
9. — The region telomeric to the transposon will be lost
10. — The region centromeric to the transposon will be lost

~~Question 91). Movement of transposons is susceptible to errors; for example, if two transposons integrate into a genome next to each other, it is not possible for the transposase enzyme to distinguish which terminal repeats belong to which transposon. However, the direction of the terminal inverted repeats must be conserved in the correct orientation for resolution (removal) of the transposon. Consider two transposons integrating into a host genome in such a way that they flank a gene encoding an enzyme for color "X." What are the possible outcomes if one or both transposons were resolved (removed)? (1 point)~~

A. ~~1~~

B. ~~1, 2 and 3~~

C. ~~4~~

D. ~~3, 5 and 6~~

E. ~~8~~

~~Question 92). Cross over events during meiosis occur when related sequences align and DNA is exchanged between chromosomes. Most occur between sister chromatids and are subtle. However, gross cross-overs can occur between different chromosomes (interchromosomal) or between different regions within the same chromosome (intrachromosomal) and are often caused by transposons. If the two transposons considered in Question 91 were integrated in the same direction and caused an intrachromosomal cross-over, what would the result be? (1 point)~~

A. — 1

B. — 3

C. — 4

D. — 5

E. — 6

~~Question 93). If the transposons described in Question 92 were in the opposite direction, what would the result of the crossover be? (1 point)~~

~~A. — 1~~

~~B. — 3~~

~~C. — 4~~

~~D. — 5~~

~~E. — 6~~

~~Question 94). If the two transposons described in Question 92 (both in same direction) caused an interchromosomal cross-over in which the first transposon in chromosome A crossed over with the second transposon contained within sister chromosome B, the resultant cross-over in chromosome A would lead to which of the following? (1 point)~~

~~A. — 1~~

~~B. — 4~~

~~C. — 6~~

~~D. — 8~~

~~E. — 5+7~~

~~Question 95). Barbara McLintock was awarded the Nobel Prize in 1983 because of her ground breaking work on transposable elements in maize. Her work focused on the effects that intact transposons had on chromosomes containing defective transposons.~~

~~For this question, consider that the defective transposons contained one “terminal inverted repeat” and no “transposase.” When a strain of maize with intact transposons (strain Ae) was crossed with maize with a defective transposon incorporated next to gene X (strain De), she noticed that a loss of color could be found in the offspring. This would arise from a change in which of the following? (1 point)~~

~~A. — 6~~

~~B. — 7~~

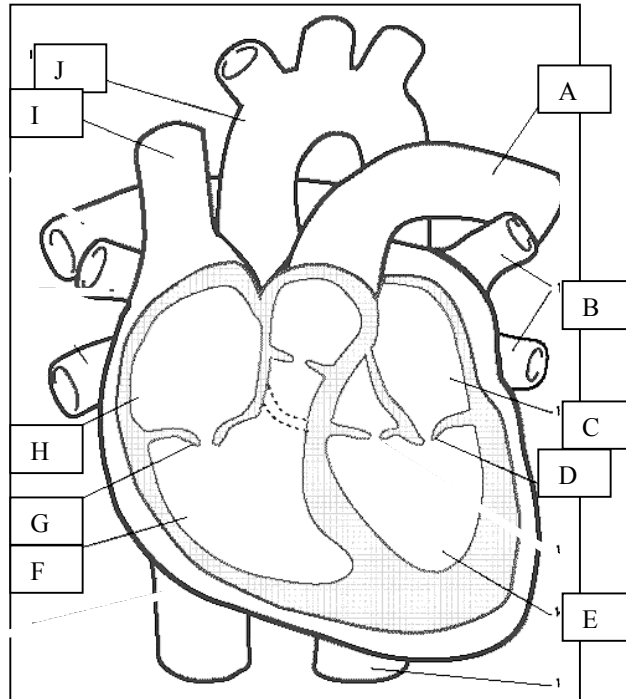
~~C. — 8~~

~~D. — 9~~

~~E. — 10~~

Questions 96-100. **The cardiovascular system in humans is a closed circulatory system consisting of a powerful pump, valves and specialized vessels.**

Question 96). Name the anatomical features of the heart indicated in the diagram (A-J) using terms from the list below (1-10). (1 point)



- | | |
|----------------------------|-----------------------|
| 1. Mitral (bicuspid) valve | 6. Superior vena cava |
| 2. Right atrium | 7. Right ventricle |
| 3. Pulmonary veins | 8. Left atrium |
| 4. Tricuspid valve | 9. Pulmonary artery |
| 5. Aorta | 10. Left ventricle |

1	2	3	4	5	6	7	8	9	10

Question 97). For the structures labelled A, B, C, E, F, H, I and J in the previous Figure, what is the correct order for the flow of blood entering from the systemic circulation? (1 point)

- A. I, H, F, J, B, C, E, A
- B. I, H, F, A, B, C, E, J
- C. A, F, H, I, B, C, E, J
- D. J, E, C, B, A, F, H, I
- E. A, F, H, J, B, C, E, I

Question 98). Flow through a tube is determined by the equation $v = \pi r^4 p / 8cl$

where: l = the length of the tube in cm

r = the radius of the tube in cm

p = the pressure difference between the two ends of the tube in dynes per cm^2

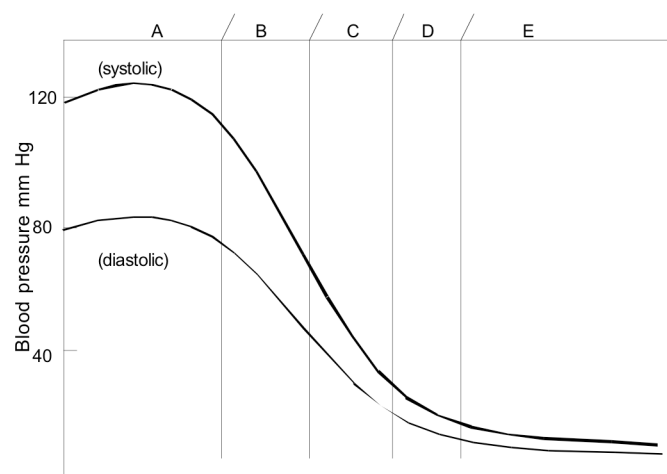
c = the coefficient of Viscosity in dyne-seconds per cm^2

v = volume in cm^3 per second

Which of the following will have the greatest effect on the resistance to blood flow? (1 point)

- A. Doubling the length of a blood vessel
- B. Doubling the diameter of a blood vessel
- C. Doubling the blood pressure
- D. Doubling the viscosity of the blood
- E. Halving the viscosity of the blood

Question 99). The following graph presents the pressure (systolic and diastolic) of a volume of blood moving through the circulation system via different blood vessels labelled A-E.



Which vessels match the letters A-E: (1 point)

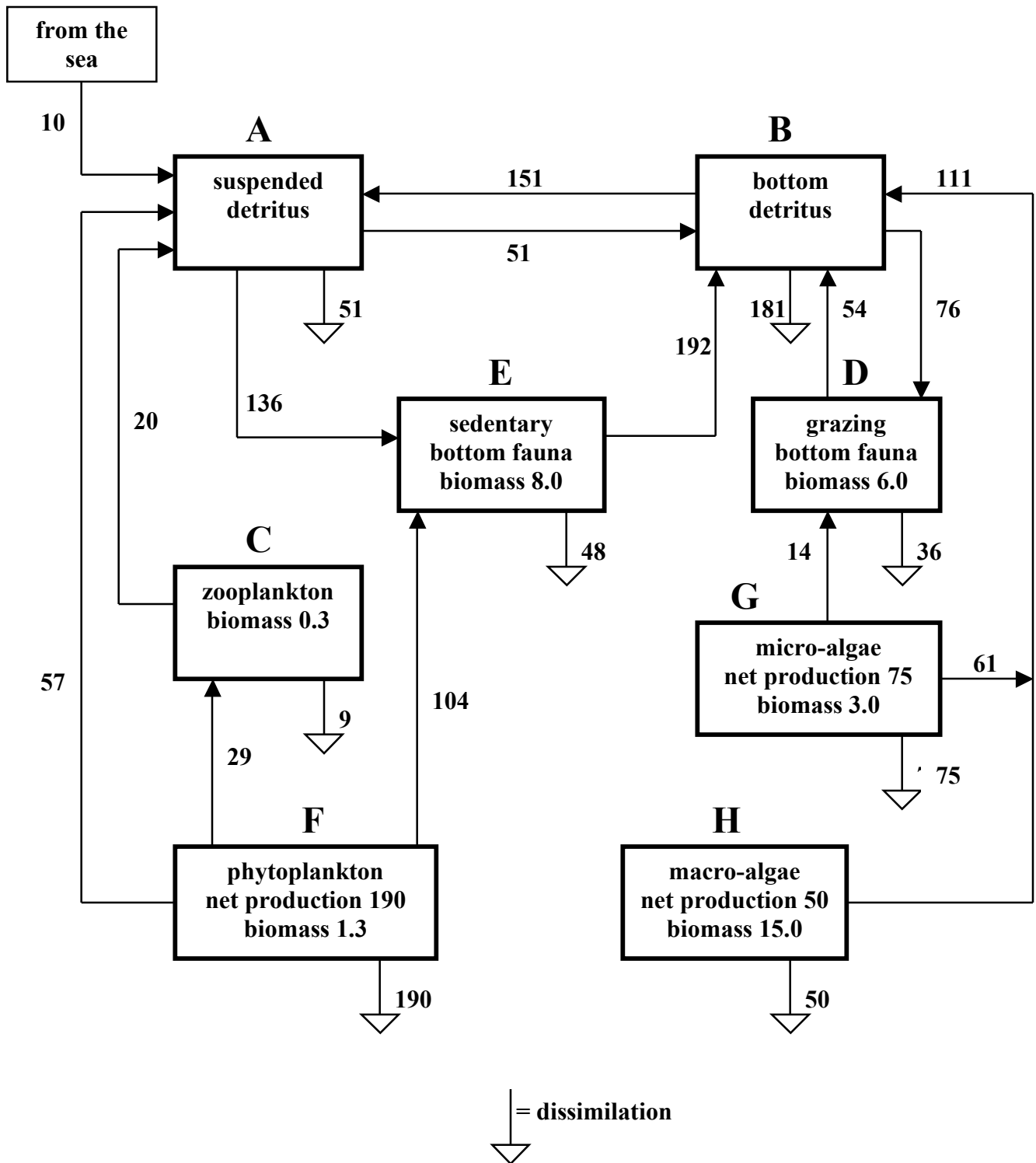
1. Venules
2. Capillaries
3. Arterioles
4. Veins
5. Arteries

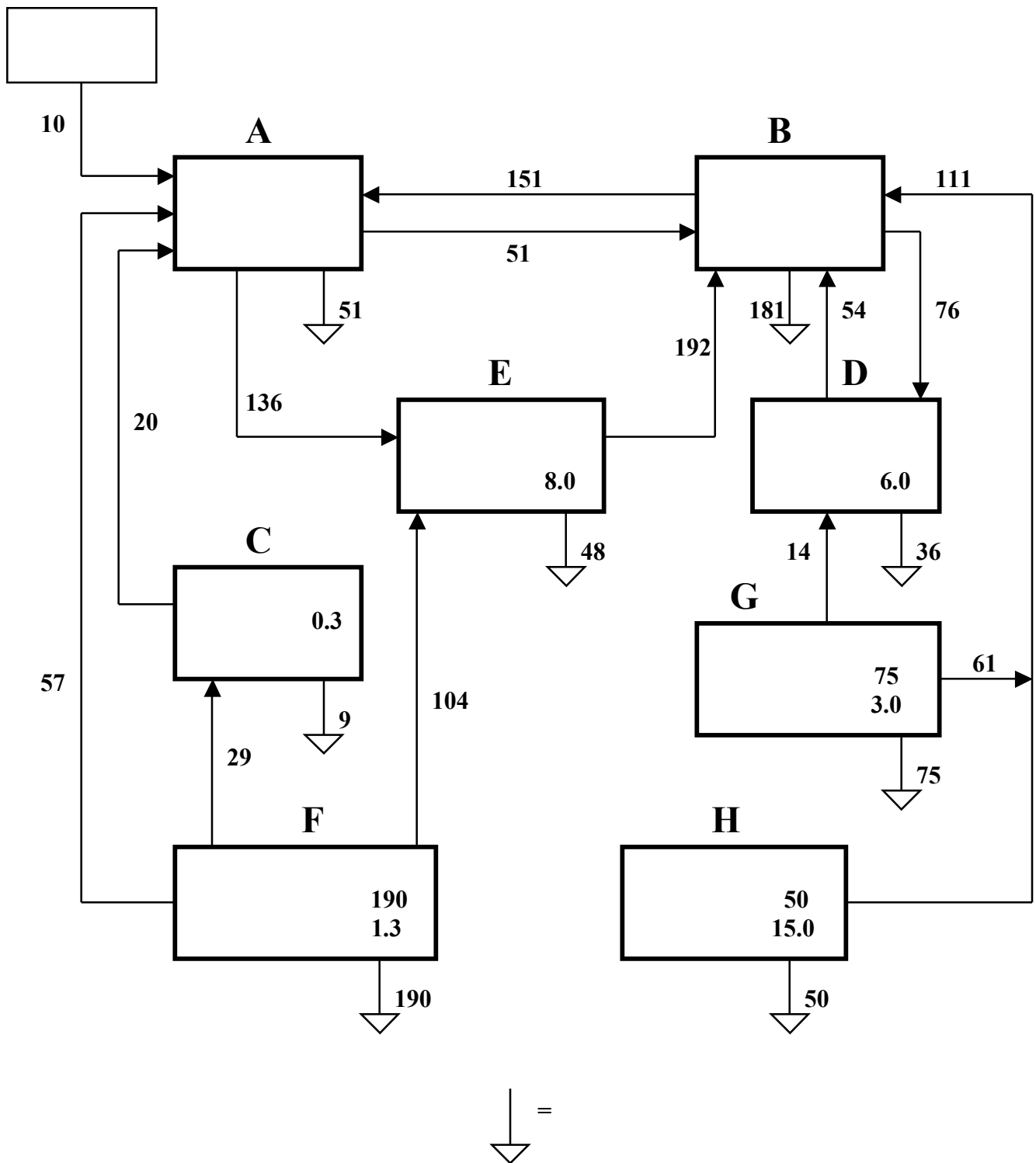
Answer [A/B/C/D/E/]

Question 100). All the following statements are FALSE EXCEPT one. Which? (1 point)

- A. A normal blood pressure for an adult is 140/90
- B. During exercise blood pressure will tend to increase
- C. Sympathetic impulses to the heart and blood vessels tends to decrease blood pressure
- D. Decreased cardiac output causes increased blood pressure
- E. A heart murmur may be caused by a leaky aortic aneurism

Question 101-105. Researchers studied the carbon cycle of a lake and summarized the results in the following scheme (numbers represent flow of carbon in gram/m² per year).





Question 101). What is the total biomass of consumers present in the scheme? (1 point)

- A. 8.3
- B. 9.6
- C. 14.0
- D. 14.3
- E. 29.0

Question 102). What is the total gross primary production of this ecosystem? (1 point)

- A. 125
- B. 240
- C. 265
- D. 315
- E. 630

Question 103). An indicator for the productive power of an ecosystem is the so-called P/B ratio, where P = net primary production and B = biomass. Which group has the highest P/B ratio?

(1 point)

- A. D (grazing bottom fauna)
- B. E (sedentary bottom fauna)
- C. F (phytoplankton)
- D. G (micro algae)
- E. H (macro algae)

Question 104). Macro-algae and micro-algae differ in their net production. Which of the following statements could explain the difference? (1 point)

- A. Per volume of biomass, macro-algae receive more light than micro-algae
- B. The proportion of micro-algae involved in photosynthesis is much bigger than macro-algae
- C. Micro-algae contribute more to production but lose it to bottom detritus
- D. Dissimilation in macro-algae is relatively much bigger than in micro-algae
- E. Macro-algae have a higher biomass, produce more but lose more to dissimilation

Question 105). In the lake, approximately how many days are necessary to renew the entire biomass of micro-algae? (1 point)

- A. 75
- B. 61
- C. 25
- D. 15
- E. 3

Questions 106-110. **All organisms reproduce by at least one of two processes – asexual or sexual. Both processes involve replication of genetic material - producing identical offspring in the case of asexual reproduction, or variable offspring (combination of gametes from two different parent organisms) in the case of sexual reproduction. In eukaryotic cells, replication of DNA is controlled by the cell cycle.**

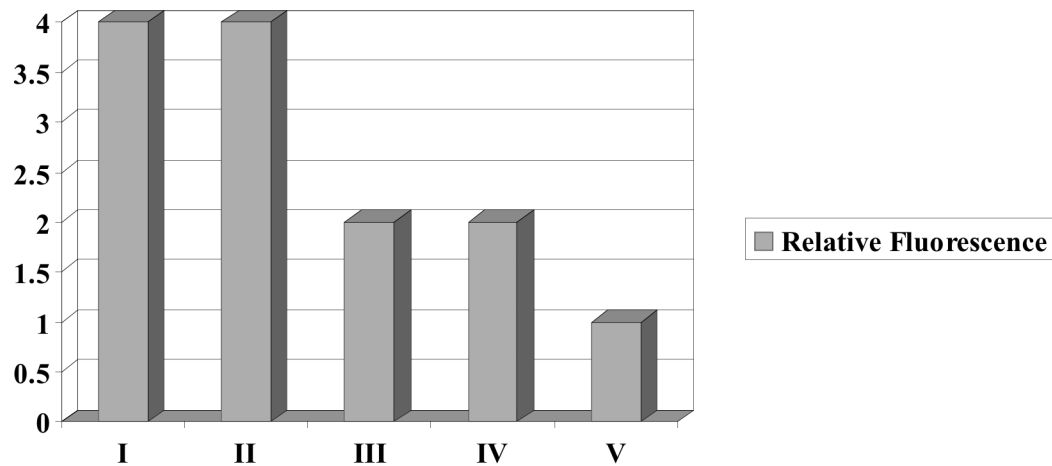
Question 106). Which of the following statements regarding human sex chromosomes is FALSE?
(1 point)

- A. X chromosomes contain hundreds of genes
- B. Y chromosomes contains the fewest genes of any human chromosome
- C. The Y chromosome has very likely evolved from an X chromosome in an ancestral species
- D. Most X chromosome genes concern female sexual development
- E. Y chromosomes are unique in that they can never undergo crossing over during meiosis

Question 107). Mitosis is a fundamental cellular process that has which of the following properties? (1 point)

- A. The outcome is two daughter cells that are genetically identical because they have each received an identical set of chromosomes
- B. Mitosis is crucial for growth, for the replacement of damaged or aging cells and for asexual reproduction
- C. In many species, haploid cells as well as diploid cells undergo mitosis
- D. Two of the above
- E. All of the above except D

Question 108). The amount of DNA in a cell can be determined by measuring the fluorescence of a dye that binds in direct proportion to the amount of DNA. The histogram below represents the fluorescence of a eukaryotic germ cell during different stages of cell division (I, II, III, IV and V).



Which of the following sequences represents the correct match of stages I-V with the division stages numbered 1-5? (1 point)

1. Anaphase I of meiosis
2. Anaphase II of meiosis
3. Cytokinesis following Telophase II
4. Prophase II of meiosis
5. Prophase I of meiosis

- A. 1 = II, 2 = IV, 3 = V, 4 = III, 5 = I
- B. 1 = I, 2 = II, 3 = III, 4 = IV, 5 = V
- C. 1 = V, 2 = IV, 3 = III, 4 = II, 5 = I
- D. 1 = I, 2 = II, 3 = IV, 4 = III, 5 = V
- E. 1 = IV, 2 = I, 3 = II, 4 = III, 5 = V

Question 109). Cytokinesis is the process that divides the cytoplasm of a parent animal cell into two daughter cells. From the following list of proteins, which are involved in cytokinesis steps? (1 point)

Tubulin

Fibronectin

Histone

Actin

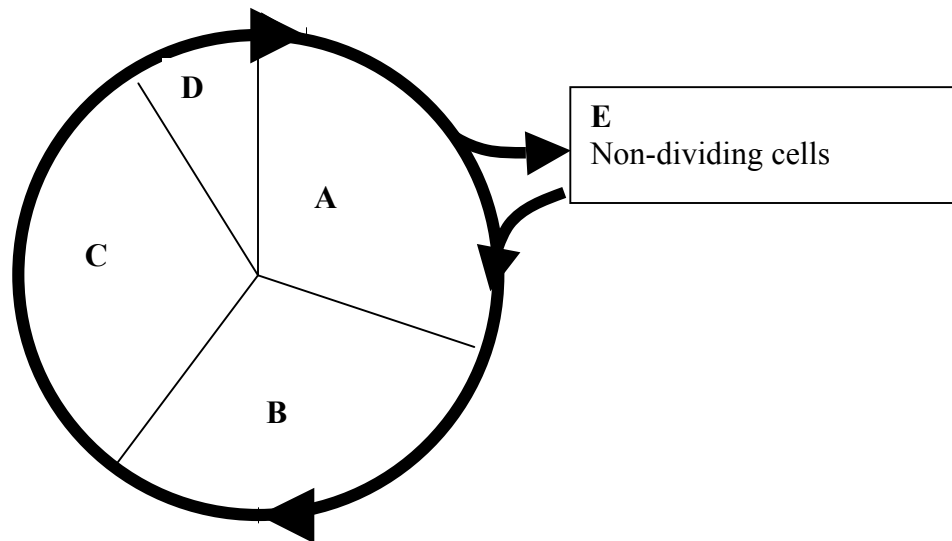
Myosin

Collagen

Albumin

- A. Tubulin, Fibronectin, Albumin, Actin
- B. Myosin, Collagen, Histone, Tubulin
- C. Actin, Histone, Collagen
- D. Tubulin, Myosin, Actin
- E. Myosin, Fibronectin, Collagen, Albumin

Question 110). The diagram below represents a eukaryotic cell cycle divided into 5 phases.



Match phases A-E on the diagram with the cell cycle stages shown in the Table and match the processes F-J with the appropriate cell cycle stage shown in the Table. (1 point)

- F. Cytokinesis
- G. Main growth period of the cell
- H. Duplication of DNA
- I. Quiescent cells
- J. Last stage of interphase

	Cell cycle stage	Phase [A,B,C,D,E]	Function [F,G,H,I,J]
1.	G ₂		
2.	M		
3.	G ₁		
4.	S		
5.	G ₀		

Questions 111-115. **A dairy cow grazes contentedly on pasture. As evening approaches, she joins the small procession to the milking shed.**

Question 111). Why do the cows go to the milking shed of their own accord? (0.5 point)

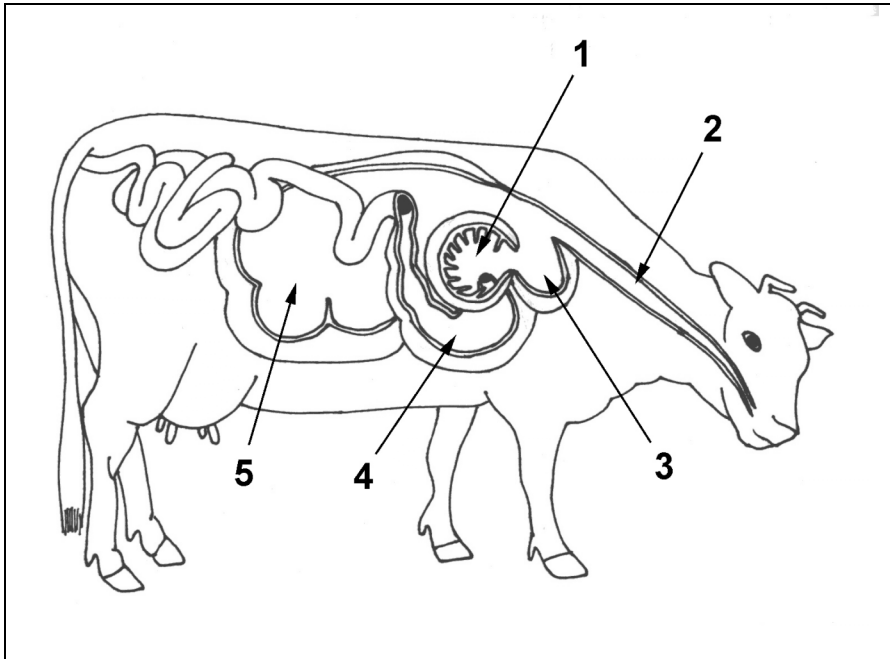
- A. Innate behaviour relating to herd instinct (gregarious nature)
- B. Innate behaviour relating to matriarchal dominance (follow-the-leader)
- C. Learnt behaviour in response to food reward (supplementary feed during milking)
- D. Learnt behaviour in response to pain relief (udder pressure relieved by milking)
- E. Learnt behaviour in response to pleasure (suckling stimulus enjoyable)

Question 112) Milk is collected twice daily from the dairy herd. Which of the following statements is FALSE? (0.5 point)

- A. The hormone oxytocin is responsible for the milk let-down reflex
- B. Milk can only be collected from lactating cows
- C. All cows milked have been pregnant
- D. Milk will only continue to be produced in response to suckling stimuli
- E. Milk is rich in butterfat and colostrum

Question 113). Cows are ruminants. They have special sacculated digestive tracts to facilitate fermentative digestion. Name the organs numbered on the diagram using the terms listed below.

(1 point)



- | | | |
|---------------|-------------|--------------|
| A. omasum | B. duodenum | C. reticulum |
| D. oesophagus | E. rumen | F. ileum |
| G. jejunum | H. abomasum | I. colon |

1.
2.
3.
4.
5.

Answer [A/B/C/D/E/F/G/H/I]

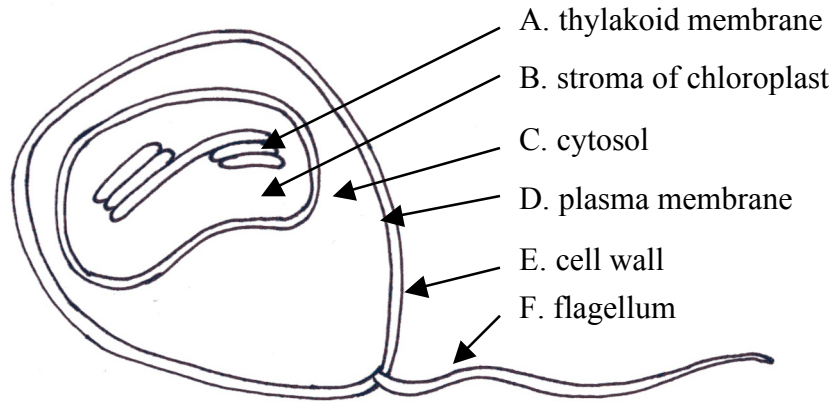
Question 114). Digestion of food is facilitated by enzymes produced by various organs. Indicate the sites of production of the listed enzymes and which substrates they act on. (2 points)

Organs	Food substrates	Enzymes	Organ (A/B/C/D/E)	Substrate (F/G/H)
A. intestines	F. polysaccharides	1. trypsin		
B. stomach	G. proteins	2. lipase		
C. pancreas	H. fat	3. aminopeptidase		
D. salivary gland		4. chymotrypsin		
E. liver		5. amylase		
		6. pepsin		

Question 115). Cows do not produce cellulase enzymes to digest plant cells. Instead, they rely on endosymbiotic micro-organisms to do so. Indicate which organisms produce cellulases in the rumen to digest plant cell walls by answering Yes (Y) or No (N). (1 point)

	Answer [Y/N]
1. viruses	
2. bacteria	
3. spirochaetes	
4. rickettsia	
5. protozoa	
6. fungi	
7. algae	
8. helminths	

Questions 116-120. The diagram below shows a single-celled green microalga from the ocean. Its single chloroplast and several other cellular components are labelled.



Question 116). Which components contain the following: (1 point)

1. orange and yellow carotenoids that harvest light energy for photosynthesis
2. starch
3. macromolecular polymers that prevent the cell from bursting if it is placed in fresh water
4. mitochondria

Answer [A/B/C/D/E/F]

Question 117). Two mineral nutrients required for the growth of algae are magnesium (Mg) and manganese (Mn). What are the roles of these minerals? (1 point)

- A. Mg assists osmosis; Mn assists the movement of flagella
- B. Mg is in chlorophyll; Mn is in the photosynthetic water-splitting complex
- C. Mg is in thylakoid cytochromes; Mn is in the terminal cytochrome oxidase of respiratory electron transport in mitochondria
- D. Mg^{2+} opens ligand-gated Ca^{2+} channels; Mn^{2+} closes these channels
- E. Mg is required for electron transport, Mn is required for membrane transport

Question 118). Indicate whether or not the generation of photosynthetic reducing power by this alga is directly essential for the indicated cellular processes by answering Yes (Y) or No (N). (1 point)

	Answer [Y/N]
1. manufacture of sugars from CO_2 and H_2O	
2. conversion of nitrate (NO_3^-) to the ammonium (NH_4^+) required for the biosynthesis of amino acids	
3. production of citrate from glucose	
4. incorporation of cytosolic phosphate ($\text{HPO}_4^{2-}/\text{H}_2\text{PO}_4^-$) into DNA and RNA	
5. assimilation of sulphate (SO_4^{2-}) into the amino acids cysteine and methionine	

Question 119). Which statement summarizes the reproductive capabilities of this alga? (1 point)

- A. Reproduces by mitosis, in which case genetically variable offspring are produced
- B. Reproduces by meiosis, in which case genetically identical offspring are produced
- C. Reproduces by mitosis, in which case genetically identical offspring are produced
- D. Reproduces by meiosis, in which case genetically variable offspring are produced
- E. Reproduces by C and D

Question 120). Flagella are common among eukaryotic organisms. Some prokaryotic organisms (bacteria) also possess flagella. Consider the following statements.

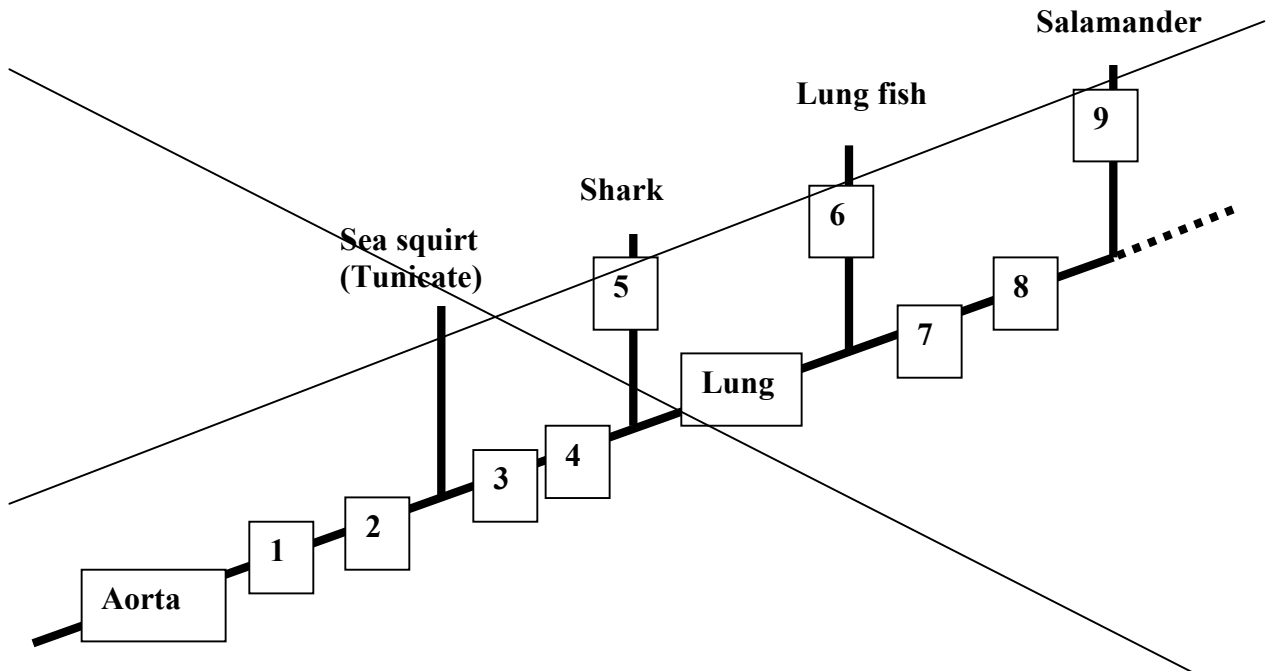
1. Bacterial flagella are covered with two membranes
2. Eukaryotic flagella undulate when driving cell movement
3. Both bacterial and eukaryotic flagella use proton gradients as direct energy sources
4. Prokaryotic flagella are formed from actin; eukaryotic flagella are formed from tubulin
5. Prokaryotic flagella are proteinaceous spiral filaments attached to multi-protein rotors
6. All prokaryotic cells have at least one flagellum
7. All eukaryotic flagella are covered with an extension of the plasma membrane
8. All functional eukaryotic flagella contain molecular motor-proteins (dyneins)
9. Prokaryotic flagella can rotate only in the one direction
10. Each eukaryotic flagellum has its own basal body

Which of these statements are true? (2 points)

- A. 2, 5, 7, 8, 10
- B. 1, 4, 7, 9, 10
- C. 3, 5, 6, 8, 10
- D. 2, 4, 7, 8, 9
- E. 1, 3, 5, 7, 9

Questions 121-123. Many genotypic and phenotypic traits recognized in animals and plants have been used in genetic mapping studies and biosystematics.

Question 121). A cladistic classification of part of the Animal Kingdom is shown below.



From the 16 options shown below (A–O), assign the nine most appropriate features to the positions numbered 1–9. (2 points)

- | | | |
|-----------------------------|--------------------------------|------------------------|
| A. Amniotic egg | F. Gill slits | K. Muscular lobed fins |
| B. Bony fin | G. Hinged jaw | L. Swim bladder |
| C. Cephalization | H. Internal development of egg | M. Vertebrae |
| D. Three-chambered heart | I. Limbs | N. Ribs |
| E. Fibrous protein skeleton | J. Long sticky tongue | O. Tail |

1	2	3	4	5	6	7	8	9

Question 122). Wing structure and function are characteristic for insect orders. Match the wing characteristics listed in the right-hand column (1-5) with the insect orders listed in the left-hand column (A-E). (1 point)

A. Odonata	1. One pair of wings, second pair of wings is transformed into halteres
B. Diptera	2. Two pairs of membranous wings
C. Orthoptera	3. Wingless
D. Lepidoptera	4. Two pairs of wings, forewings are leathery, hindwings are membranous
E. Phthiraptera (Anoplura)	5. Two pairs of wings covered with tiny scales

1	2	3	4	5

Question 123). Three alleles (a , b and c) are linked on a normal chromosome (autosome) of a

plant . An hybrid $\frac{ABC}{abc}$ was crossed with a recessive $\frac{abc}{abc}$ and the types and numbers of gametes

were recorded as follows:

ABC	414	Abc	70
aBc	28	abC	1
abc	386	aBC	80
AbC	20	ABc	1

1. What is the order of these genes on the chromosome? (1 point)

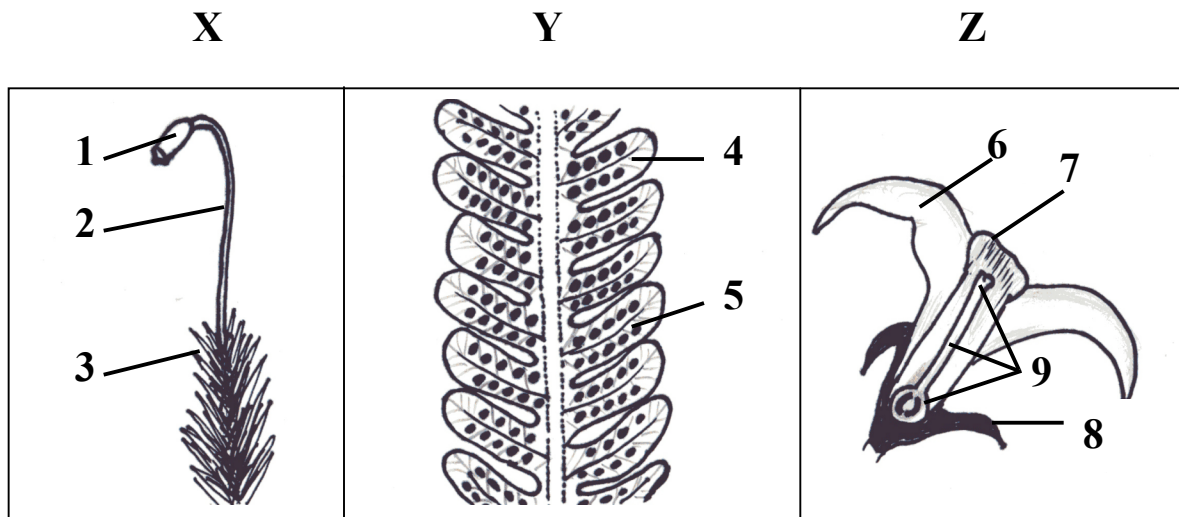
- A. abc
- B. acb
- C. bac

2). What is the correct distance between the three loci (in map units)? (2 points)

	distance between a and c	distance between b and c
A.	2.1	2.4
B.	3.4	5.0
C.	5.0	15.2
D.	15.2	3.4
E.	15.2	5.0

Questions 124-126. A plant biologist studies the sexual reproduction of a moss, a fern, and a flowering plant (tomato). The biologist makes the following drawings:

- X. moss leaves, seta and capsule
- Y. underside of part of a fern leaf
- Z. cross-section of a tomato flower



Nine structures are numbered 1 to 9.

Question 124). Indicate which structures conform to the following statements: (2 points)

1. Haploid cells that carry out photosynthesis

- A. Only 4, 5
- B. Only 3
- C. Only 1, 2, 6
- D. Only 4, 8

2. Diploid cells that carry out photosynthesis

- A. Only 1, 2, 3
- B. Only 3
- C. Only 3, 4, 8
- D. Only 4, 8

3. Leaves modified for functions other than photosynthesis

- A. Only 1, 2
- B. Only 1, 2, 6, 7
- C. Only 1, 5, 9
- D. Only 6, 7, 9

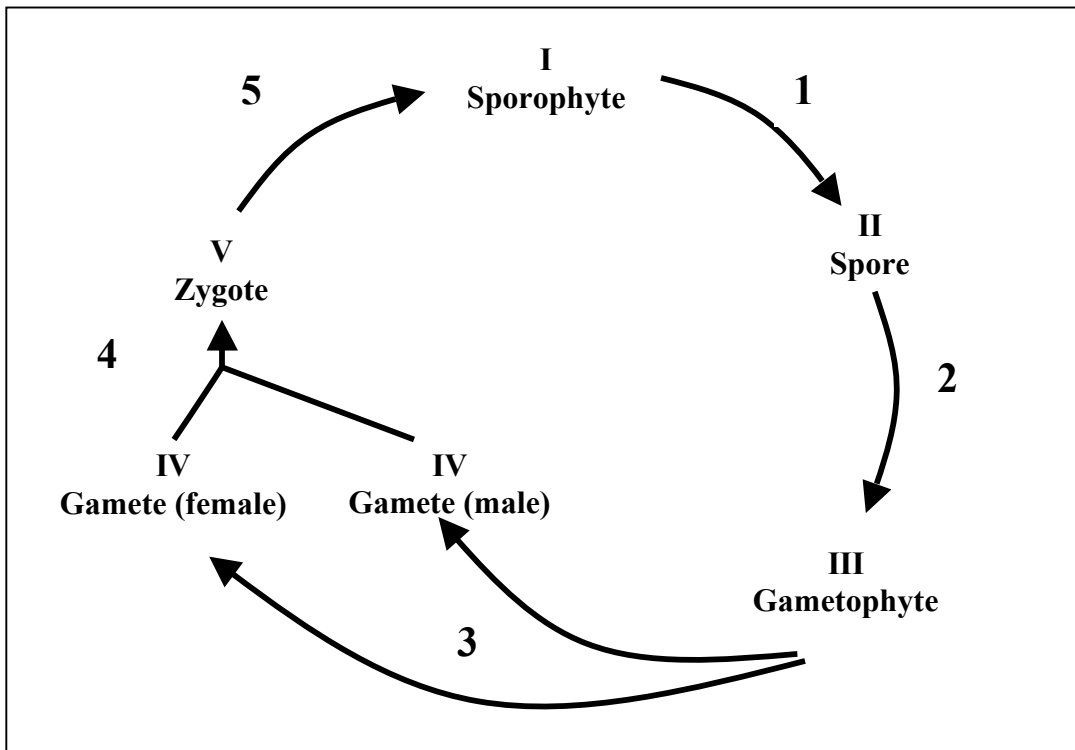
4. Structures where meiosis is occurring, or has recently occurred

- A. Only 1, 5, 7, 9
- B. Only 3, 4, 8
- C. Only 1, 2, 5
- D. Only 2, 8

5. Structure(s) that will produce spores destined to germinate and produce a haploid
photosynthetic plant

- A. Only 1
- B. Only 1, 5
- C. Only 1, 5, 7
- D. Only 5, 7

Question 125). The life cycle of a fern is shown in the diagram below. Five processes (numbered 1, 2, 3, 4, 5) and five stages (labelled I, II, III, IV, V) are indicated.



Select the processes, or stages, corresponding to the following items: (2 points)

1. Those producing genetic diversity

- A. Only 1, 3
- B. Only 2, 3, 4
- C. Only 1, 4
- D. Only 3

2. Those undergoing meiosis

- A. Only 1
- B. Only 1, 2, 3
- C. Only 2, 5
- D. Only 3, 4

3. Those with haploid cells

- A. Only I, III, IV
- B. Only II, III, IV
- C. Only I, V
- D. Only IV

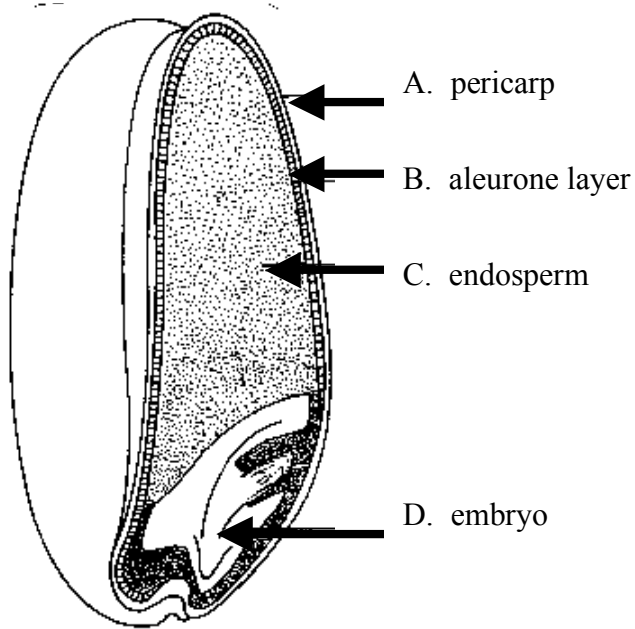
4. Those with diploid cells

- A. Only I, II, III
- B. Only I, II, III, V
- C. Only II, V
- D. Only I, V

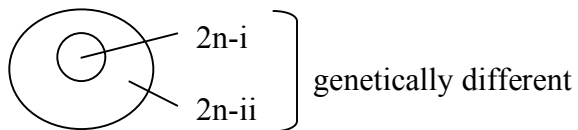
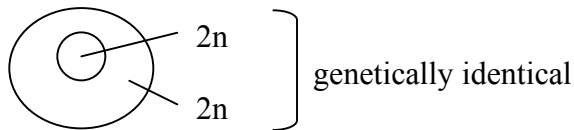
5. Those stages (or equivalents) not present in the human life cycle

- A. Only I, III
- B. Only II, III
- C. Only III, IV
- D. Only II, III, V

Question 126). The biologist examines sexual reproduction in a grass. He/she examines a rice grain, makes a cross-sectional drawing and labels the component parts.



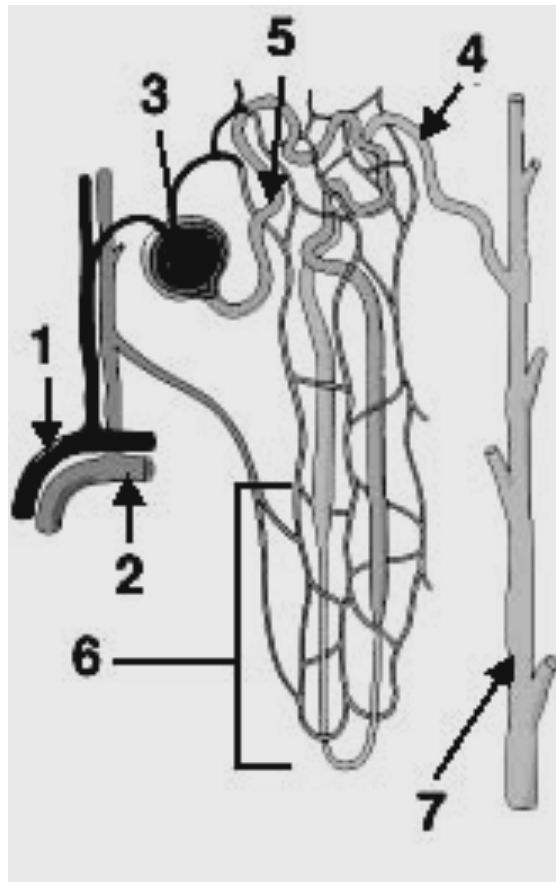
For each part, select the **ploidy** of the tissue (n , $2n$, $3n$, etc) and if two or more tissues have the same ploidy, indicate whether they are genetically identical or not, as follows:



- | | | | | |
|----|-----------|------------|-------------|------------|
| A. | A: $2n$ | B: n | C: n | D: $2n$ |
| B. | A: $2n-i$ | B: $3n$ | C: $3n$ | D: $2n-ii$ |
| C. | A: $3n-i$ | B: $3n-ii$ | C: $3n-iii$ | D: $2n$ |
| D. | A: $2n-i$ | B: n | C: $2n-ii$ | D: $3n$ |
| E. | A: $2n$ | B: $3n-i$ | C: $3n-ii$ | D: $2n$ |

Questions 127-131. **Albumin, with a molecular mass of 68,000 Da, is the most abundant protein in blood plasma, accounting for approximately 60% of all plasma protein.**

Question 127). A person was found to have reduced levels of plasma albumin, losses occurring as the result of kidney damage. Indicate the part of the kidney shown in the following diagram that you would expect to be the primary site of damage for this patient. (1 point)



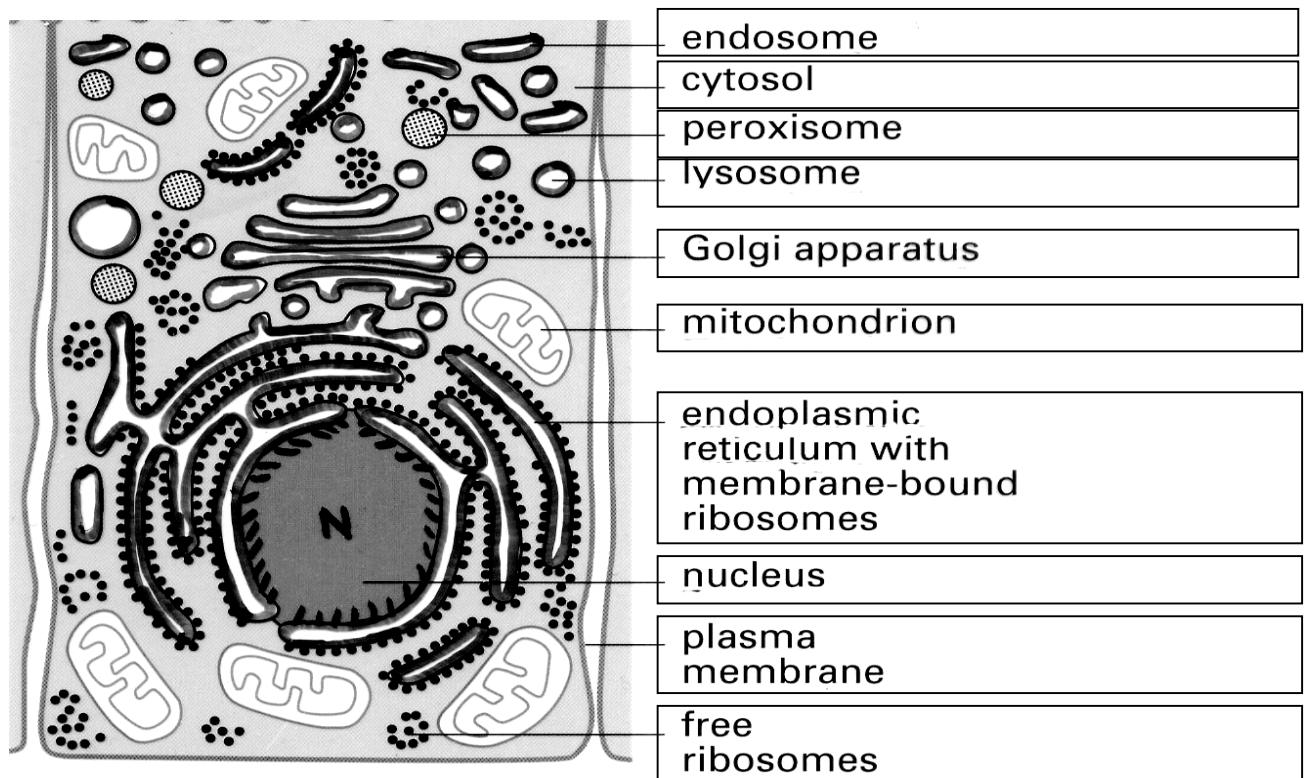
- A. 1
- B. 2
- C. 3
- D. 4
- E. 5
- F. 6
- G. 7

Question 128). A major function of albumin is to maintain blood osmolality (osmotic pressure).

The patient had swelling around the feet. An explanation for this symptom is that loss of albumin from plasma leads to which of the following? (1 point)

- A. High blood pressure
- B. Loss of tissue fluid
- C. Increased blood supply to feet
- D. Increased blood vessel size
- E. Low blood volume

Question 129). Albumin is synthesized in liver cells and secreted into the blood plasma. A diagram showing the ultrastructure of a liver cell is given below.



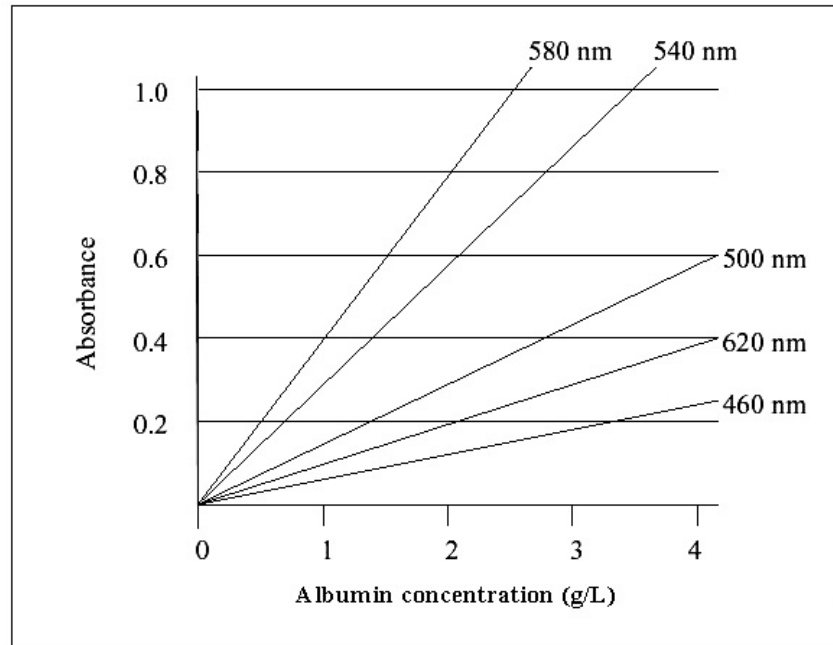
Which combination of organelles would be involved in the synthesis and transport of albumin to the plasma membrane for secretion? (1 point)

- A. nucleus, free ribosomes
- B. mitochondria, endosomes
- C. peroxisome, endoplasmic reticulum
- D. endoplasmic reticulum, Golgi apparatus
- E. Golgi apparatus, lysosomes
- F. endosomes, cytosol

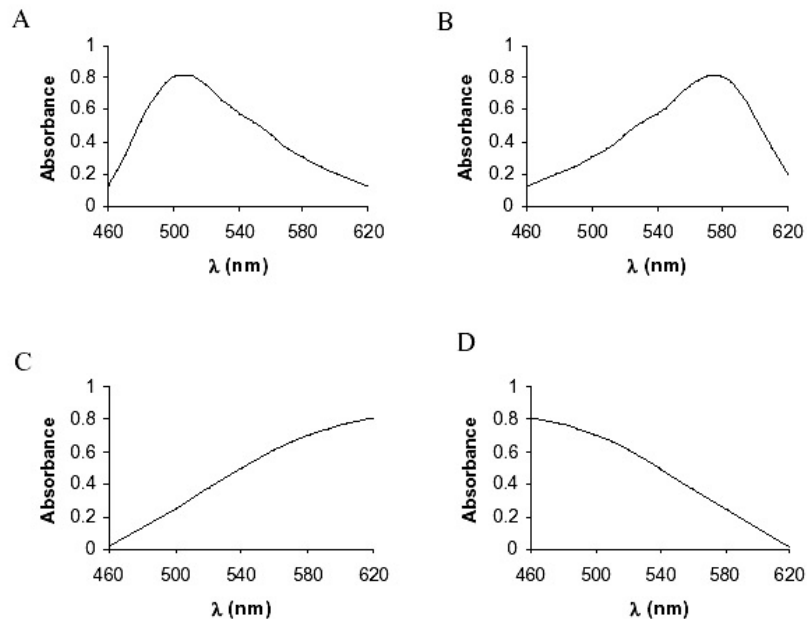
Question 130). Eukaryotic proteins encoded by the nuclear genome are translated from an initiation AUG codon – thus newly synthesized proteins have a methionine residue at the extreme amino-terminus. However, albumin isolated from human blood plasma does not have an amino-terminal methionine. Which of the following statements accounts for this? (1 point)

- A. Albumin is encoded by the mitochondrial genome, not the nuclear genome
- B. Albumin is modified in the plasma by proteolytic enzymes
- C. Albumin is processed by proteases as it passes through the endomembrane system
- D. The isolation procedure modifies the amino-terminus of the albumin protein
- E. The amino-terminus of albumin is modified by passage across the hepatocyte cell membrane

Question 131). The concentration of albumin in the blood plasma of a patient can be determined using a test based on the specific binding of albumin to a chemical dye. The graph shows the absorbance readings of the albumin-dye complex at different light wavelengths.



Which absorption spectrum is consistent with the above data for albumin at 2 g/L? (1 point)



E. None of the above

Questions 132-136. **When oxygen levels are low, some cells may resort to the process of fermentation to obtain energy. Examples include yeast cells used in bakeries, breweries and wineries.**

Question 132). The manufacture of bread, beer and wine all involve alcoholic fermentation of glucose to ethanol by yeast. Which combination of the following eight statements concerning this process is correct? (2 points)

1. Yeast carry out this fermentation because they lack mitochondria
2. For every molecule of ethanol produced, one molecule of CO_2 is evolved
3. The net generation of ATP is only two molecules per molecule of glucose fermented
4. More than 80% of the chemical energy of the glucose is released as heat
5. Glycolysis is an integral part of this fermentation
6. The conversion of one molecule of citrate to one molecule of malate and two molecules of CO_2 is an integral part of this fermentation
7. The electron donor for ethanol formation (catalysed by alcohol dehydrogenase) is NADH
8. CO_2 is evolved when beer is produced by alcoholic fermentation, but not when bread or wine are produced by alcoholic fermentation

- A. 1, 2, 3, 4, 5
- B. 1, 4, 7, 8
- C. 2, 3, 5, 7
- D. 2, 3, 6, 7, 8
- E. 3, 4, 5, 7, 8

Question 133). A healthy student decides to enter a 200 metre race. He has not trained to be an athlete, so he has little chance to prepare except to eat well. On the day of the race, he completes the run in 27 seconds. He finishes exhausted and suffers from leg-muscle cramps. (1 point)

1. What was the student's main source of energy during the race?
 - A. Muscle glucose and glycogen
 - B. Free amino acids in his muscle
 - C. The lipid component of blood low-density lipoproteins
 - D. Starch being digested from his last meal

2. What was the student's leg-muscle metabolism during the race?
 - A. Predominantly aerobic respiration
 - B. Both aerobic respiration and fermentation
 - C. Predominantly fermentation
 - D. Reactions were fully dependent on the O₂ supply delivered by blood haemoglobin

3. Which of the following biochemical pathways were important in his muscle during the race?
 - A. Fatty acid oxidation
 - B. Glycolysis
 - C. Gluconeogenesis
 - D. NADPH-generating oxidative pentose-phosphate pathway

4. Why did the student suffer leg cramps?

- A Bubbles of CO₂ generated by rapid respiration had accumulated in his muscles
- B Lactic acid generated by fermentation had accumulated in his muscles
- C Extensive exocytosis of Ca²⁺ from his muscle cells occurred
- D Muscle motor proteins (myosin) no longer required ATP to attach to muscle microfilaments (actin)

Question 134). Glucose in human liver cells can be synthesized from which combination of the following non-sugar sources? (1 point)

- 1. adenine
 - 2. alanine
 - 3. lactate
 - 4. palmitate
 - 5. glycerol
-
- A. Only 1, 2, 3
 - B. Only 1, 4
 - C. Only 2, 3, 4, 5
 - D. Only 4, 5
 - E. Only 2, 3, 5

Question 135). Which statements are FALSE for fermentation? (1 point)

1. Animal cells are capable of fermentation, but plant cells are not
2. In lactic acid fermentation, pyruvate is an electron acceptor instead of O_2
3. In ethanol fermentation, pyruvate is an electron acceptor instead of O_2
4. Oxidative phosphorylation occurs
5. Substrate level phosphorylation occurs
6. Photophosphorylation occurs

- A. Only 1, 5
- B. Only 1, 2, 6
- C. Only 1, 3, 4, 6
- D. Only 2
- E. Only 2, 5

Question 136). Which of the following statements is correct? (1 point)

- A. Fermentations always involve organic molecules (rather than O_2) acting as the ultimate acceptor of electrons
- B. Fermentations always involve the formation of a single product
- C. Fermentations always involve the production of CO_2
- D. Fermentations always involve yeast or bacteria growing in a large vat of fermentable substrate
- E. Fermentations always involve the formation of ethanol

Questions 137-141. **Mitochondria are double-membrane organelles found in most eukaryotic cells. They are involved in cellular respiration and metabolism.**

Question 137). A widely-held theory is that mitochondria evolved from endosymbiotic bacteria.

Indicate which statements support this theory by answering Yes (Y) or No (N). (1 point)

1. Mitochondria have their own DNA
2. Mitochondria have their own ribosomes
3. Mitochondria are derived from pre-existing mitochondria by division
4. Human mitochondrial genes lack introns
5. Some mitochondrial gene DNA sequences are similar to those of certain aerobic bacteria

[Y/N]

Question 138). Which of the following statements about mitochondria are correct? (Y = correct; N = incorrect) (1 point)

1. Acetyl-CoA conversion to citrate occurs in the Krebs cycle
2. Glucose oxidation to pyruvate occurs in the mitochondrial matrix
3. The mitochondrial electron transport chain is located on the inner mitochondrial membrane
4. The inner mitochondrial membrane prevents the free movement of metabolites into and out of the mitochondrion
5. Mitochondria contain specific membrane transporters

[Y/N]

uestion 139). During oxidation of NADH by the electron transport chain, protons are pumped across the inner mitochondrial membrane. Which of the following statements about this process is INCORRECT? (1 point)

- A. Proton pumping is achieved by alternating hydrogen and electron carriers in the electron transport chain
- B. Ubiquinone (Coenzyme Q) is a hydrogen carrier
- C. Cytochromes are electron carriers but not hydrogen carriers
- D. The ATP synthase complex uses the proton gradient to make ATP
- E. The ATP synthase reaction involves a rotor mechanism
- F. Proton pumping can decrease the pH in the mitochondrial matrix by 1 pH unit
- G. Iron-sulphur (Fe-S) proteins are electron carriers

Question 140). Which of the following statements about mitochondrial DNA and protein synthesis is correct? (1 point)

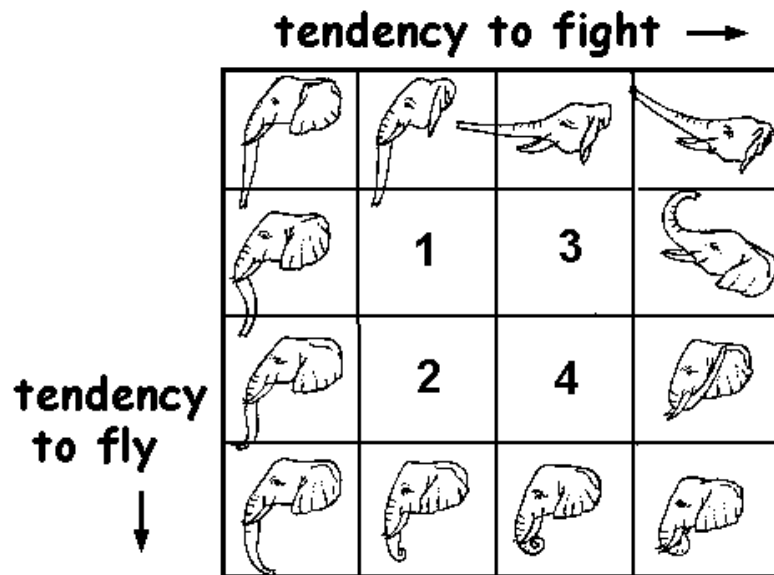
- A. All mitochondrial proteins are coded for by mitochondrial DNA
- B. Mitochondrial DNA accumulates mutations more slowly than nuclear DNA (per 1,000 base pairs)
- C. Mitochondrial DNA is inherited equally from both parents
- D. Mitochondrial ribosomes are the same size as mammalian ribosomes
- E. Antibiotics are known which inhibit protein synthesis in both bacteria and mitochondria
- F. Mitochondrial DNA codes for active RNA molecules but not for proteins
- G. The production of ATP by mitochondria is unaffected by age

Question 141). An electrochemical proton gradient is also responsible for powering bacterial flagella. During oxidation of glucose, protons are pumped out of the cell to help establish an electrochemical gradient. The flagellar motor is driven directly by the flux of protons back into the bacterial cell from the proton gradient. Addition of FCCP, a proton ionophore, to these bacteria in a medium containing a high concentration of K^+ , results in loss of bacterial motility. Which statement best explains the action of FCCP? (1 point)

- A. FCCP equilibrates the H^+ concentration across the bacterial membrane
- B. FCCP allows K^+ ions across the bacterial membrane
- C. FCCP depletes glucose
- D. FCCP allows proteins across the bacterial membrane
- E. FCCP inhibits glucose oxidation

Questions 142-146. **Animals have developed complex patterns of behaviour which scientists are slowly learning to decipher through rigorous experimentation. Animals live in complex ecosystems and many varied parameters influence their behaviour.**

Question 142). The following matrix shows elephant head positions relative to their tendency to fight or fly (with four illustrations labelled 1-4 missing).



The missing illustrations are shown below in random order (labelled I-IV).



Which illustrations (I-IV) correctly match positions (1-4) in the matrix? (1 point)

	Position 1	Position 2	Position 3	Position 4
A.	I	II	III	IV
B.	I	IV	II	III
C.	II	I	IV	III
D.	II	IV	III	I
E.	III	I	II	IV

Question 143). Scientists put mallard ducklings (*Anas platyrhynchos*) into a large outdoor enclosure and then moved a silhouette shape (pictured below) across the top of the enclosure at intermittent intervals and in either direction (as shown).



Eight possible behaviours are listed below for different test conditions.

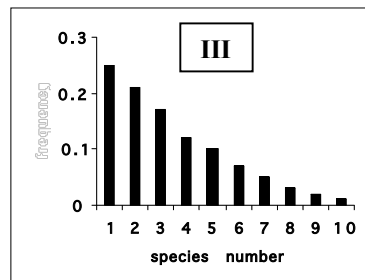
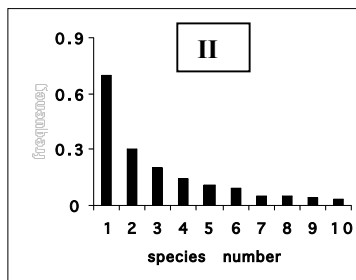
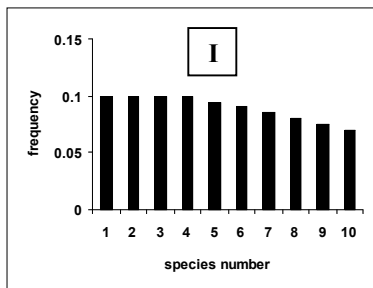
1. The ducklings crouch and run during movement of the shape from left to the right.
2. The ducklings do not respond during movement of the shape from right to the left.
3. The ducklings respond more to the 'hawk' shape than the 'duck' shape.
4. Ducklings reared and tested together with ducks are more likely to crouch than run in response to the 'hawk' shape.
5. Ducklings will respond more to the 'duck' shape than the 'hawk' shape.
6. Ducklings reared and tested alone are more likely to run than crouch in response to the 'hawk' shape.
7. Ducklings reared and tested together with ducks are more likely to run than crouch in response to the 'hawk' shape.
8. Ducklings reared and tested alone are more likely to crouch than run in response to the 'hawk' shape.

Which combination of duckling behaviours is correct? (1 point)

- A. 1, 5, 8
- B. 3, 5, 6
- C. 2, 3, 7
- D. 3, 4, 6
- E. 4, 7, 8

Question 144). Consider three hypothetical communities I, II and III, each containing ten species.

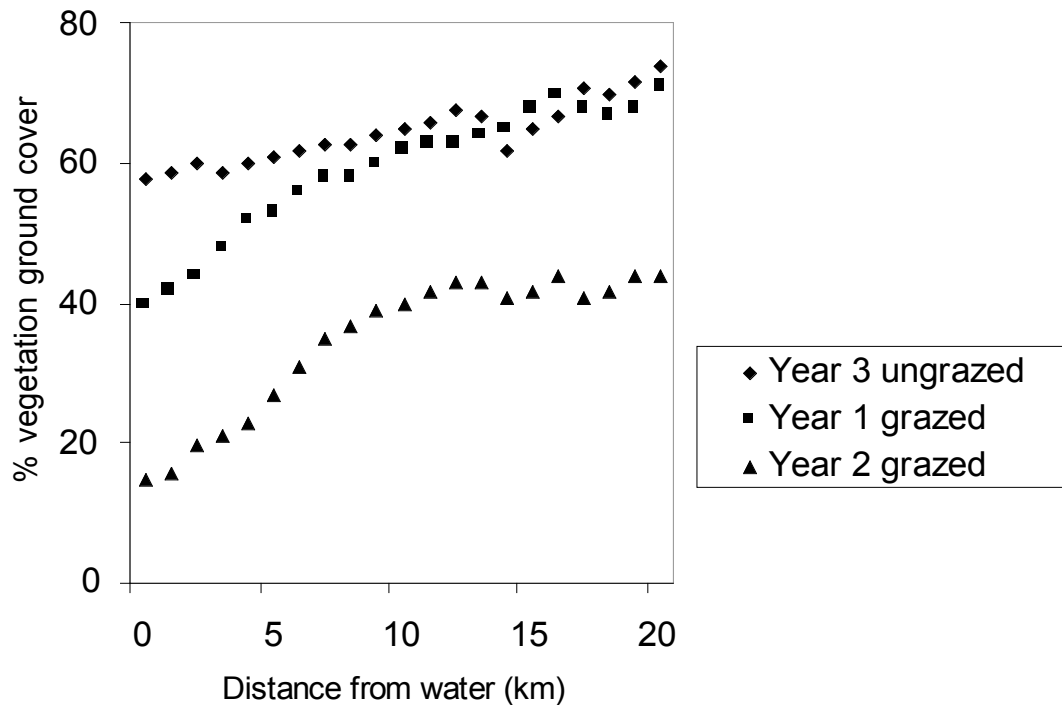
The following graphs show the relative abundance (vertical axis) of each species, when the species are ranked in decreasing order of abundance on the horizontal axis.



How would you rank the communities in decreasing order of biodiversity? (1 point)

- A. $I = II = III$
- B. $I > III > II$
- C. $III > II > I$
- D. $II > III > I$
- E. $I > II > III$

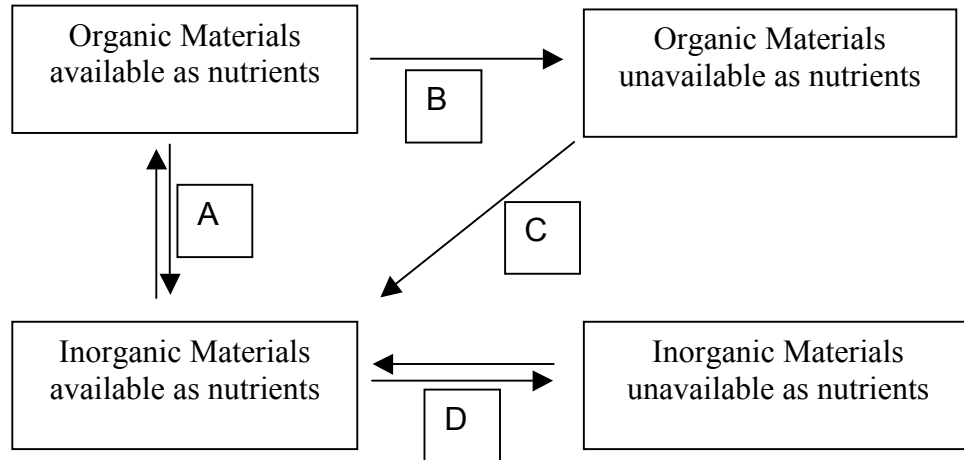
Question 145). The following graph indicates the variation in vegetation ground cover with distance from a stock water supply point in a semi-arid pasture during three successive years. The pasture was grazed in Years 1 and 2 but was ungrazed in Year 3.



The patterns of variation in vegetation cover with distance from water indicate which of the following? (1 point)

- A. Rainfall was approximately equal in Years 1 and 3, and substantially less in Year 2
- B. Grazing pressure is much more severe over the entire area in a dry year than in a wet year
- C. Grazing in Years 1 and 2 affects the vegetation cover in Year 3, and grazing pressure is inversely proportional to distance from the water supply point
- D. The animals graze only within 10 km of the water supply point
- E. Stocking density was higher in year 1 than year 2

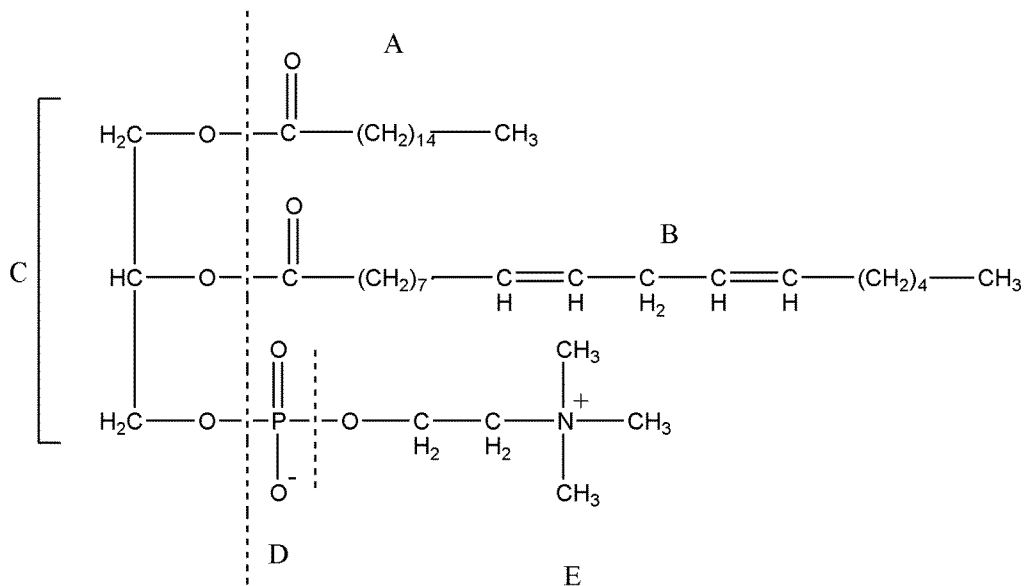
Question 146). Consider the following schematic diagram of generalized nutrient cycling within ecosystems. The labelled arrows A to D represent transfer between the pools.



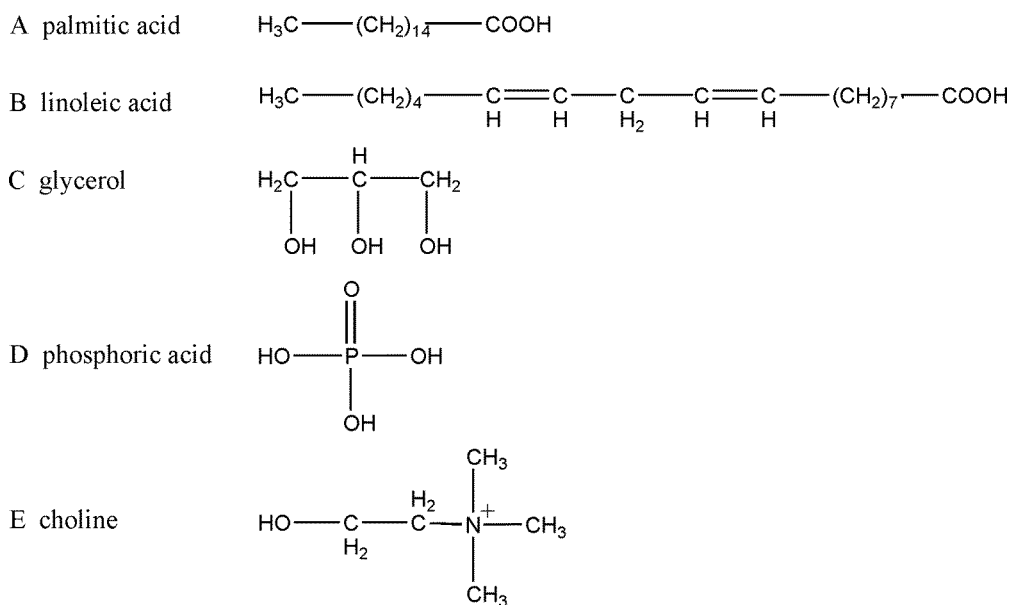
Which of the following statements about the rate of transfer per unit time between these pools is correct? (1 point)

- A. The rate at which transfer A occurs is slower than the rate at which B occurs
- B. The rate at which transfer D occurs is faster than the rate at which transfer A occurs
- C. All transfers occur at similar rates
- D. The rate at which transfer A occurs is faster than the rate at which B occurs
- E. These rates are largely unaffected by human actions

Questions 147-151. **Phospholipids and proteins are the major components of biological membranes. The structure of 1-palmitoyl-2-linoleoyl-phosphatidylcholine, a common phospholipid, is shown below.**



The structures of the components (labelled A-E) are shown separately below.



Question 147). Phospholipids are often represented as having a head (H) and tail (T) region.



Indicate where each of the component parts of phosphatidylcholine are found. (1 point)

A. palmitic acid
B. linoleic acid
C. glycerol
D. phosphoric acid
E. choline

Answer [H/T]

Question 148). Which of the components A, B, C, D or E conform to the following descriptions?

(1 point)

1. This molecule is a polyunsaturated fatty acid component of 1-palmitoyl-2-linoleoyl-phosphatidylcholine
2. A diet rich in animal fats results in enrichment of this fatty acid in cell membranes
3. This molecule is also a component of DNA

Answer [A/B/C/D/E]

Question 149). Considering the roles of membrane lipids and proteins, and the functions of the following membranes, match the protein/lipid ratios given below to the following membranes.

(1 point).

- A. Schwann cell membrane (myelin sheath)
- B. Erythrocyte (red blood cell) membrane
- C. Inner mitochondrial membrane

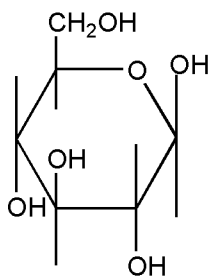
	protein/lipid ratio	Answer
1.	1:1	[A/B/C]
2.	4:1	
3.	1:4	

Question 150). Proteins can span a membrane by means of a stretch of 20 nonpolar amino acids in an α -helical arrangement. Given that the α -helix has a pitch of 0.54 nm and has 3.6 amino acid residues per turn, what is the thickness of the nonpolar central section of the lipid bilayer?

(1 point)

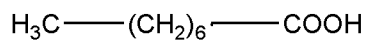
- A. 0.18 nm
- B. 3.0 nm
- C. 5.5 nm
- D. 10.2 nm
- E. 37.0 nm

Question 151). Select two of the following molecules which you would expect to be able to diffuse readily across a biological bilayer membrane. (1 point)



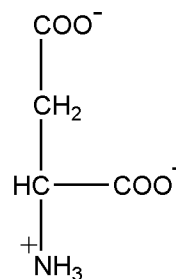
1

β -D-glucose



2

Octanoic acid



3

Aspartic acid



4

Water

- A. 1+2
- B. 1+3
- C. 1+4
- D. 2+3
- E. 2+4
- F. 3+4

Questions 152-156. Two species of nectarivorous bird are feeding in the same meadow. Both species of bird have already migrated some distance from their wintering ground to reach the meadow. They need to migrate further to reach their breeding grounds. While on the meadow, each individual bird holds a feeding territory. They are feeding on the nectar in the flowers of one species of plant.

Question 152). What are the two main resources that the nectar provides? (1 point)

- A. Fat and protein
- B. Pollen and carbohydrate
- C. Carbohydrate and protein
- D. Fat and carbohydrate
- E. Water and protein

Question 153). What will be the birds' primary objective during their time on the meadow?

(1 point)

- A. Find a mate
- B. Maximise its net rate of energy gain
- C. Rear young
- D. Minimise its rate of energy consumption
- E. Compete with other species

Question 154). The types of interaction between the plant and the birds, and between the two species of bird, are called which of the following, respectively? (1 point)

- A. Predation and mutualism
- B. Predation and competition
- C. Mutualism and predation
- D. Competition and mutualism
- E. Mutualism and competition

Question 155). All else being equal, what type of flowers would the birds prefer to choose?

(1 point)

- A. Flowers with more nectar
- B. Flowers that are purple
- C. Flowers with variable supplies of nectar
- D. Flowers closer to the ground
- E. Flowers that have recently been pollinated

Question 156). A few of the plants have a gene that, when expressed, means they secrete no nectar. Which of the following statements is true? (1 point)

- A. These plants will have no offspring because the birds will not visit their flowers
- B. Plants that do not secrete nectar cannot set seed
- C. Plants that do not secrete nectar save energy that can be used for growth and other plant functions
- D. Failure to secrete nectar must be a recessive trait that confers no selective advantage
- E. Plants that secrete more nectar will have more offspring

-----END-----