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 and 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. _____

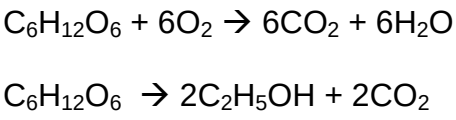
Choose from the following options:

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.

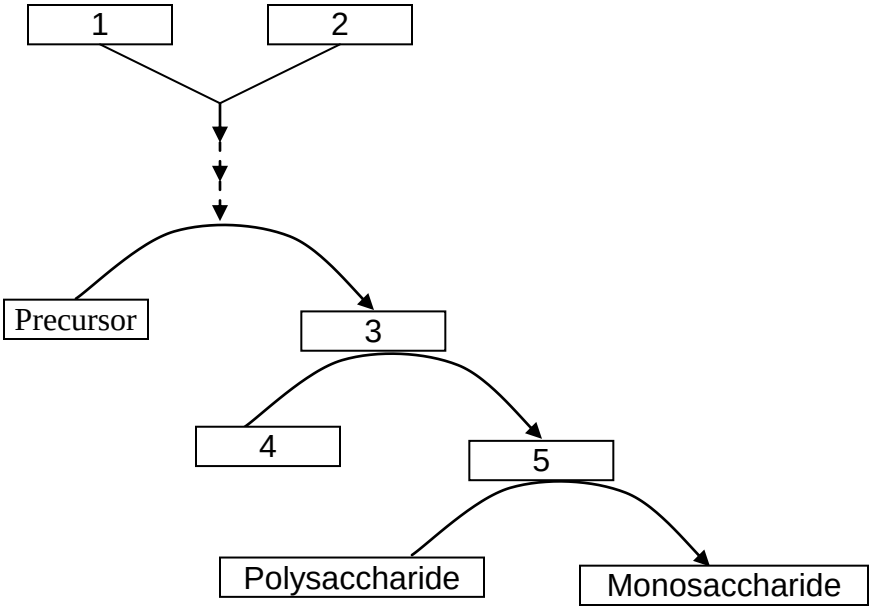
Answer: _____

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

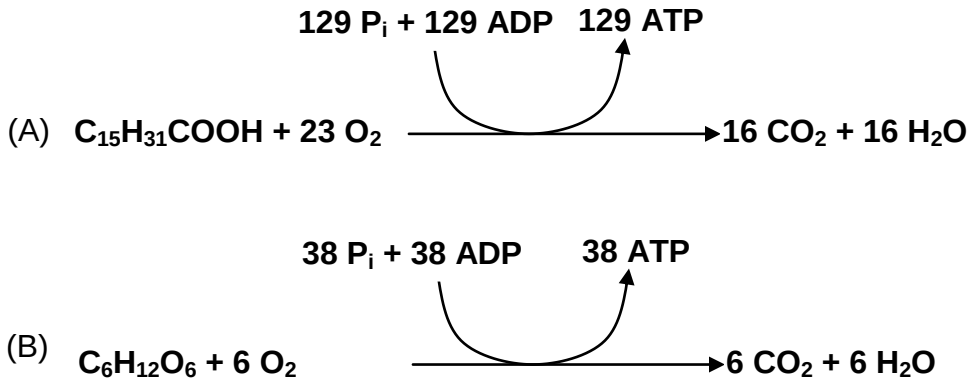
F. Organic inhibitor

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:



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 abundance of oxygen, the Respiratory Quotient tends to be < 1.

b. High-intensity exercise is primarily fuelled by fat when oxygen concentration is limiting.

c. Reaction A represents the energy-acquiring process of nervous tissue while Reaction B is more common in skeletal muscles involved in rapid movement.

d. Under conditions of hypoxia, the shift of tissue metabolism from fatty acid oxidation to glucose oxidation will yield more ATP.

	True	False
a.		
b.		
c.		
d.		

7. (1+1+2 = 4 points) Leena is a molecular biology student. She purifies two fragments of DNA, 800 and 300 base pairs long. These were obtained from a plasmid after digesting it with *Hin*dIII. Each of these fragments has a single *Eco*RI recognition site.

   Leena wants to join these two fragments to get a 1.1kb gene as shown in Figure 7.1. She suspects that this gene has a unique protein-coding sequence.

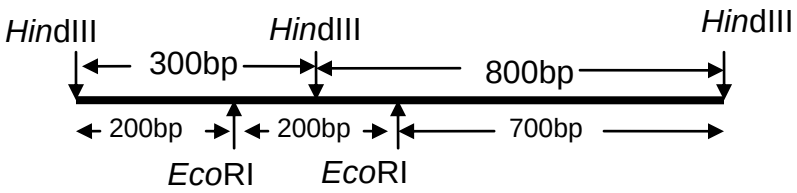


Figure 7.1

She, therefore, mixes the two fragments in the presence of excess DNA ligase in an appropriate buffer and incubates the mixture. She removes an aliquot (a small part of the reaction mixture) after 30 minutes and loads it on an agarose gel to check the results. She is surprised to find many bands along with the expected 1.1kb band (as shown in the figure 7.2) in the gel!

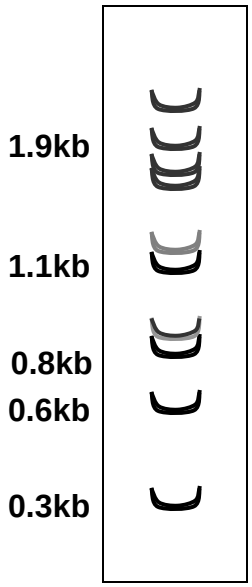


Figure 7.2

I. Which one of the following statements can explain this result?

a. The two fragments used for ligation were not sufficiently purified.

b. The multiple bands on the gel are due to the degradation of DNA in the reaction mixture.

c. The observed band pattern is a result of ligation of randomly-selected fragments.

d. DNA ligase did not function, and hence, it led to the random catenation of the DNA molecules.

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

a.	b.	c.	d.

II. If another aliquot of the reaction mixture is removed after 8 hours, which one of the following would be expected?

a. Prominent bands of high molecular weight.

b. Prominent bands of low molecular weight.

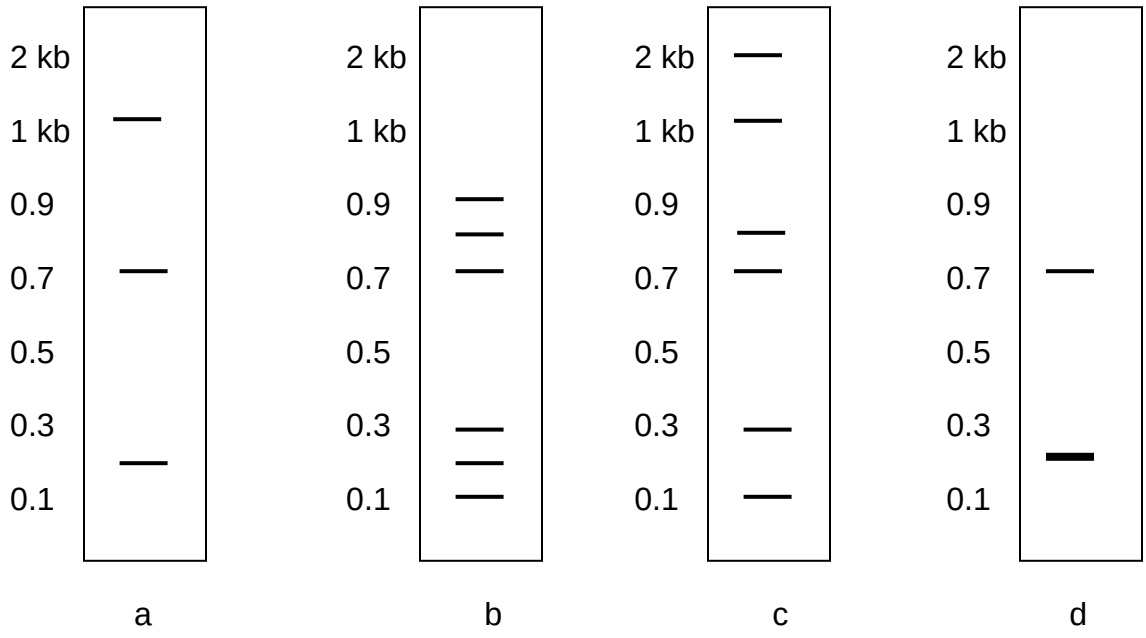
c. Large number of molecules of varying lengths leading to a smearing on the gel.

d. The gel pattern would remain the same. Only the intensity of bands would increase.

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

a.	b.	c.	d.

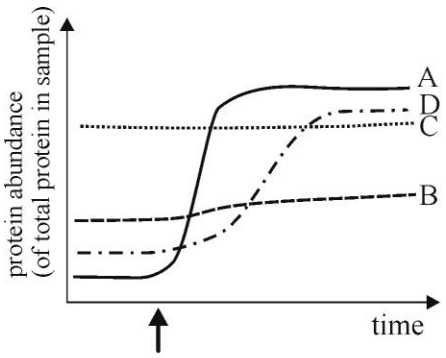
III. Leena is interested in the 1.1kb fragment shown in Figure 7.1. Hence, she elutes the 1.1kb fragment from the gel shown in Figure 7.2 and subjects part of this sample to *Hin*dIII digestion. She obtains the expected pattern with two bands, 800 and 300 base pairs long. To confirm its restriction map, she subjects the remaining sample to complete *Eco*RI digestion. Which pattern of bands would she obtain?

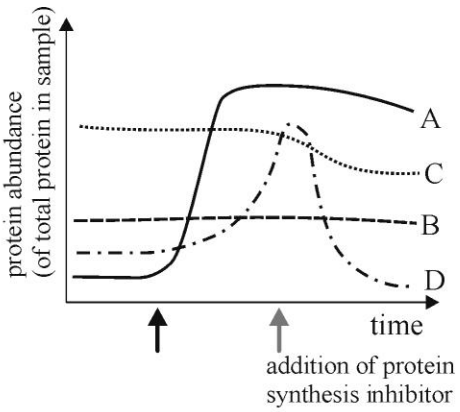


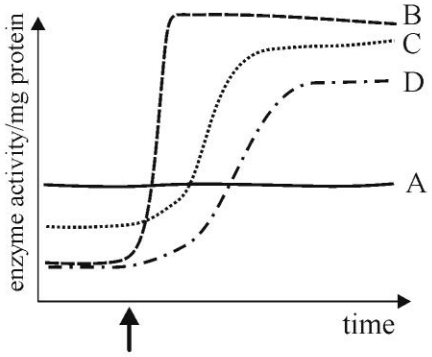
Put a tick mark (√) in the appropriate box.

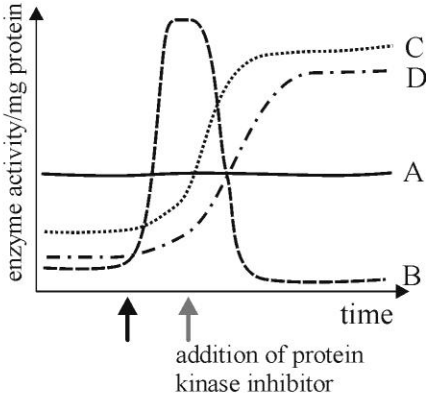
a.	b.	c.	d.

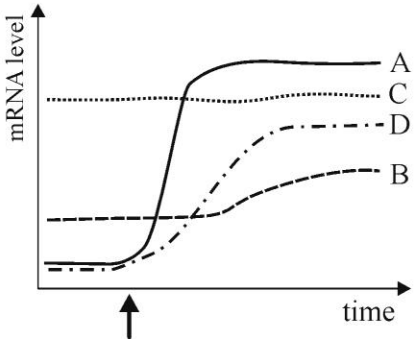
8. (2.5 points) Protein function can be regulated at many levels. By interpreting the graphs below, find out how each of these proteins (A to D) is regulated. They are all enzymes involved in the same physiological process, their activity is induced by the same treatment and their respective activities in a sample can be measured with specific assays. The arrows indicate the beginning of the activating treatment.











Match the proteins A to D with their mode(s) of regulation (I to IV) by putting tick marks (√) in the appropriate boxes.

I. Post-translational modification, but not phosphorylation

II. Transcriptional regulation

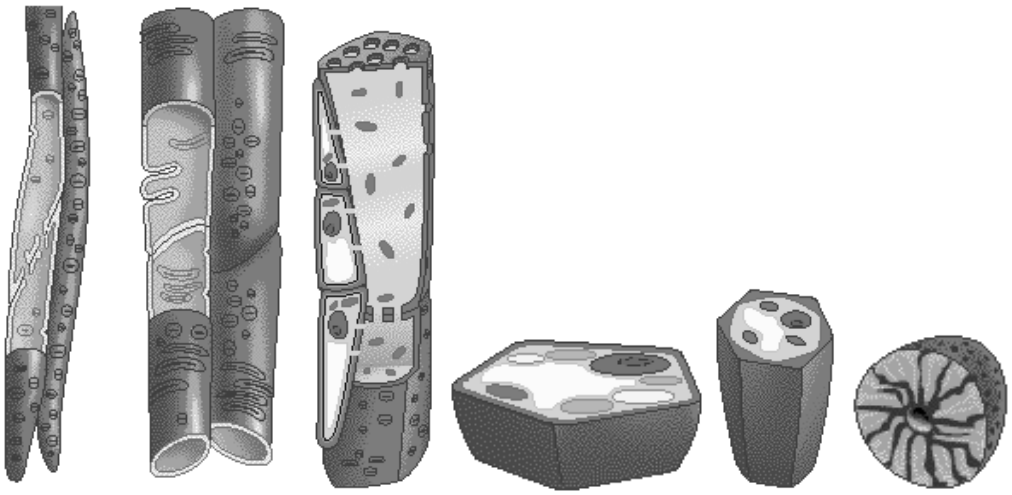
III. Proteasomal degradation and rapid turnover

IV. Phosphorylation

Protein	Mode of regulation			
	I	II	III	IV
A				
B				
C				
D				

PLANT SCIENCES (15 points)

9. (4 points) Study the schematics of the plant tissues/cells shown below and fill in the blank column with appropriate letter/s.



A **B** **C** **D** **E** **F**

No.		Answer
I	Cell/s that is/are not alive when functional.	
II	Plasmodesmata can be found associated with this/these cell/s.	
III	When you eat potato, you eat the tissue formed of this/these cell/s.	
IV	Cell/s that harden/s the nut skin.	

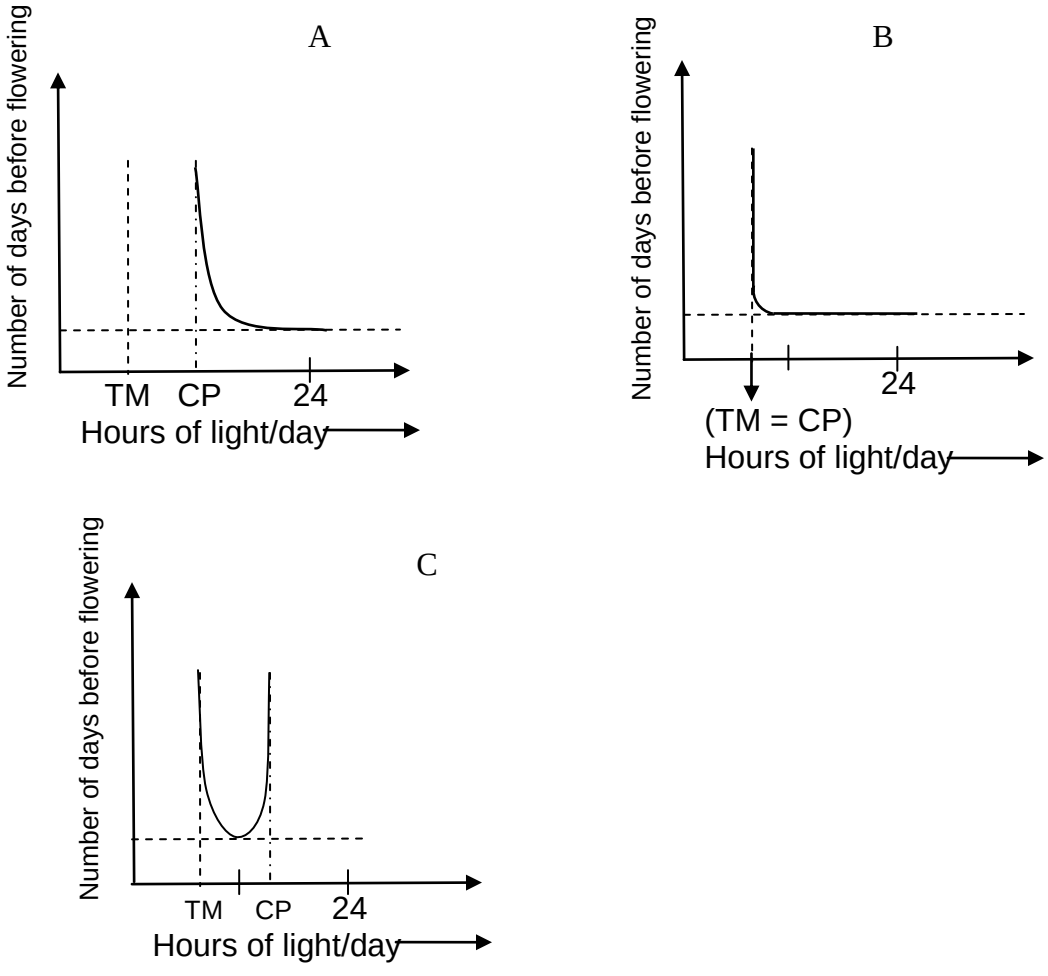
10. (1.5 points) On the basis of the photoperiod required for flowering, plants can be described as:

    I. Short-day plants

    II. Long-day plants

    III. Day-length indifferent plants

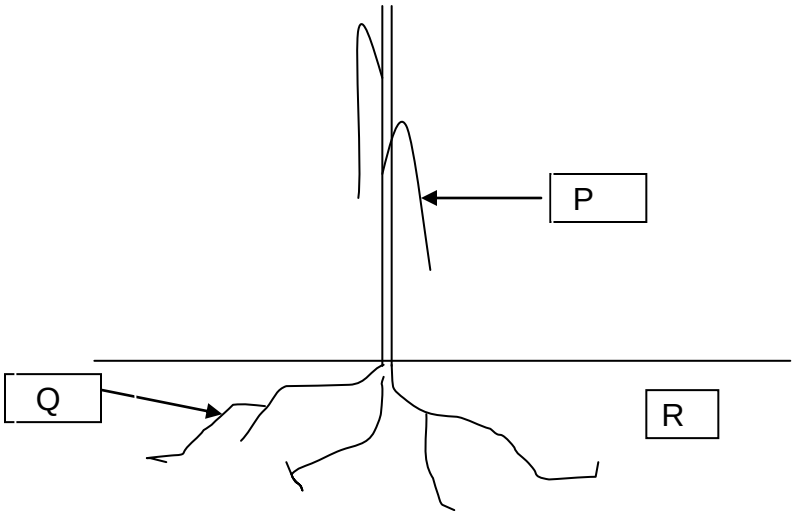
    The effect of varying light periods on flowering in these three types of plants is depicted in the graphs below, where TM, trophic minimum, is the minimum light that is required to produce the organic matter indispensable to its metabolism and CP is the critical period for flowering.



Choose a plant type (I, II or III) for each of the three graphs and fill in the table.

Graph	Plant type
A	
B	
C	

11. (2 points) (A) A mesophyte was planted in soil with high salt concentration and watered. It showed wilting. Assign the appropriate values of water potentials to the regions marked P, Q, and R in the schematic representation of this plant.



Choose from the options given below and fill in the table:

- -1 atm
- -5 atm
- -8 atm

Region	Water potential
P	_____ atm
Q	_____ atm
R	_____ atm

(B) Which of the following remedial measures will completely reverse wilting in this plant? Put a tick mark (√) in the appropriate box.

a. Increasing environmental humidity.

b. Irrigation to flush out the excess salts.

c. Applying wax on the surface of leaves.

d. Placing the plant in shade.

a.	b.	c.	d.

12. (4 points) A few characteristics of some organisms are listed in the table. Put a tick mark (√) against the appropriate organisms.

	Chlamydomonas	Cyano-bacteria	Green-sulphur bacteria	Purple-sulphur bacteria
Phototrophic autotrophs				
Photosystem II absent				
Respiratory enzymes located on plasma membrane				
Chlorophyll *a* as the major photosynthetic pigment				

13. (3.5 points) The total respiration (R) of a young growing plant is described by the following expression:

$$R = 0.27\ P + 0.015\ W,$$

where P is the total amount of glucose produced per day and W is the average mass of the plant.

Of the processes listed below, some influence the factor 0.27 of the above equation whereas the others do not.

1. Movement of water within the cells
2. Reduction of nitrate (NO_3^-) ions to ammonium (NH_4^+) ions
3. Uptake of K^+ ions through the plasma membrane of endodermal cells
4. Uptake of CO_2 in cells of palisade parenchyma
5. Opening and closing of stomata
6. Lengthening of a polypeptide chain
7. Absorption of light by chlorophyll *a*

Indicate with a tick mark (√) in the appropriate column in the table below, which of these processes do or do not affect the factor 0.27.

Process	Does affect	Does not affect
1		
2		
3		
4		
5		
6		
7		

ANIMAL SCIENCES (18.5 points)

14. (2 points) The tidal volume is defined as the volume of air entering the lungs in a single inspiration (inhalation), which is approximately equal to the volume exhaled during subsequent expiration (exhalation) on normal quiet breathing. Exchange of gases with the blood occurs in the alveoli of lungs. In the conducting airways (e.g. trachea), which also contain a volume of air, no exchange takes place. The space within these airways is called the anatomic dead space. Thus the volume of fresh air entering the alveoli during each inspiration equals the tidal volume minus the volume of air in the anatomic dead space. The total volume of fresh air entering the alveoli per minute is called the alveolar ventilation and is expressed in ml/min; it varies directly with the respiration rate.

Consider the hypothetical breathing patterns of three individuals A, B and C:

Individual	Tidal volume (ml/breath)	Frequency (breaths/min)	Anatomic dead space (ml/breath)
A	800	12	600
B	500	16	350
C	600	12	200

Which of the following holds true about the alveolar ventilation of these three individuals?

a. B has considerably greater alveolar ventilation than C.

b. A has considerably greater alveolar ventilation than C.

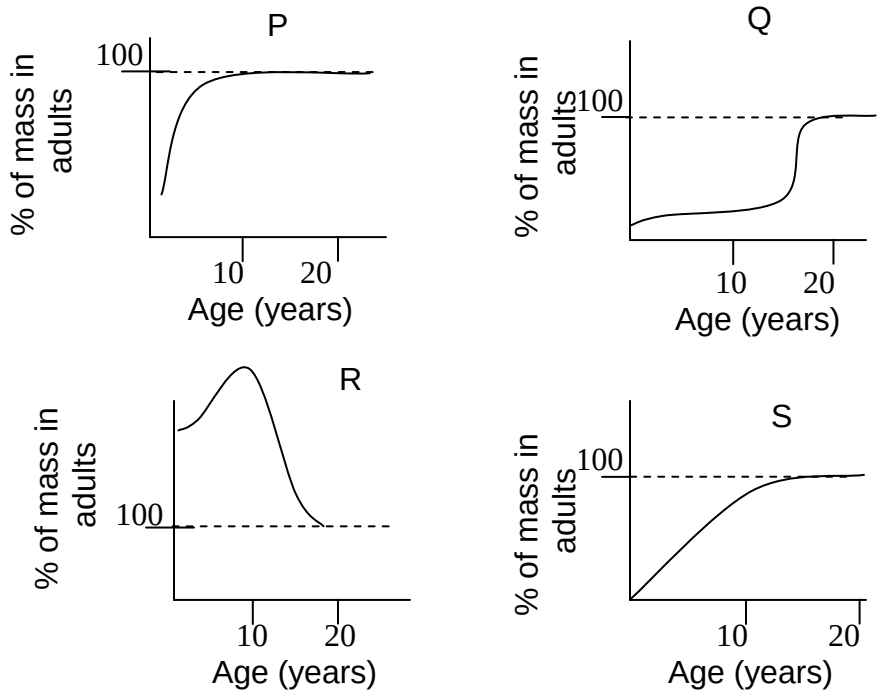
c. C has considerably greater alveolar ventilation than B.

d. A has considerably greater alveolar ventilation than B.

Put a tick mark (√) for the correct statement(s) in the appropriate box of the table.

a.	b.	c.	d.

15. (2 points) The relative growth rates of four organs of the human body are shown in the following graphs.



Match the graphs with the organs by putting a tick mark (√) in the appropriate box of the table.

	P	Q	R	S
Liver				
Brain				
Thymus				
Gonads				

16. (2 points) A few statements regarding the respiratory processes in vertebrates are given below:

    a. Amphibians use negative pressure to force air into the lungs.

    b. Reptiles, birds, and mammals use positive pressure to force air into the lungs.

    c. Lungs of amphibians and mammals are incompletely ventilated during each breathing cycle.

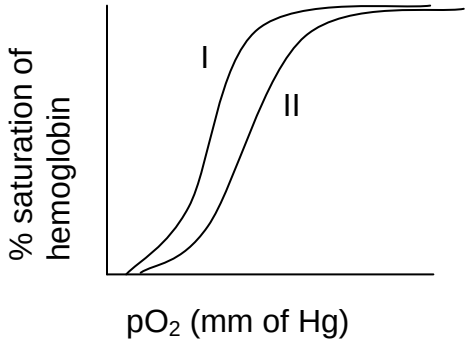
    d. Lungs of birds are completely ventilated during each breathing cycle.

    Mark whether each statement is true or false by putting a tick mark (√) in the appropriate box of the table.

	True	False
a.		
b.		
c.		
d.		

17. (2 points) The oxygen saturation of hemoglobin when plotted versus pO_2 is sigmoid and this is conventionally referred to as the oxygen dissociation curve. Many parameters such as pH, pCO_2, temperature, and metabolic activity of the cell affect the oxygen dissociation curve.

Two such curves, I and II, are depicted in the following graph



Determine whether the curves could represent the sets of conditions given below. Put a tick mark (√) in the appropriate boxes in the table.

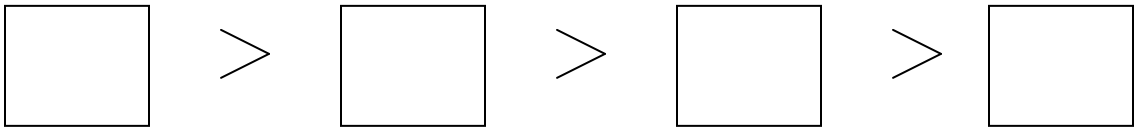
Set	Condition	True	False
A	Curve I. Normal blood pH and Curve II. Acidosis		
B	Curve I. 40°C and Curve II. 30°C		
C	Curve I. Elephant hemoglobin and Curve II. Cat hemoglobin		
D	Curve I. Fetal hemoglobin and Curve II. Maternal hemoglobin		

18. (2 points) Given below are the data on breathing rate, heart rate and body temperature of four different mammals A, B, C, and D.

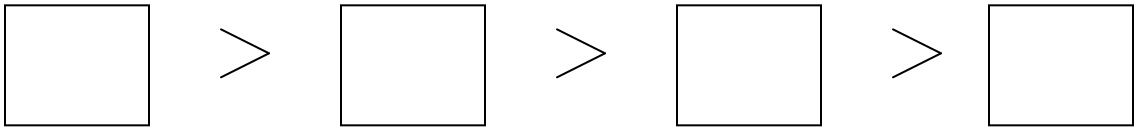
Animals	Breathing rate (inhalations/min)	Heart rate (beats/min)	Body temperature (°C)
A	160	500	36.5
B	15	40	37.2
C	28	190	38.2
D	8	28	35.9

Study the data and rank these animals in descending order of surface area per unit volume as well as the total volume of blood by filling in the boxes with appropriate letters (A to D).

Surface area per unit volume of the body



Total volume of blood in the body



19. (5 points) In order to find out the nature of factors involved in humoral immunity, three groups of mice were immunized according to the scheme below:

Immunization scheme

1. Mice → Isolate serum **(S1)** after 2 weeks
2. Mice → Immunized with pathogen P → Isolate serum **(S2)** after 2 weeks
3. Mice → Immunized with pathogen Q → Isolate serum **(S3)** after 2 weeks

Using sera from the above immunization schemes, the following experiments were conducted to test the response of these sera towards pathogens P or Q:

Number	Experiment
I	Serum S1 → Add pathogen P or Q → No lysis of pathogen P or Q
II	Serum S2 → Add pathogen P → Lysis of pathogen P
III	Serum S3 → Add pathogen Q → Lysis of pathogen Q
IV	Serum S2 → Add pathogen Q → No lysis of pathogen Q
V	Serum S3 → Add pathogen P → No lysis of pathogen P
VI	Serum S2 → Heat at 55°C for 30 min → Add pathogen P → No lysis of pathogen P
VII	Serum S3 → Heat at 55°C for 30 min → Add pathogen Q → No lysis of pathogen Q
VIII	Serum S2 → Heat at 55°C for 30 min → Add serum S1 → Add pathogen P → Lysis of pathogen P

IX	Serum S2 → Heat at 55°C for 30 min → Add serum S1 heated at 55°C for 30 min → Add pathogen P → No lysis of pathogen P
X	Serum S2 → Heat at 55°C for 30 min → Add serum S3 → Add pathogen P → Lysis of pathogen P

Answer the following questions:

(A) If serum S3 is heated at 55°C for 30 min, and mixed with serum S1, which of the following pathogen would it lyse?

a. Only P

b. Only Q

c. P and Q both

d. Neither P nor Q

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

a.	b.	c.	d.

(B) If serum S2 is heated at 55°C for 30 min, and mixed with serum S3, which of the following pathogen would it lyse?

a. Only P

b. Only Q

c. P and Q both

d. Neither P nor Q

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

a.	b.	c.	d.

(C) Which of the following statements are TRUE or FALSE for the above experiment?

a. The lysis of pathogen requires only one component, which is heat-labile.

b. The lysis of pathogens requires at least two components. One component is induced by the pathogen, while the other is non-inducible and is pathogen non-specific.

c. The pathogen-induced component is heat-labile whereas the non-specific component is heat-stable.

d. The pathogen-induced component is heat-stable whereas the non-specific component is heat-labile.

e. The pathogen-specific components cannot function if present together.

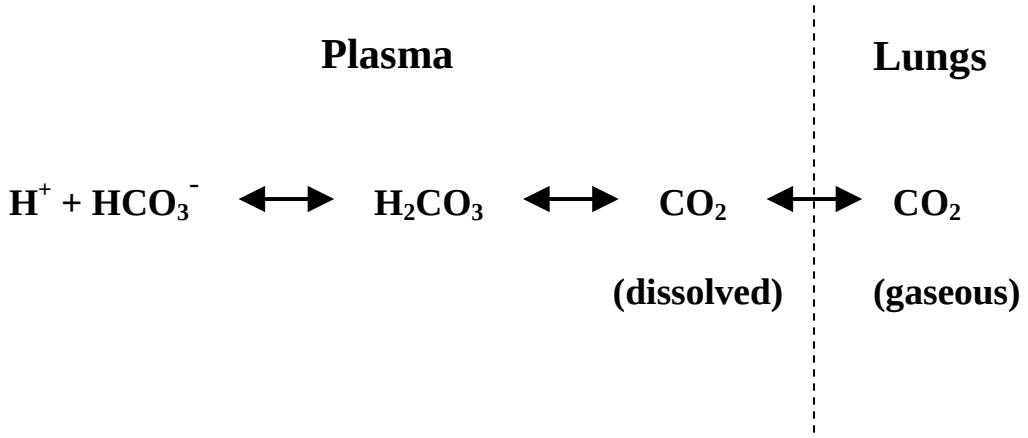
f. The non-specific component has to be derived from the same mice in which the pathogen-specific component would be induced.

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

Options	True	False
a.		
b.		

c.		
d.		
e.		
f.		

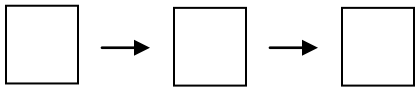
20. (3.5 points) In air-breathing animals, bicarbonate ions present in the blood play an important role of buffering. Various equilibria that occur in lungs and plasma are shown below.



Indicate the events that will occur in sequence as a result of following activities by filling in the boxes with the appropriate numbers I to VI of the given options:

A. A person is hyperventilated as a result of rapid breathing.

B. A person continues vigorous exercise:



Options:

I. Decrease in plasma carbon dioxide concentration

II. Decrease in blood bicarbonates

III. Acidosis

IV. Increase in blood bicarbonates

V. Increase in exhalation of carbon dioxide

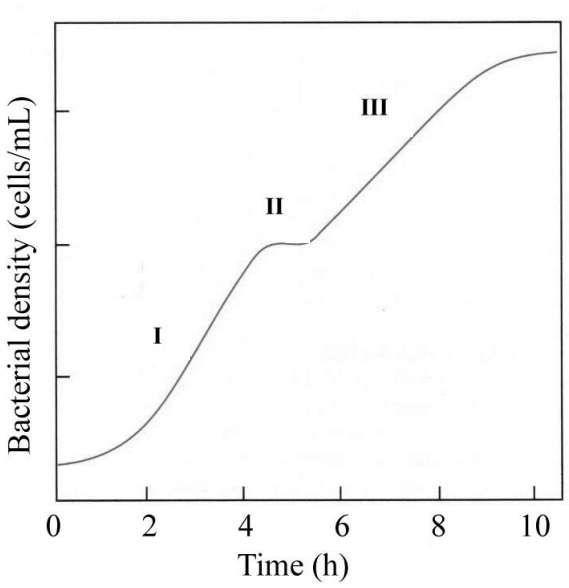
VI. Alkalosis

GENETICS AND EVOLUTION (20.5 points)

21. (2 points) Cystic fibrosis is an autosomal recessive trait. If parents who are both carriers for this gene have 3 children, what is the probability that exactly two will be phenotypically normal?

Answer: _____

22. (2 points) *E. coli* cells were grown in a medium containing glucose and lactose, and a growth curve was obtained which is shown below.



Fill in the table using tick marks (√) to indicate which of the listed events would predominate during the three phases of growth (I to III).

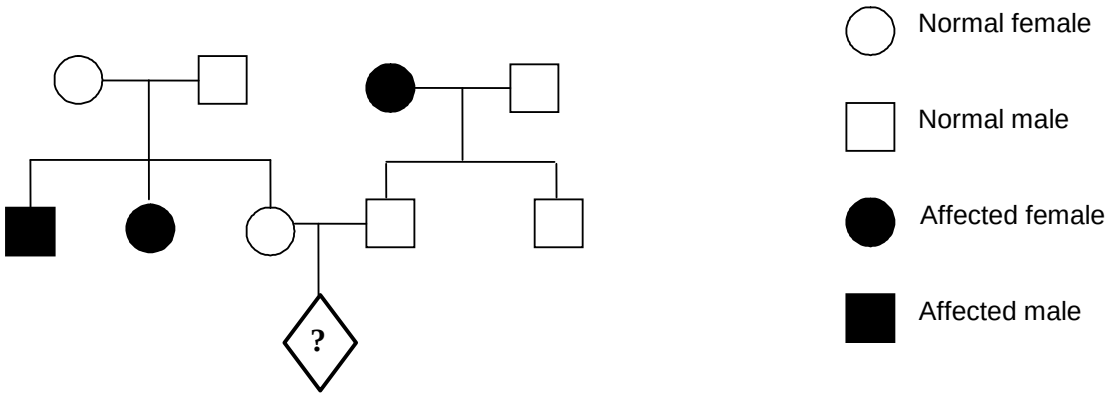
	I	II	III
Lactose hydrolysis by β-galactosidase			
Reduction of *lac* repressor's affinity for the *lac* operator			
Binding of the CAP-cAMP complex to the *lac* promoter			
Utilization of glucose			

23. (2 points) In a small tribal population, the frequencies of two alleles *A* and *a* at a particular locus were 0.3 and 0.7, respectively. However, not all the individuals with genotype *aa* could live up to the reproductive age and the relative fitness of this genotype was found to be 0.5. The remaining genotypes had a relative fitness of 1.

What is the expected percentage of heterozygotes among newborns in the next generation?

Answer: _____%

24. (2 points) In the following pedigree, the probability that the individual marked as ◊ will be affected is:

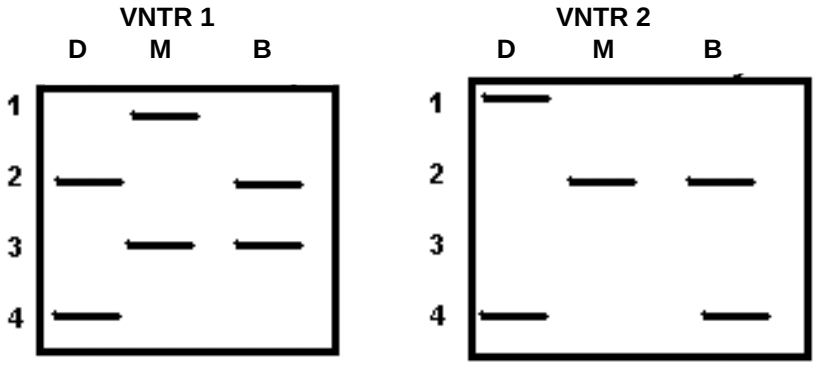


Answer: _____

25. (2 points) If two heterozygotes (*Aa*) mate, what is the minimum number of offspring they should have such that the probability of at least one offspring having genotype *aa* is greater than 90%?

Answer: _____

26. (2 points) A celebrity has been named in a paternity suit. The defendant (labeled D in the autoradiogram), the mother (labeled M), and the baby (labeled B) have each been typed for two loci VNTR1 and VNTR2, as shown in the autoradiograms below. Each of these VNTR loci has four alleles. For VNTR1, the frequencies of the alleles 1, 2, 3, and 4 in the general population are 0.2, 0.4, 0.3, and 0.1, respectively. For VNTR2, the frequencies of alleles 1, 2, 3, and 4 are 0.1, 0.1, 0.2, and 0.6, respectively.



a. Do the autoradiograms indicate that D could be the father of the baby B?

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

Yes	No

b. What is the probability that another male in the general population could be the father of the baby B?

Answer: _____

27. (2 points) In some populations, inbreeding takes place amongst first cousins. Inbreeding leads to a reduction in the frequency of heterozygotes and is measured as the inbreeding co-efficient, F, where

$$f_{\text{observed}}^{\text{heterozygotes}} = f_{\text{expected}}^{\text{heterozygotes}} \times (1 - F)$$

The symbol f denotes frequency.

If F = 1 (complete inbreeding), the population consists entirely of homozygotes.

In a population of 150 individuals, the observed numbers of MN blood group genotypes are: 60 *MM*, 36 *MN*, 54 *NN*.

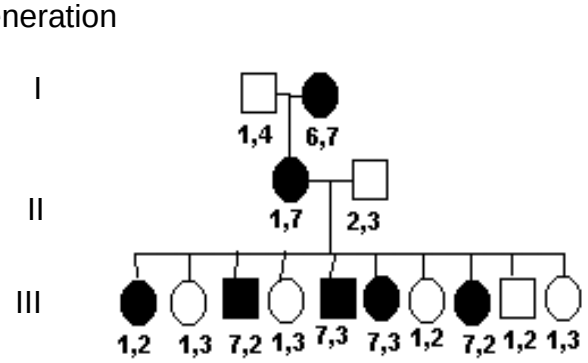
a. Calculate F.

Answer: _____

b. If, for another population of the same species, the allelic frequencies remain the same but the value of F is half of that calculated in a, what will be the frequency of the heterozygotes (*MN*) observed in this group?

Answer: _____

28. (2 points) The transmission pattern of a disease caused by an autosomal dominant gene is shown in the following pedigree:

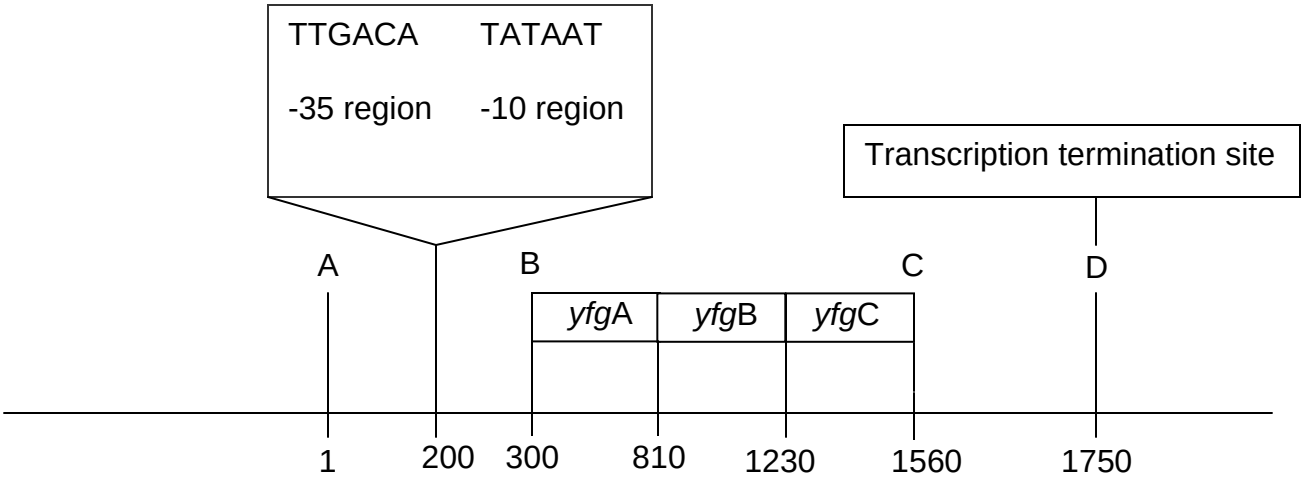


Each family member has been typed for a seven-allele microsatellite polymorphism. Based on the genotypes in Generation III, calculate the recombination frequency between the disease and microsatellite loci.

Answer: _____

29. (2 points) The figure given below depicts a region of double stranded DNA, in a bacterium, containing a polycistronic operon with three of your favorite genes *yfgA*, *yfgB* and *yfgC*, as shown. The positions of certain bases in the nucleotide sequence around *yfg* operon, with respect to position A are marked in the figure.

The *yfg* operon



Length of DNA in base pairs

Answer the following questions:

I. What is the expected minimum number and length of the transcript(s) from this operon?

a. A single transcript of 1260b

b. A single transcript of 1450b

c. A single transcript greater than 1451b but less than 1550b

d. Three transcripts of 330b, 420b and 510b

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

a.	b.	c.	d.

II. From the above figure, calculate the maximal expected mass of the YfgA protein. _____ kDa

(Assume the mass of an amino acid to be 110 Da)

30. (2.5 points) The map distance between two genes on a chromosome can be calculated using the frequency of crossing over between them. In case of a genetic cross involving three genes, the crossover (CO) classes of progeny can be categorized as

(i) Single crossover I (SCO I),

(ii) Single crossover II (SCO II), and

(iii) Double crossover (DCO).

DCO requires the simultaneous occurrence of the two SCOs.

Among the progeny of a test cross, the number of non-crossovers (NCO) is the highest followed by SCO I and II. The DCO is the least frequent.

A *Drosophila* fly, heterozygous for alleles *p*, *q* and *r*, when crossed with a homozygous recessive fly, had the following progeny:

(p^+, q^+, and r^+ indicate wild-type alleles whereas *p*, *q*, and r indicate the mutant alleles.)

Genotype	Number of progeny
$p\ q^+\ r$	375
$p^+ q\ r^+$	355
$p\ q\ r$	50
$p^+\ q^+\ r^+$	45
$p^+\ q^+\ r$	75
$p\ q\ r^+$	85
$p\ q^+\ r^+$	8
$p^+\ q\ r$	7
	Total = 1000

The middle gene is the one that has altered position in the DCO classes compared to that in the NCO classes.

(A) Which is the middle gene in the given cross? Put a tick mark (√) in the appropriate box.

p	
q	
r	

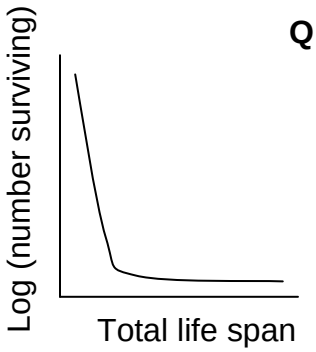
(B) Assuming 1% crossover as one map unit (mu), calculate the distance between *p*, *q*, and *r*.

Distance between *p* and *q*	_____ mu
Distance between *p* and *r*	_____ mu
Distance between *q* and *r*	_____ mu

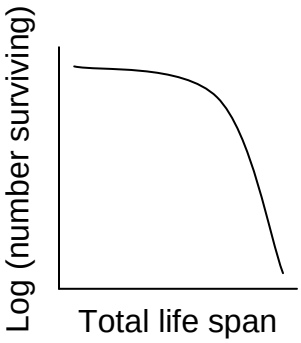
ECOLOGY (16.5 points)

31. (1.5 points) Consider a population of r-selected insects in the early part of its growth season. Choose the appropriate growth curve at this stage, survivorship curve and current age structure (from each pair of graphs) that represent this population and put the corresponding letter in the boxes below.

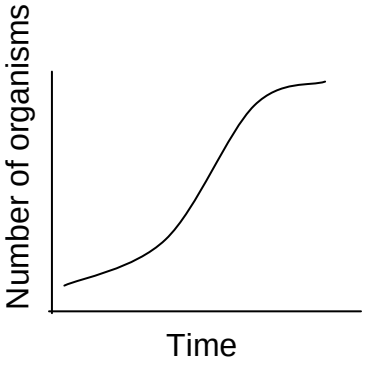
P



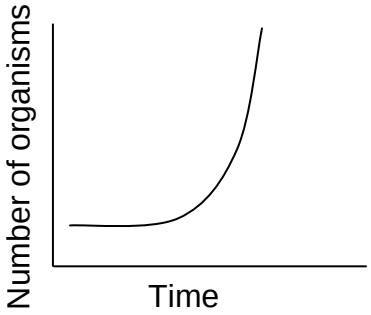
Q



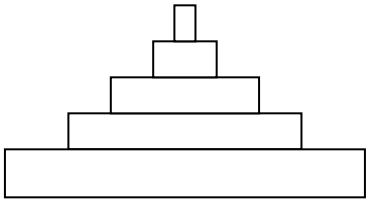
R



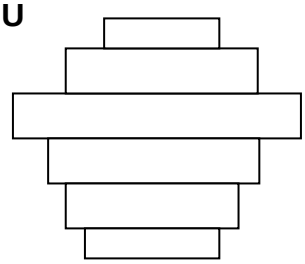
S



T



U



Growth curve	Survivorship curve	Age structure

32. (3 points) Nitrogen, as a mineral nutrient, has the greatest effect on plant growth. Atmosphere contains nearly 80% nitrogen gas (N_2), yet plants have to be provided ammonium salts or nitrates as fertilizers for optimum growth and yield. Certain nitrogen-fixing bacteria (rhizobia, cyanobacteria, etc.) can convert atmospheric N_2 into ammonia using nitrogenase by the following reaction:

$$N_2 + 8\ e^- + 8\ H^+ + 16\ ATP \longrightarrow 2\ NH_3 + H_2 + 16\ ADP + 16\ P_i$$

Such bacteria can be used as biofertilizers in agriculture. In soil, ammonia is protonated to ammonium (NH_4^+). This, in turn, is converted to nitrate (NO_3^-) and then to N_2 gas by the action of nitrifying and denitrifying bacteria, respectively. Plants require nitrogen mainly in the form of nitrate, which is exported from roots to shoots, reconverted to ammonium and assimilated as amino acids.

(A) Plants do not themselves fix N_2, because:

a. it is easily available from the soil.
b. they lack the nitrogenase enzyme complex.
c. the process has a very high requirement of ATP per mole of N_2 fixed.
d. hydrogen evolved in the process is deleterious to plants.

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

a.	b.	c.	d.

(B) Processes related to nitrogen conversion to different chemical forms in the soil, carried out by the nitrogen-fixing bacteria, nitrifying bacteria and denitrifying bacteria can be, respectively, described as:

a. reduction, oxidation and oxidation.
b. reduction, oxidation and reduction.
c. reduction, reduction and oxidation.
d. oxidation, oxidation and reduction.

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

a.	b.	c.	d.

(C) Based on the given information, which type of soil bacteria will NOT be beneficial for plants?

a. Nitrogen-fixing bacteria
b. Nitrifying bacteria
c. Denitrifying bacteria

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

a.	b.	c.

33. (2 points) The relationship between members of different species is termed as interspecific relationships. Some such relationships are listed below. -

1. Mosses (A) grow on the trunks and branches of trees (B).

2. A female moth (A), the only pollinator, arrives at a *Yucca* flower (B) with a ball of Y*ucca* pollen. She places her pollen ball on the stigma and then lays eggs in some, but not all, of the ovules. Offspring development kills the seeds on which they feed. If too many seeds are killed, the fruit is aborted by the plant, killing the developing moth larva.

3. *Wolbachia*, a rickettsia-like bacterium (A) infects some insects (B). The infected males are either killed or develop as females, leading to distorted sex ratios (female bias) in the population.

4. Certain plants (A) attract ants (B) through extra-floral nectaries to deter herbivores.

Indicate in the table given below whether the species (A and B) involved in each of these are benefited (indicate by +), harmed (indicate by –) or not affected (indicate by 0). Identify also the type of interaction by choosing from the options I to VII given below.

Options:

I. Amensalism

II. Commensalism

III. Competition

IV. Mutualism

V. Parasitism

VI. Predation

Number	A	B	Type of interaction
1.			
2.			
3.			
4.			

34. (4 points) Mathematical models can be applied to many aspects of predator behavior.

In a simple mathematical model, it is assumed that a predator can feed on two prey species, Prey1 and Prey2 and that it captures and consumes every prey it encounters. For this predator, the variables T_s, N_1, N_2, E_1, E_2, T_{H1}, and T_{H2} are defined as follows:

T_s: Total time spent searching for the prey species

N_1: Number of Prey1 encountered per unit time

N_2: Number of Prey2 encountered per unit time

E_1: Energy gained from a single Prey1

E_2: Energy gained from a single Prey2

T_{H1}: Handling time needed for each Prey1. This includes time required for capturing and consuming the prey.

T_{H2}: Handling time needed for each Prey2

(A) Once a prey has been captured, the profitability (calories gained per unit time) of each prey species for the predator is, respectively:

a. $\frac{E_1}{T_{H1}}$ and $\frac{E_2}{T_{H2}}$

b. $\frac{E_1}{T_{H1}+T_{H2}}$ and $\frac{E_2}{T_{H1}+T_{H2}}$

c. $\frac{E_1}{N_1 T_{H1}}$ and $\frac{E_2}{N_2 T_{H2}}$

d. $\frac{E_1}{T_{H1} + T_{H2} + T_S}$ and $\frac{E_2}{T_{H1} + T_{H2} + T_S}$

Put a tick mark (√) in the appropriate box

a.	b.	c.	d.

(B) The total energy gain E for the predator will be:

a. $E = (E_1 + E_2)T_S$

b. $E = E_1N_1 + E_2N_2$

c. $E = (E_1N_1 + E_2N_2)T_S$

d. $E = \frac{E_1N_1 \times E_2N_2}{T_S}$

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

a.	b.	c.	d.

(C) The total time (T) spent to gain the total energy E will be:

a. $T = T_S + T_S(N_1T_{H1} + N_2T_{H2})$

b. $T = T_S + T_{H1} + T_{H2}$

c. $T = 1 + N_1T_{H1} + N_2T_{H2}$

d. $T = T_S + N_1T_{H1} + N_2T_{H2}$

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

a.	b.	c.	d.

(D) In one situation, the following data were obtained:

T_s = 60 minutes

Prey1	Prey2
N_1 = 2/min	N_2 = 5/min
T_{H1} = 10 min	T_{H2} = 20 min
E_1 = 1000 cal	E_2 = 700 cal

Which of the following hypothesis does the above mathematical model support?

a. The predator should specialize on Prey1 as it leads to a better rate of energy gain.

b. The predator should specialize on Prey2 as it leads to a better rate of energy gain.

c. The predator should not specialize on one particular prey as a combination of both prey species is more beneficial

d. The predator should specialize on both prey species as any one of them may be likely to be unavailable in future.

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

a.	b.	c.	d.

35. (6 points) A female gall fly (*Eurosta solidaginis*) typically lays a single egg in the bud of some plants. After the egg hatches, the larva burrows its way through the bud and produces a tumor-like structure called a gall. Larvae inside these galls present a very nutritious food source for many birds.

(A) After observing some galls, a student proposed a hypothesis that birds choose larger galls in preference to smaller ones. In order to gather the data to test this hypothesis, she conducted a survey of one such site and measured the widths of disturbed (fed on by the birds) as well as undisturbed galls. The results are as follows:

Disturbed galls		Undisturbed galls	
Gall number	Width (mm)	Gall number	Width (mm)
1.	12	1.	18
2.	15	2.	15
3.	30	3.	22
4.	20	4.	12
5.	23	5.	20

You need to put this hypothesis to test. (Some of the required statistical formulae as well as the Student-t and Chi-square probabilities are provided in the **Annexure** at the end of Part B-Question Paper.)

I. Which of the following is the correct null hypothesis?

a. The birds do not choose galls of smaller size.

b. The birds do not choose galls of larger size.

c. The birds do not choose galls based on size.

d. The birds do not choose galls of smaller size in preference to larger size.

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

a.	b.	c.	d.

II. The test that you will require to do is:

a. Student's t test

b. Chi-square test

c. Both Student's t test and chi-square test

d. Either Student's t test or chi-square test

Put a tick mark (√) in the appropriate box

a.	b.	c.	d.

III. The degree/s of freedom is/are: Answer:_____

IV. The value/s of the statistic/s (up to two decimal points):

Answer: _____

V. Mark the correct interpretation:

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.	

(B) After observing more sites, another student came up with a hypothesis that patches with high density of galls are foraged more than those with low density. To test this hypothesis, he surveyed six patches. The results are as follows:

Gall description	Site I	Site II	Site III	Site IV	Site V	Site VI	Total
Density	High	Low	High	High	Low	Low	
Foraged	15	6	10	14	7	8	60
Undisturbed	5	3	7	8	7	9	39
Total	20	9	17	22	14	17	99

I. The null hypothesis will be:

a. The birds do not choose galls in less dense areas.

b. Density of galls is not more important than the size of the gall.

c. Choosing of galls by birds is independent of the gall density in the patch.

d. Choosing of galls by birds is not dependent on the size of galls but on the density of the patch.

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

a.	b.	c.	d.

II. To test the hypothesis, the test that will be required is:

a. Student's t test

b. Chi-square test

c. Both Student's t test and chi-square test

d. Either Student's t test or chi-square test

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

a.	b.	c.	d.

III. The degree/s of freedom is/are: _____

IV. The value/s of the statistic/s (up to two decimal points):

_____

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.

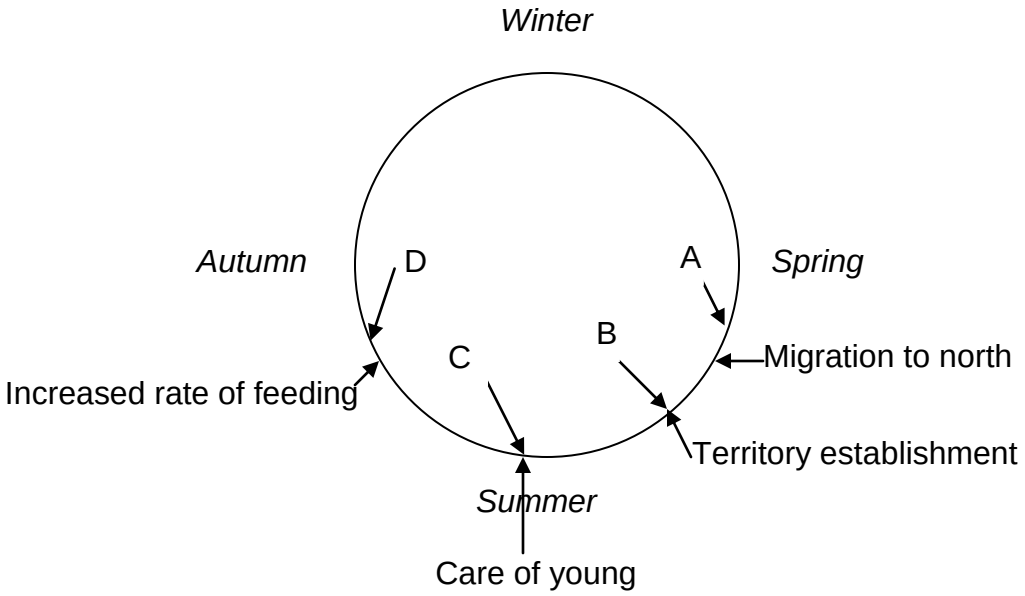
a. Hawk is an ESS and when all individuals in a population play this strategy, a mutation to Dove can never be successful.

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)

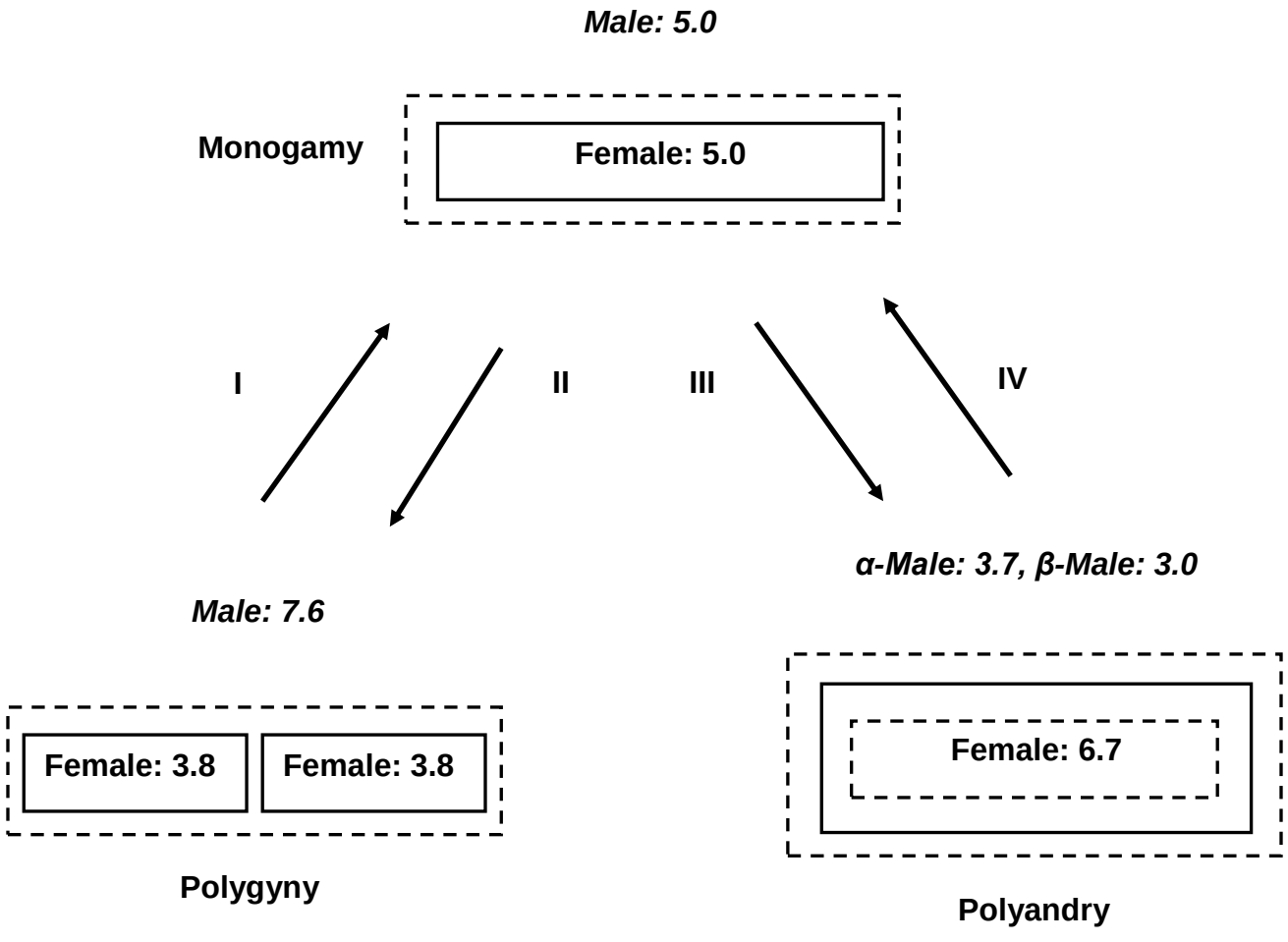
III. Gonadal development (development of the reproductive tissue)

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

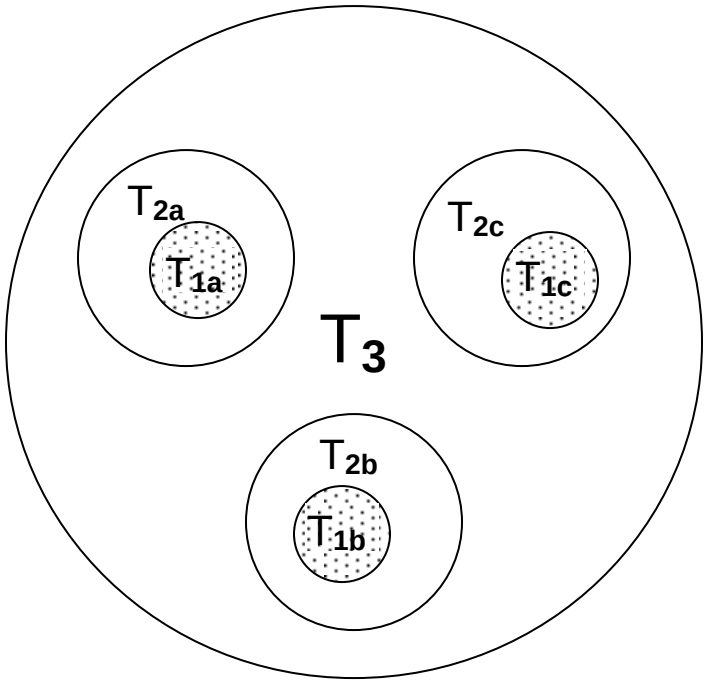
d. II and IV

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	

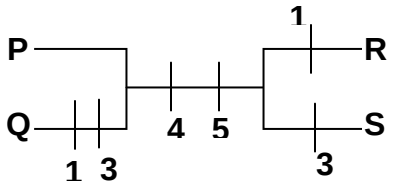
T2b	
T1b	
T2c	
T1c	

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

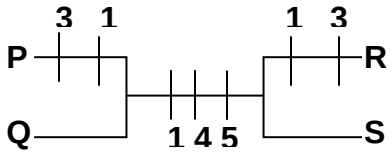
Species	Sequence site				
	1	2	3	4	5
P	A	G	T	T	C
Q	C	G	A	T	C
R	C	G	T	A	T
S	A	G	A	A	T

The most parsimonious phylogenetic classification of these species would be:

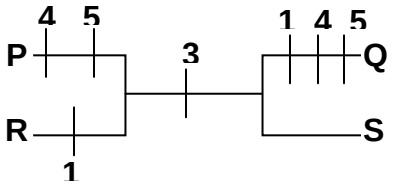
a.



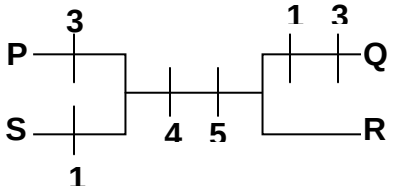
b.



c.



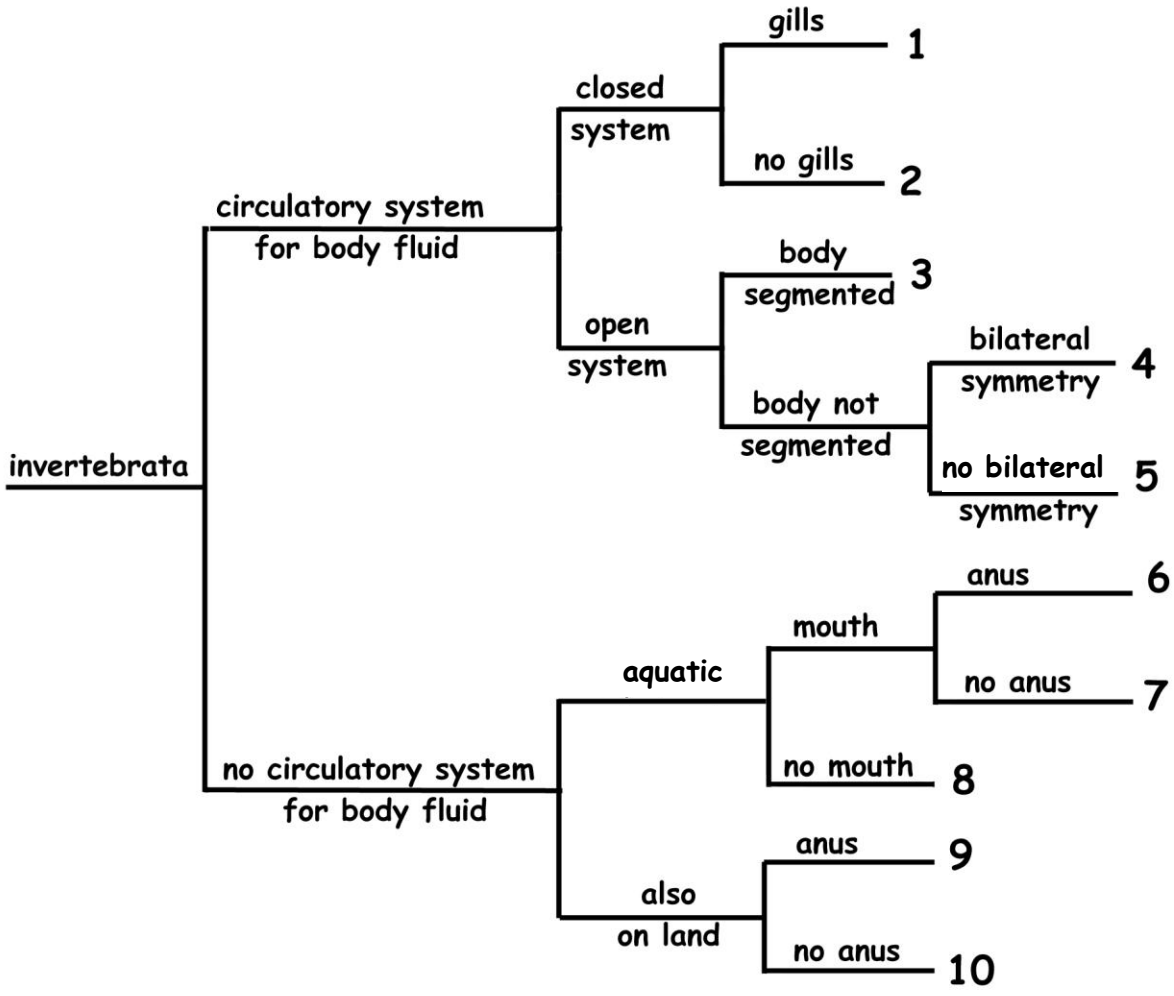
d.



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:



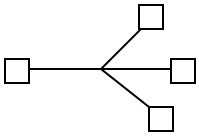
Fill in the appropriate numbers from the classification chart against the respective groups in the table below:

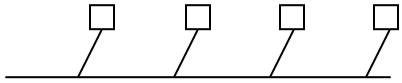
Group	Number	Group	Number
Annelida (Earthworms)		Mollusca (Land snails)	
Arthropoda (Crayfishes)		Mollusca (Squids)	
Cnidaria (Jellyfishes)		Nematoda (Roundworms)	
Echinodermata (Starfishes)		Platyhelminthes (Tapeworms)	
Mollusca (Bivalvia)		Porifera (Sponges)	

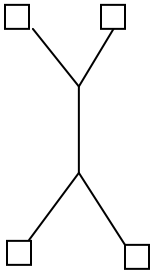
43. (4 points) The genetic distances between four species are provided in a matrix below. The numbers represent the percentage differences between each pair of species.

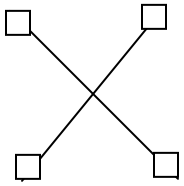
	A	B	C	D
A	-	-	-	-
B	5	-	-	-
C	13	14	-	-
D	15	16	6	-

(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. 

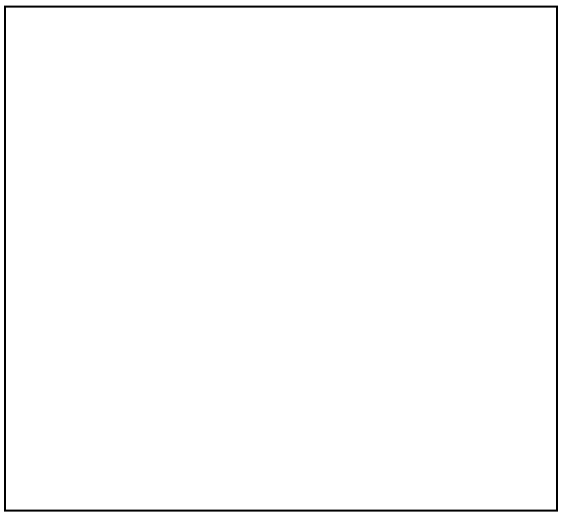
c. 

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 **********

ANNEXURE

Student's t test

The *t* statistic:

1. $$t = \frac{\overline{X}_1 - \overline{X}_2}{SE},$$

where $\overline{X}_1$ is the mean of sample 1, $\overline{X}_2$ is the mean of sample 2 and SE is the standard error.

2. SE = Standard Error, $$SE = \sqrt{s_1^2 / n_1 + s_2^2 / n_2},$$

where s is the standard deviation and n is the number of observations.

Chi-square (χ^2) test

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

where O = the observed frequency, and E = the expected frequency

Chi-Square Probabilities

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	0.000	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.300
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.041	30.813	33.924	36.781	40.289	42.796
23	9.260	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.195	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278	50.993
29	13.121	14.256	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.953	16.791	18.493	20.599	40.256	43.773	46.979	50.892	53.672
40	20.707	22.164	24.433	26.509	29.051	51.805	55.758	59.342	63.691	66.766
50	27.991	29.707	32.357	34.764	37.689	63.167	67.505	71.420	76.154	79.490
60	35.534	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.379	91.952
70	43.275	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.425	104.215
80	51.172	53.540	57.153	60.391	64.278	96.578	101.879	106.629	112.329	116.321
90	59.196	61.754	65.647	69.126	73.291	107.565	113.145	118.136	124.116	128.299
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

Student's t-test Probabilities

α: One Tail:	0.250	0.100	0.050	0.025	0.010	0.005
α: Two Tails:	0.500	0.200	0.100	0.050	0.020	0.010
df						
1	1.000	3.078	6.314	12.706	31.821	63.657
2	0.816	1.886	2.920	4.303	6.965	9.925
3	0.765	1.638	2.353	3.182	4.541	5.841
4	0.741	1.533	2.132	2.776	3.747	4.604
5	0.727	1.476	2.015	2.571	3.365	4.032
6	0.718	1.440	1.943	2.447	3.143	3.707
7	0.711	1.415	1.895	2.365	2.998	3.499
8	0.706	1.397	1.860	2.306	2.896	3.355
9	0.703	1.383	1.833	2.262	2.821	3.250
10	0.700	1.372	1.812	2.228	2.764	3.169
11	0.697	1.363	1.796	2.201	2.718	3.106
12	0.695	1.356	1.782	2.179	2.681	3.055
13	0.694	1.350	1.771	2.160	2.650	3.012
14	0.692	1.345	1.761	2.145	2.624	2.977
15	0.691	1.341	1.753	2.131	2.602	2.947
16	0.690	1.337	1.746	2.120	2.583	2.921
17	0.689	1.333	1.740	2.110	2.567	2.898
18	0.688	1.330	1.734	2.101	2.552	2.878
19	0.688	1.328	1.729	2.093	2.539	2.861
20	0.687	1.325	1.725	2.086	2.528	2.845
21	0.686	1.323	1.721	2.080	2.518	2.831
22	0.686	1.321	1.717	2.074	2.508	2.819
23	0.685	1.319	1.714	2.069	2.500	2.807
24	0.685	1.318	1.711	2.064	2.492	2.797
25	0.684	1.316	1.708	2.060	2.485	2.787
26	0.684	1.315	1.706	2.056	2.479	2.779
27	0.684	1.314	1.703	2.052	2.473	2.771
28	0.683	1.313	1.701	2.048	2.467	2.763
29	0.683	1.311	1.699	2.045	2.462	2.756
30	0.683	1.310	1.697	2.042	2.457	2.750
40	0.681	1.303	1.684	2.021	2.423	2.704
50	0.679	1.299	1.676	2.009	2.403	2.678
60	0.679	1.296	1.671	2.000	2.390	2.660
70	0.678	1.294	1.667	1.994	2.381	2.648
80	0.678	1.292	1.664	1.990	2.374	2.639
90	0.677	1.291	1.662	1.987	2.368	2.632
100	0.677	1.290	1.660	1.984	2.364	2.626

STUDENT CODE:

Student Code: _____

19th INTERNATIONAL BIOLOGY OLYMPIAD

13th – 20th July, 2008

Mumbai, INDIA

THEORETICAL TEST – PART B

ANSWER SHEET

STUDENT CODE:

CELL BIOLOGY (26 points)

1. (6 points)

   a. Answer: _____Molar

   b. Answer: _____metre

   c. Answer: _____

2. (3 points)

	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			

STUDENT CODE:

3. (2 points)

   Situation I: _____

   Situation II: _____

   Situation III: _____

   Situation IV: _____

4. (3 points)

   a. Answer: _____%

   b. Answer: _____

5. (2.5 points)

1	2	3	4	5

6. (4 points)

   I. _____

   II. _____

   III. _____

   IV. _____

   V.

	True	False
a.		
b.		
c.		
d.		

STUDENT CODE:

7. (3 points)

I.

a.	b.	c.	d.

II.

a.	b.	c.	d.

III.

a.	b.	c.	d.

8. (2.5 points)

Protein	Mode of regulation			
	I	II	III	IV
A				
B				
C				
D				

STUDENT CODE:

9. (4 points)

No.		Answer
I	Cell/s that is/are not alive when functional.	
II	Plasmodesmata can be found associated with this/these cell/s.	
III	When you eat potato, you eat the tissue formed of this/these cell/s.	
IV	Cell/s that harden/s the nut skin.	

10. (1.5 points)

Graph	Plant type
A	
B	
C	

STUDENT CODE:

11. (2 points)

(A)

Region	Water potential
P	_____ atm
Q	_____ atm
R	_____ atm

(B)

a.	b.	c.	d.

12. (4 points)

	Chlamydomonas	Cyano-bacteria	Green-sulphur bacteria	Purple-sulphur bacteria
Phototrophic autotrophs				
Photosystem II absent				
Respiratory enzymes located on plasma membrane				

STUDENT CODE:

Chlorophyll *a* as the major photosynthetic pigment				

13. (3.5 points)

Process	Does affect	Does not affect
1		
2		
3		
4		
5		
6		
7		

14. (2 points)

a.	b.	c.	d.

15. (2 points)

	P	Q	R	S
Liver				
Brain				
Thymus				
Gonads				

STUDENT CODE:

16. (2 points)

	True	False
a.		
b.		
c.		
d.		

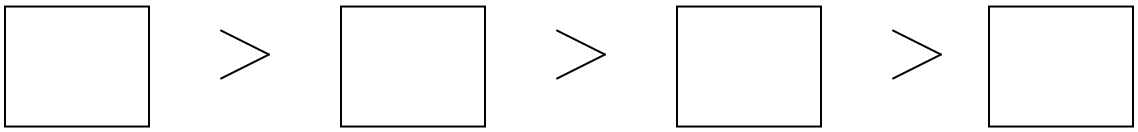
17. (2 points)

Set	Condition	True	False
A	Curve I. Normal blood pH and Curve II. Acidosis		
B	Curve I. 40°C and Curve II. 30°C		
C	Curve I. Elephant hemoglobin and Curve II. Cat hemoglobin		
D	Curve I. Fetal hemoglobin and Curve II. Maternal hemoglobin		

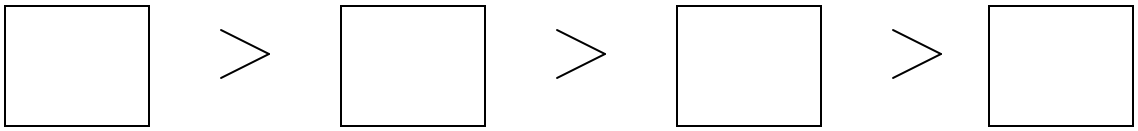
STUDENT CODE:

18. (2 points)

Surface area per unit volume of the body



Total volume of blood in the body



19. (5 points)

a.

a.	b.	c.	d.

b.

a.	b.	c.	d.

STUDENT CODE:

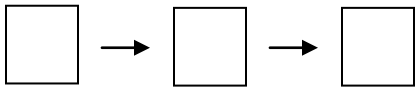
c.

Options	True	False
a.		
b.		
c.		
d.		
e.		
f.		

20. (3.5 points)

A.

B.



21. (2 points)

Answer: _____

STUDENT CODE:

22. (2 points)

	I	II	III
Lactose hydrolysis by β-galactosidase			
Reduction of *lac* repressor's affinity for the *lac* operator			
Binding of the CAP-cAMP complex to the *lac* promoter			
Utilization of glucose			

23. (2 points)

Answer: _____%

24. (2 points)

Answer: _____

25. (2 points)

Answer: _____

26. (2 points)

a.

Yes	No

STUDENT CODE:

b. Answer: _____

27. (2 points)

a. Answer: _____

b. Answer: _____

28. (2 points)

Answer: _____

29. (2 points)

I.

a.	b.	c.	d.

II. _____ kDa

30. (2.5 points)

(A)

p	
q	
r	

STUDENT CODE:

(B)

Distance between *p* and *q*	_____ mu
Distance between *p* and *r*	_____ mu
Distance between *q* and *r*	_____ mu

31. (1.5 points)

Growth curve	Survivorship curve	Age structure

32. (3 points)

(A)

a.	b.	c.	d.

(B)

a.	b.	c.

STUDENT CODE:

(C)

a.	b.	c.

33. (2 points)

Number	A	B	Type of interaction
1.			
2.			
3.			
4.			

34. (4 points)

(A)

a.	b.	c.	d.

(B)

a.	b.	c.	d.

(C)

a.	b.	c.	d.

(D)

a.	b.	c.	d.

STUDENT CODE:

35. (6 points)

(A)

I.

a.	b.	c.	d.

II.

a.	b.	c.	d.

III. Answer: _____

IV. Answer: _____

V.

a.	
b.	

(B)

I.

a.	b.	c.	d.

STUDENT CODE:

II.

a.	b.	c.	d.

III. Answer: _____

IV. Answer: _____

V.

a.	
b.	

36. (2 points)

(A)

a.	
b.	

(B)

a.	b.	c.	d.

STUDENT CODE:

37. (3 points)

(A)

		Opponent	
		Hawk	Dove
Attacker	Hawk		
	Dove		

(B)

Statement	True	False
a.		
b.		

38. (2 points)

Points in the behavioral cycle	Physiological changes
A	
B	
C	
D	

STUDENT CODE:

39. (4 points)

(A)

a.	b.	c.	d.

(B)

a.	b.	c.	d.

40. (2 points)

Taxon	Option
T3	
T2a	
T1a	
T2b	
T1b	
T2c	
T1c	

41. (2 points)

a.	b.	c.	d.

STUDENT CODE:

42. (5 points)

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)

(A)

a.	b.	c.	d.

(B)

.

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