Country:	Student Code: _____

19th INTERNATIONAL BIOLOGY OLYMPIAD

13th – 20th July, 2008

Mumbai, INDIA

THEORETICAL TEST – PART B

Write all answers in the **ANSWER SHEET**.

Dear Participants

- You have a total of 150 minutes for answering Part B.
- The questions in Part B may have more than one correct answer. Fill your answers in the **Answer Sheet** for Part B. The marks for the questions in Part B vary depending on the number of answers and the complexity of the question. These marks have been indicated along with the question.
- Mark your answers clearly. Avoid any corrections in the Answer Sheet.
- NOTE: Some of the questions may be marked “Skipped” / “Deleted”. DO NOT attempt these questions. Also, read the question completely before attempting it as some questions may continue from one page to the next.
- The maximum number of points is **120.5.**
- Your Answer Sheets will be collected at the end of the examination.

Good Luck!!

Country: _____

First name: _____

Middle name: _____

Family name: _____

Student Code: _____

CELL BIOLOGY (26 points)

1. (2+1+2 = 5 points) A bacterium has a single copy of a 4 x10^6 bp circular genomic DNA.

   Use a value of 3 for π, 6 x 10^{23} for the Avogadro's number and 660 for the molecular weight of 1 bp of DNA. Note that 10 bp of linear DNA has a length of 3.4 nm. The volume of a sphere of radius *r* is $\frac{4}{3}\pi r^3$.

a. If the diameter of this spherical cell is 1 μm, what would be the molar concentration of DNA in this cell?

   Answer: _____Molar

b. If the DNA assumed a conformation as proposed by Watson and Crick, what would be the linear length of the bacterial DNA.

   Answer: _____metre

c. How many bacterial cells one should take to get 1 mg of DNA?

   Answer: _____

2. (3 points) Smooth endoplasmic reticulum (SER) is mainly concerned with the following functions:

   I. Lipid synthesis

   II. Drug detoxification

   III. Ca^{++} storage

   IV. Gluconeogenesis

   Fill in the following table with a tick mark (√) wherever appropriate <u>and</u> indicate the function/s of SER wherever it is extensively present, by choosing from options I – IV above.

	Organ/Cell	SER extensively present	SER not extensively present	Function/s (if extensively present)
a.	Adrenal gland			
b.	Sebaceous glands			
c.	Intestinal villi			
d.	Muscles			
e.	Liver			
f.	Pancreas			

3. (2 points) There are various mechanisms by which a cell can commit suicide – a phenomenon known as “apoptosis”. One of the mechanisms is triggered by reactive oxygen species. The outer membrane of mitochondria normally expresses a protein Bcl-2 on its surface. Another protein Apaf-1 binds Bcl-2. Reactive oxygen species cause Bcl-2 to release Apaf-1 and a third protein Bax to penetrate the mitochondrial membrane, releasing cytochrome c. The released cytochrome c forms a complex with Apaf-1 and caspase 9. This complex sequentially activates many proteases that digest cellular proteins. Finally, the cell is phagocytosed.

What will be the fate of a cell exposed to reactive oxygen species in the following situations? Choose from the options given on the next page.

Situation I: The cell receives a signal for inhibition of expression of Apaf-1 protein. _____

Situation II: The cell expresses low-affinity Bcl-2 proteins. _____

Situation III: A competitive inhibitor of Apaf-1 for Bcl-2 binding is added to the cell in excess quantity. _____

Situation IV: A chemical which significantly lowers the ratio of Bax to Bcl-2 is added to the cell. _____

Choose from the following options:

A. The cell resists apoptosis.

B. The cell is forced towards apoptosis.

C. The fate of the cell cannot be predicted.

4. (3 points) The stoichiometry of aerobic and anaerobic degradation of glucose by yeast are as follows:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

In an experiment, the complete utilization of 0.5 mol of glucose, partly under aerobic and partly under anaerobic conditions, yielded 1.8 mol of CO_2.

a. Calculate the fraction of glucose that is utilized aerobically.

Answer: _____%

b. Calculate the Respiratory Quotient, which is defined as the molar ratio of the CO_2 produced to the O_2 utilized.

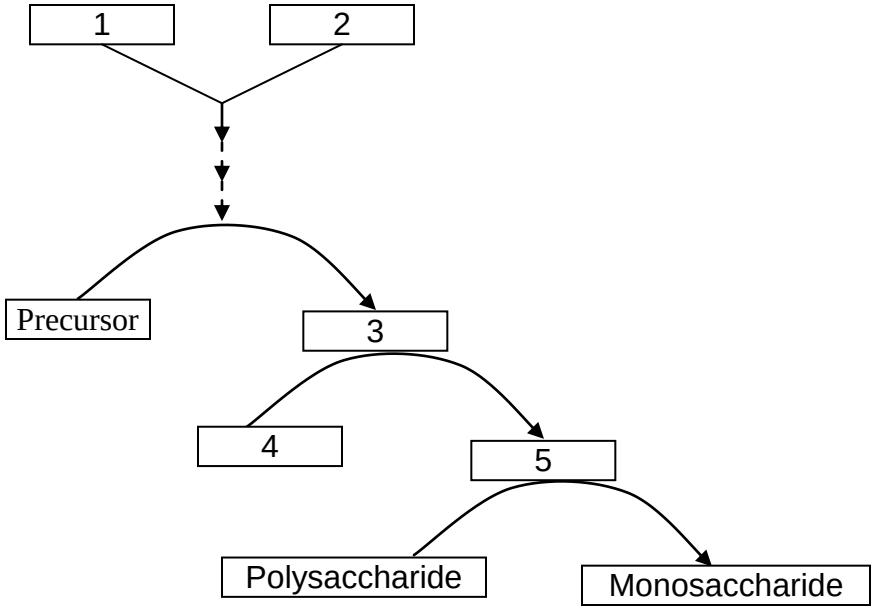
Answer: _____

5. (2.5 points) In order to study the effect of a hormone on the breakdown of a polysaccharide in liver tissue, fresh liver was homogenized in an isotonic buffer system. Part of this homogenate was centrifuged to obtain a clear supernatant and a pellet.

The following experiments were then conducted.

Experiment	Reaction mixture	Result	
		Quantity of enzyme	Activity of enzyme
I	Liver homogenate	++++	±
II	Liver homogenate + hormone	++++	++++
III	Supernatant + hormone	++++	±
IV	Pellet + hormone	±	±
V	Supernatant + small quantity of reaction mixture from Experiment IV	++++	++++
VI	Supernatant + small quantity of heated reaction mixture from Experiment IV	++++	++++
VII	Supernatant + small quantity of heated pellet + hormone	++++	±

Complete the signal transduction pathway for the breakdown of the polysaccharide in the following schematic.



Options:

A. Membrane-bound protein

B. Heat-stable molecule

C. Inactive enzyme

D. Active cytosolic enzyme

E. Hormone

F. Organic inhibitor

G. Heat shock protein

Fill in the appropriate letters in the table from the options given.

1	2	3	4	5

6. (4 points) Sugars and fatty acids are important biomolecules that provide energy to the majority of living systems. The estimated utilization of palmitic acid and glucose in the human body is shown in the equation below:

(A) $$C_{15}H_{31}COOH + 23\ O_2 \xrightarrow{129\ P_i + 129\ ADP \rightarrow 129\ ATP} 16\ CO_2 + 16\ H_2O$$

(B) $$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{38\ P_i + 38\ ADP \rightarrow 38\ ATP} 6\ CO_2 + 6\ H_2O$$

Answer the following questions:

(Atomic weights of H: 1, C: 12 and O: 16)

I. ATP yield (in moles) per mole of oxygen in Reaction A :_____

II. ATP yield (in moles) per mole of oxygen in Reaction B:_____

III. ATP yield (in moles) per gram of fuel in Reaction A: _____

IV. ATP yield (in moles) per gram of fuel in Reaction B:_____

V. Based on the above reactions, state whether the following statements are true or false by putting tick marks (√) in the appropriate boxes.

Statements:

a. Under conditions of mild-intensity exercise and

V. Based on the value you obtain, the correct interpretation is:

a. At $p < 0.05$, the null hypothesis can not be rejected.

b. At $p < 0.05$, the null hypothesis is rejected.

Put a tick mark (√) in the appropriate box.

a.	
b.	

ETHOLOGY (11 points)

36. (2 points) In a population of prey animals, most individuals are solitary and stay well apart from others. But some mutant types arise that search out others, use them as shields against predators and take away fitness from the solitary types by making them more conspicuous to their predators. Let the fitness payoff for a solitary individual living in a population consisting of only solitary types be P. But when a solitary individual is found and used by a social type, the solitary animal loses some fitness (B) to the social type. There is also an additional cost C to being social in terms of the time required to find a solitary individual to hide behind and that arising from the resulting increased conspicuousness to predators. When two social types interact, assume that they each have an equal chance of hiding behind the other when the predator attacks. A game theory diagram summarizes these interactions as follows:

Payoff for	In presence of	
	Solitary	Social
Solitary	P	P – B
Social	P + B – C	P + B/2 – B/2 – C = P – C

(A) If B is greater than C, what behavioral type will predominate in the population over time?

a. Solitary

b. Social

Put a tick mark (√) in the appropriate box.

a.	
b.	

(B) The average fitness payoff of a prey

(i) when it enters a population composed entirely of solitary types and

(ii) when it enters a population composed entirely of social types

would, respectively, be:

a. P – B/2 – C/2, P + B/2 – C/2

b. P – B/2, P + B/2 – C

c. P + B/2 – C/2, P – B/2 – C/2

d. P + B/2, P – B/2 – C

Put a tick mark (√) in the appropriate box.

a.	b.	c.	d.

37. (3 points) Game theory models have been borrowed from economics and often applied to behavioral ecology in order to understand the strategies that animals use against each other while competing for resources. In a Hawk-Dove game, for example, in which there were two kinds of competing individuals, Hawks and Doves, with different behavioral strategies, John Maynard Smith suggested the following pay-offs:

Winner	+50
Injury	-100
Loser	0
Display	-10

(A) Assuming that (a) Hawks always win against Doves, (b) Hawks win on half the occasions when they meet other Hawks but suffer injury during the other half, (c) Doves always display when they meet other Doves, but win on only half of these occasions, and (d) Doves never display to Hawks, what would be the average pay-off to the attacker in different fights as listed in the following matrix?

		Opponent	
		Hawk	Dove
Attacker	Hawk		
	Dove		

(B) An Evolutionary Stable Strategy (ESS) is one that will always win against any other strategy and no other strategy can be successful within the population. Evaluate whether the following statements are true or false given the pay-offs for the Hawk and Dove strategies listed above.

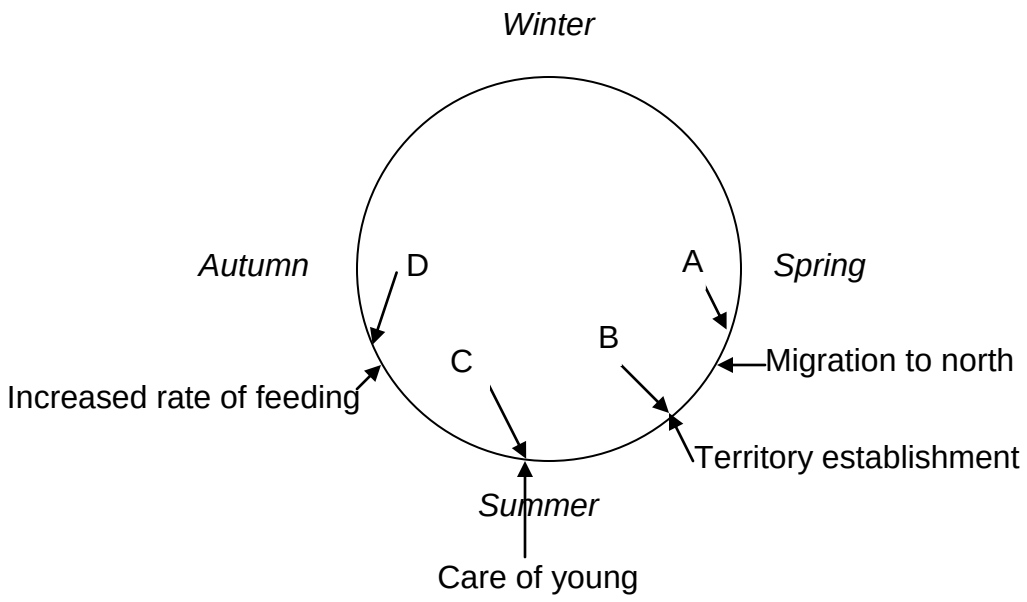
a. Hawk is an ESS and when all individuals in a population play this strategy, a mutation to Dove can never be successful.

b. Dove is an ESS and when all individuals in a population play this strategy, a mutation to Hawk can never be successful.

Put a tick mark (√) in the appropriate box.

Statement	True	False
a.		
b.		

38. (2 points) White crown sparrows that live in temperate regions show a complex annual cycle of behavior.



Match the physiological changes (I to V) in these birds with the appropriate points in the behavioral cycle (A to D). Choose from the following options and fill in the table given below with the appropriate numbers:

Options:

I. Molting / moulting

II. Gonadal regression (shrinking of reproductive tissue)

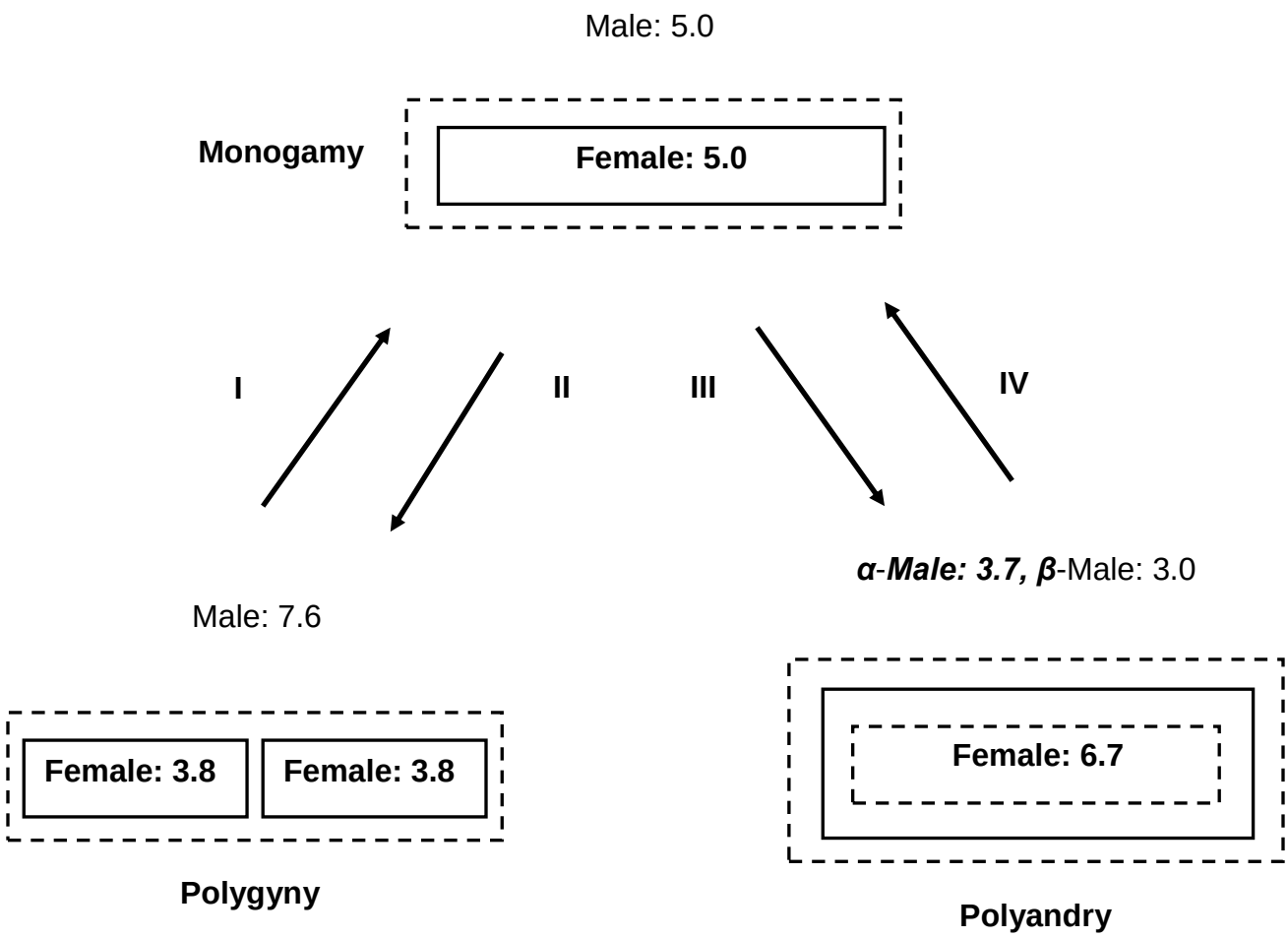
III. Gonadal development (development of the reproductive tissue)

IV. Fat deposition

V. Hibernation

Points in the behavioral cycle	Physiological changes
A	
B	
C	
D	

39. (4 points) The dunnock is a common bird of the British Islands. The females of this species establish territories represented by solid lines in the figure below, which may be defended by one or two (α and β) unrelated males (dashed lines). The numbers in the figure refer to the average number of young raised per season by males and females in the different mating combinations. The arrows indicate the directions in which the behaviour of the males and females encourage changes in the mating system.



(A) Identify the specific individuals, which would attempt to change the mating system in the directions shown by the arrows.

a. I: Male, II: Female, III: Female, IV: β-Male

b. I: Female, II: Male, III: β-Male, IV: α-Male

c. I: Female, II: Male, III: Female, IV: α-Male

d. I: Male, II: Female, III: α-Male, IV: β-Male

Put a tick mark (√) in the appropriate box.

a.	b.	c.	d.

(B) Which of the following statements are true?

I. The benefit of polygyny to males is the increased amount of food brought for the chicks by two females instead of one.

II. The cost of polygyny to females is shared male care because the contribution of the male's feeding efforts is essential for the survival of the chicks.

III. The cost of polyandry to females is the aggression that often results between the two males who have mated with her.

IV. The cost of polyandry to males is shared paternity.

a. I and II

b. II and III

c. I and IV

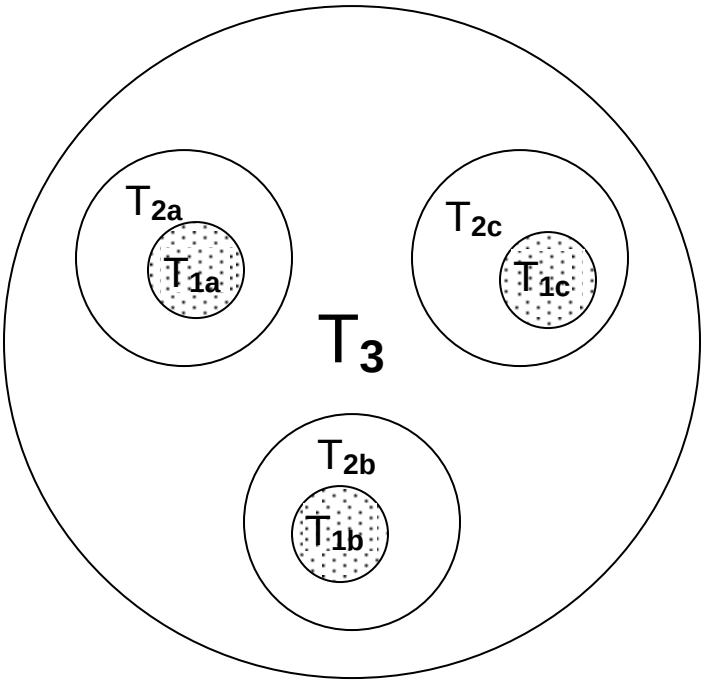
d. II and IV

Put a tick mark (√) in the appropriate box.

a.	b.	c.	d.

BIOSYSTEMATICS (13)

40. (2 points) The schematic diagram below represents group-in-group relationships. The **T_3 taxon**, represented by the largest circle, includes three **T_2 taxa**. Each of these three **T_2 taxa** has one **T_1 taxon**, represented by circles filled with dots; the dots represent individuals.



According to above scheme, assign the correct taxa from the options given below to each of the circles. Fill in your answers by writing the appropriate number in the table. **Points will be awarded only if the entire table is correctly filled.**

Options:

I. Annelida

II. Lepidoptera

III. Polychaeta

IV. Mollusca

V. Orthoptera

VI. Insecta

VII. Arthropoda

VIII. Crustacea

IX. Gastropoda

X. Arachnida

XI. *Lumbricus* (earthworm)

XII. *Hirudo* (leech)

XIII. *Gryllus* (cricket)

XIV. *Unio* (freshwater mussel)

XV. *Euscorpias* (scorpion)

XVI. *Daphnia* (water flea)

Taxon	Option
T3	
T2a	
T1a	

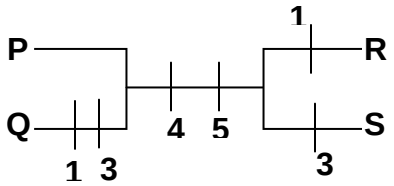
T2b	
T1b	
T2c	
T1c	

41. (2 points) The sequence of a pentanucleotide DNA segment of four species P, Q, R and S are given.

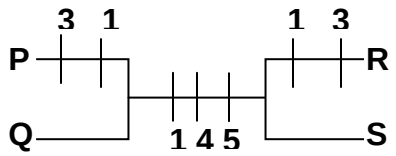
Species	Sequence site				
	1	2	3	4	5
P	A	G	T	T	C
Q	C	G	A	T	C
R	C	G	T	A	T
S	A	G	A	A	T

The most parsimonious phylogenetic classification of these species would be:

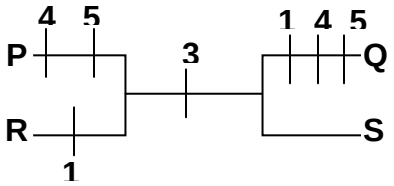
a.



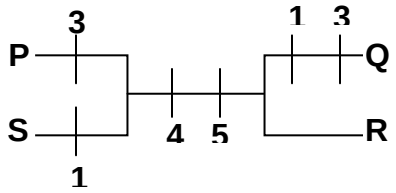
b.



c.



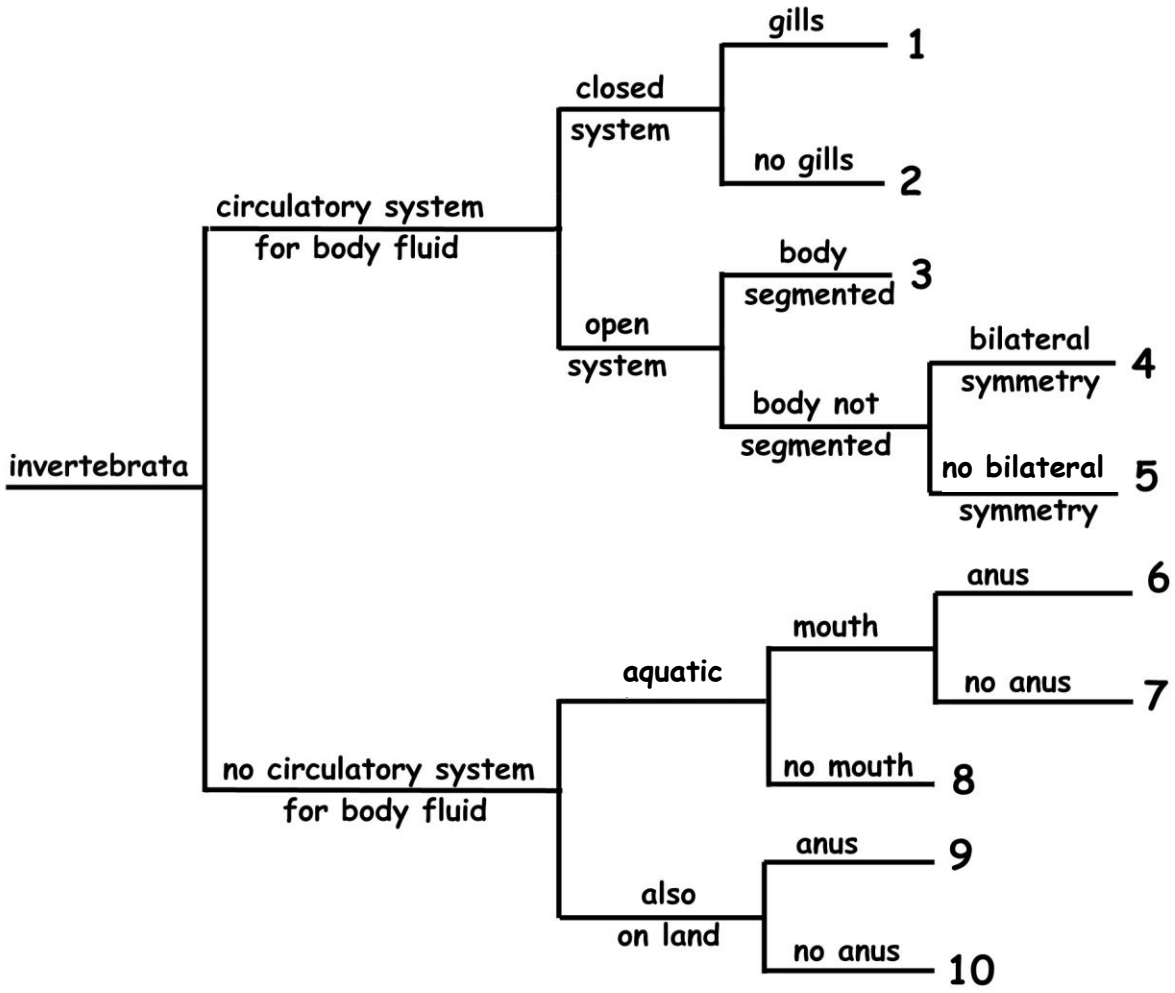
d.



Put a tick mark (√) in the appropriate box.

a.	b.	c.	d.

42. (5 points) A classification chart based on certain characteristics of invertebrates is shown below:



Fill in the appropriate numbers from the classification chart against the respective groups in the table below:

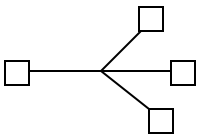
Group	Number	Group	Number
Annelida (Earthworms)		Mollusca (Land snails)	
Arthropoda (Crayfishes)		Mollusca (Squids)	
Cnidaria (Jellyfishes)		Nematoda (Roundworms)	
Echinodermata (Starfishes)		Platyhelminthes (Tapeworms)	
Mollusca (Bivalvia)		Porifera (Sponges)	

43. (4 points) The genetic distances between four species are provided in a matrix below. The numbers represent the percentage differences between each pair of species.

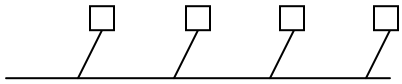
	A	B	C	D
A	-	-	-	-
B	5	-	-	-
C	13	14	-	-
D	15	16	6	-

(A) Which of the following tree structures represent the matrix data most appropriately? (Squares in the figure represent species and the lengths of the lines approximate the genetic distance between them.)

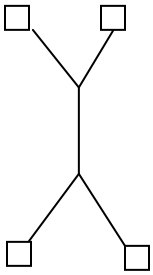
a.



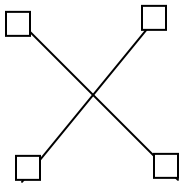
b.



c.



d.



Put a tick mark (√) in the appropriate box.

a.	b.	c.	d.

(B) Based on the answer selected in the previous question and using the data given in the matrix, construct the tree that correctly shows the genetic relatedness of the four species, where the numbers on the lines should approximate the genetic distance between them.

********** END OF PART B **********