

Version No.			

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Answer Sheet No. _____

Sign. of Candidate _____

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BIOLOGY HSSC-II (3rd Set Solution)

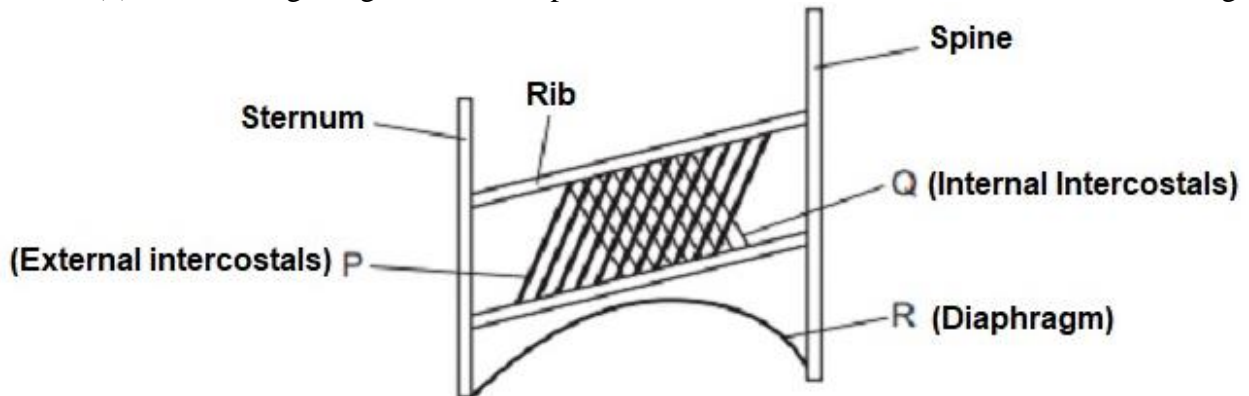
SECTION – A (Marks 17)

Time allowed: 25 Minutes

Section – A is compulsory. All parts of this section are to be answered on this page and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. **Do not use lead pencil.**

Q.1 Fill the relevant bubble for each part. All parts carry one mark.

(1) The diagram given below represents some of the muscles involved with breathing.



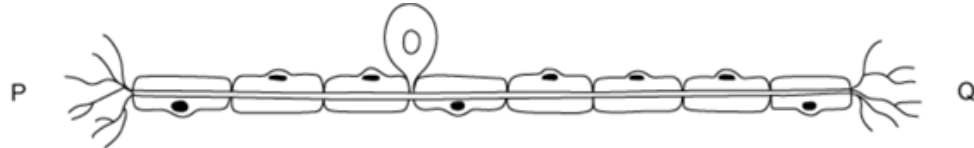
Which muscles are contracting during inspiration?

- A. P and Q B. Q and R
 C. P and R D. P, Q and R

(2) When the outer air temperature is higher than body temperature, which of the following combination of control mechanisms is the most likely to occur?

	constriction of blood vessels in skin	shivering	sweating
A	✓	✓	✓
B	✓	x	x
C	x	✓	x
D	x	x	✓

- (3) The hamstring muscles are present:
- A. at the back of the upper part of the leg
 - B. at the front of the upper part of the leg
 - C. at the back of the lower part of the leg
 - D. at the front of the lower part of the leg
- (4) Maintaining a resting membrane potential across the membrane required energy from ATP. In which of the following event, the ATPs are hydrolyzed?
- A. Movement of Na^+ ions into the neuron by Na^+ pump
 - B. Movement of Na^+ ions out of the neuron by Na^+ gate
 - C. Movement of K^+ ions into the neuron by K^+ pump
 - D. Movement of K^+ ions out of the neuron by K^+ gate
- (5) The image below shows a cell from the nervous system. The cell is the part of a reflex arc.



Identify the cell shown in the diagram and if an impulse move along the cell from Q to P, what structure would be found at P and Q?

	cell type shown in diagram	P	Q
A.	Motor neuron	Receptor	Inter neuron
B.	Sensory neuron	Inter neuron	Receptor
C.	Sensory neuron	Motor neuron	Inter neuron
D.	Motor neuron	Gland	Inter neuron

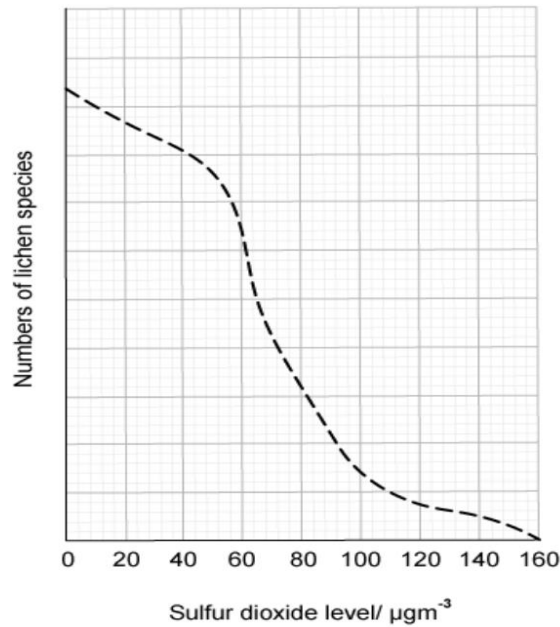
- (6) Which row in the following table correctly describes what happens in the body after a person consumes a glass of sugary drink?

	role of the pancreas	role of the liver	effect
A	releases glucagon	converts glycogen into glucose	blood sugar levels rise
B	releases insulin	converts excess glucose into glycogen	blood sugar level falls
C	releases glucagon	converts excess glucose into glycogen	blood sugar level falls
D	releases insulin	converts glycogen into glucose	blood sugar levels rise

- (7) The honey bees can communicate the distance to the food source by:
- 1- speed of the dance
 - 2- length of buzzing while dancing
 - 3- a straight run
- A. 1 only
 - B. 2 only
 - C. 1 and 2 only
 - D. 2 and 3 only
- (8) Students were discussing how to remember the difference between two group of cells, “many, minute and motile” or “few, large and non-motile”. Which of the following group of cells were they referring to?
- A. Animal and plant cells
 - B. Red and white blood cells
 - C. Xylem and phloem cells
 - D. Male and female gamete cells

- (9) During birth following events happen:
 1- Rupturing of amniotic sac
 2- Contraction of myometrium
 3- Cutting of umbilical cord
 4- Inhibition of progesterone secretion
 Which one of the following is the correct sequence of these events from start to end?
 A. 1 → 2 → 3 → 4 B. 2 → 4 → 3 → 1
 C. 4 → 3 → 2 → 1 D. 4 → 2 → 1 → 3
- (10) If one pair of alleles exhibits complete dominance while the other pair exhibits incomplete dominance, what will be the outcome in F1 generation of a cross between **AABB** (Male) X **aabb** (female) parents?
 A. all phenotypes will be similar to the male parent
 B. all phenotypes will be similar to the female parent
 C. there will be 1:1 between both parental phenotypes
 D. there will be 100% recombinant phenotypes
- (11) Albinism is a recessive trait. A normal woman with albino father and normal mother marries an albino man. What is the probability of albinism in her children?
 A. Zero % B. 25%
 C. 50% D. 100%
- (12) Five different amino acids (number 1-5 below) from the following sequence is part of a polypeptide chain:
 1 — 2 — 3 — 4 — 2 — 5 — 3
 and mRNA codons which corresponds to these amino acids are:
 1=UGU, 2=GAU, 3=CAC, 4=UAG, 5=AAG.
 Which one of the following DNA base sequences could provide the code for the give section of polypeptide?
 A. ACACUAGUGAUGCUAUUCGU
 B. ACACTAGTGATGCTAAACGTG
 C. ACACTAGTGATCCTATTCGTG
 D. CACATCUTUCTUATCTTAUTU
- (13) An mRNA codon for the amino acid alanine is GCC. How many alanine molecules are present in the polypeptide, containing 8 amino acids coded for by the following DNA template?
 TCGGCCTACCGGGCCCATGCCAAT
 A. Zero B. One
 C. Two D. Three
- (14) When populations of a species that share the same habitat become reproductively isolated from each other and evolve into different species after many generations. Such origin of new species is called:
 A. sympatric speciation B. allopatric speciation
 C. parapatric speciation D. natural selection
- (15) Which one of the following stage of sewage treatment consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface?
 A. primary B. secondary
 C. tertiary D. quaternary

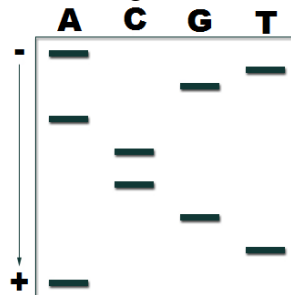
- (16) The graph shows the relationship between the number of lichens and the levels of sulfur dioxide pollution. It indicates that as the sulfur dioxide levels increase, the number of lichen decreases



Which one of following is the best conclusion drawn from the above graph?

- A. Sulfur dioxide is an essential nutrient for lichen growth
- B. Lichens are good pollution indicators
- C. Lichens use sulfur dioxide in photosynthesis
- D. Sulfur dioxide has no relation with lichen growth

- (17) Following is the gel pattern taken from Sangar's method of DNA sequencing. Read the sequence given in the gel:



- A. 5'-ATGCCAGTA-3'
- B. 5'-ATGACCGTA-3'
- C. 3'-TACGGTCAT-5'
- D. 3'-ATGCCAGTA-5'



Federal Board HSSC-II Examination
Biology Model Question Paper
(Curriculum 2006)

Time allowed: 2:35 hours

Total Marks: 68

Note: Answer any fourteen parts from Section 'B' and attempt any two questions from Section 'C' on the separately provided answer book. Write your answers neatly and legibly.

SECTION – B (Marks 42)

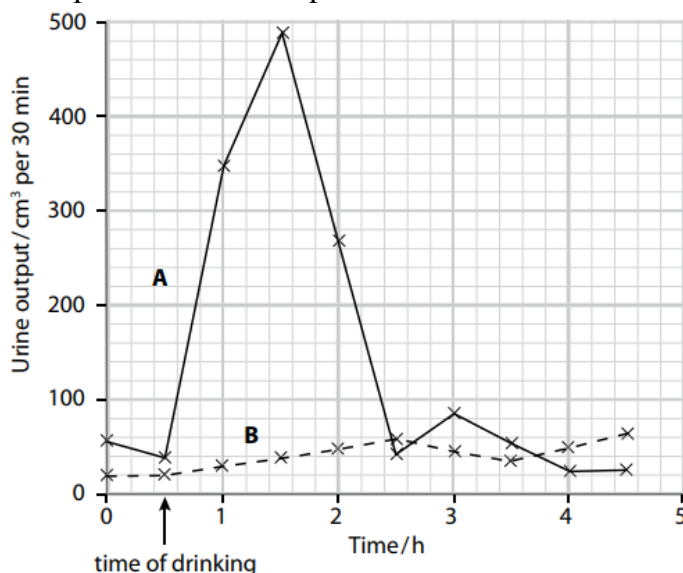
Q.2 Attempt any **FOURTEEN** parts from the following. All parts carry equal marks.

(14 × 3 = 42)

- i. Cigarette smoke contains tar, nicotine and carbon monoxide. Tar is a highly toxic chemical of the smoke. How does it affect the internal structure of the lungs?

Ans: The first event appears to be thickening and callusing (over growth) of the cells lining the bronchi. Then there is a loss of cilia so that it is impossible to prevent dust and dirt from setting in the lungs. The tumor may grow until the bronchus is blocked, cutting off the supply of air to that lung

- ii. In an investigation of the factors that influence urine production, a person drank one litre of water. The person's urine was collected at half-hourly intervals for four hours after drinking. The results are shown as line A on the figure. On the following day, the same person drank one litre of a dilute salt solution and the urine was collected in the same way (line B). Dilute salt solution has about the same water potential as blood plasma.



- a. Calculate how much urine was produced in the two hours after drinking the litre of water. (01)

Ans: $40 + 340 + 480 + 260 = 1120 \text{ cm}^3$ approximately.

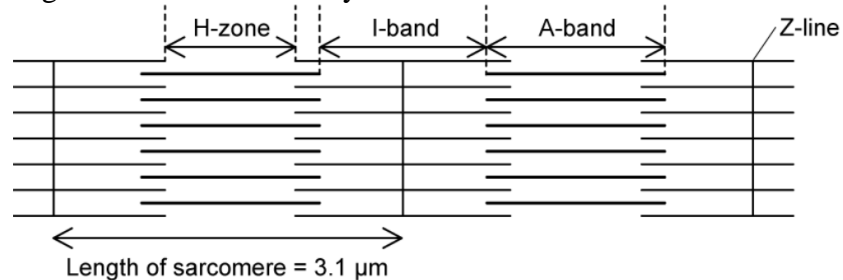
- b. Suggest why the results during the second day were so different from those on the first day. (02)

Ans: On the following day, the same person drank one litre of a dilute salt solution which has about the same water potential as blood plasma therefore, water could not be absorbed by blood from GIT. Hence, the results during the second day were so different from those on the first day.

iii. In which condition kidney transplant is required? Write two characteristics of matching kidney donor which improve graft survival.

Ans: Kidney transplantation is required in a person with chronic kidney failure. ABO blood group compatibility between donor and recipient is essential. It is usual to select donor kidneys based on human leucocytes antigen (HLA) matching as this improves graft survival.

iv. The figure given below shows a myofibril strand in a relaxed muscle fiber

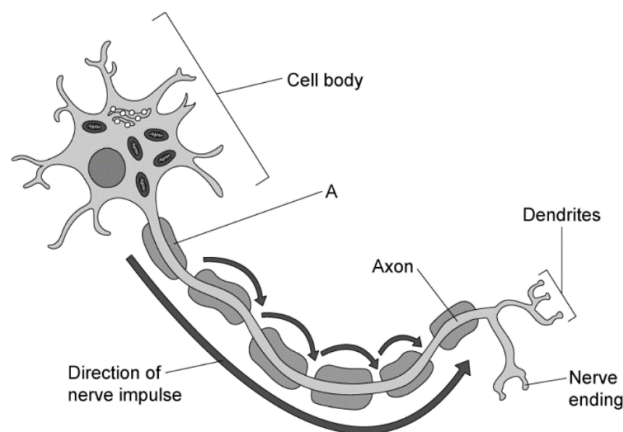


What will happen on the length of the A-band, I-band and H-zone, when muscle will perform contraction? (1+1+1)

Ans: When muscle will perform contraction:

- the length of the A-band will remain unaffected.
- The length of the I-band will be reduced
- The length of the H-zone will also be reduced and ultimately disappeared.

v. Figure given below shows the general structure of a neuron.



Identify the structure A in the figure, give its role and explain how it influences the speed of conduction in the neuron.

Ans:

- The structure A in the given diagram is a Schwann cell with myelin sheath.
- It is the type of protective and nutritive cells of nervous system
- Since it is impermeable for ionic movement, so the impulse will be jumped from one node of Ranvier to another. Thus, a faster impulse has been developed.

- vi. Identify **ONE** key factor which contributes to establishing a resting membrane potential of about -70mV and explain how this is achieved by that factor.

Ans: One of the key factors which contribute to establishing a resting membrane potential of about -70mV is the distribution and active movement of Na^+ and K^+ ions.

The concentration of potassium (K^+) is 30 times greater in the fluid inside the cell than outside and the concentration of sodium ions (Na^+) is nearly 10 times greater in the fluid outside the cell than inside. These ions are continuously moved against their concentration gradient through active transport pumps by the expenditure of energy. For every two K^+ that are actively transported inward, three Na^+ are pumped out. So inside becomes more negative than outside of the neuron membrane

- vii. What are the sites of secretion of progesterone during pregnancy and menstrual cycle and write its brief function in both cases.

Ans:

Hormone	During pregnancy	During menstrual cycle
Sites of secretion	Corpus leuteum (before establishment of placenta) and Placenta	Corpus leuteum
Brief function	Maintain pregnancy	Develops endometrial lining for implantation of blastocyst

- viii. Define and give examples of hostile and helpful intraspecific interactions.

Ans: In bees hive, hostile interaction is seen among the worker bees. Old worker bee which is unable to perform its duties in hive is killed by other worker bees. On the other hand helpful interaction is found among these bees as different bees have specific duties to perform over all functions of the hive. Worker bees collect nectar and transform it into honey, drones are specific to perform the duty to fertilize the eggs and queen lays eggs.

- ix. Identify the structure of male and female reproductive systems and write brief function of each as one of them is solved in the given table.

Ans:

Structure	Found in	Brief function
Epididymis	Male reproductive system	Function in the transport and storage of the sperms.
Urinogenital duct	Male reproductive system	Ejaculation of semen and sperms
Myometrium	Female reproductive system	Shows contraction during labour
Leydig cells	Male reproductive system	Secretion of testosterone

- x. a. Why are neural crest cells considered as fourth germ layer of the human embryo. (1)

Ans: Neural crest cells subsequently migrate to various parts of the embryo, forming peripheral nerves, medulla of the adrenal gland, teeth, skull bones and so many other different cell types that some have proposed considering neural crest cells as a "fourth germ layer".

- b. What were the two conclusions of Spemann's delayed nucleation experiments? (1+1)

Ans: Spemann's delayed nucleation experiments served as compelling evidence for two important conclusions:

- a) All cells contain the same nuclear information (thus disproving the Roux- Weismann hypothesis),
 b) Cytoplasm in the area of the grey crescent must contain information essential for normal development.

- xi. a. How ovulation and menstruation are regulated during pregnancy? (1)

Ans: Both of Ovulation and menstruation remain stopped throughout the pregnancy.

- b. List two features of reproduction which make it different from rest of the life characteristics. (2)

Ans: Human reproduction needs internal fertilization. The reproductive system is unique in two respects.

1. Firstly, the fact that it does not become functional until it is 'turned on' at puberty by the action of sex hormones. In contrast, all other body systems are functional at birth or shortly thereafter.
2. Secondly, the other organ systems of the body exhibit slight differences in male and female while the reproductive system is quite different in male and female.

- xii. Pure-breeding *Drosophila* with straight wings and grey bodies were crossed with pure-breeding curled-wing, ebony-bodied flies. All the offspring were straight-winged and grey-bodied. Female offspring were then test crossed with curled-wing, ebony-bodied males, giving the following results:

straight wing, grey body = 113

straight wing, ebony body = 30

curled wing, grey body = 29

curled wing, ebony body = 115

- a. State the ratio of phenotypes expected in a dihybrid test cross like above. (1)

Ans:

Phenotype	straight wing, grey body	straight wing, ebony body	curled wing, grey body	curled wing, ebony body
Actual No.	113	30	29	115
Ratio	3	1	1	3

- b. Explain the discrepancy between the expected result and the results given. (1)

Ans: From probability point of view, it was expected that there should be equal proportion of all combinations. However, the given data shows the outcome of less recombinants that expected which indicates that there might be a loose or incomplete linkage between the loci.

- c. Calculate the cross over value. (1)

Ans:

$$\text{Crossover value} = \frac{\text{Sum of recombinants}}{\text{Sum of all combination}} \times 100$$

$$\text{Crossover value} = \frac{30+29}{113+30+29+115} \times 100$$

$$\text{Crossover value} = \frac{59}{287} \times 100$$

$$\text{Crossover value} = 20.5\%$$

- xiii. In human, it is known that the allele for red-green color blindness is recessive to the allele for trichromatic vision. If both husband and wife have trichromatic vision, can have colorblind son and daughter? Justify your answer by drawing the diagram of their cross.

Ans:

Data:

Husband = Trichromate color vision
 Wife = Trichromate color vision
 Colorblind Son = ?
 Colorblind Daughter = ?

Solution:

Parents	→	Husband x	Wife
Phenotype	→	Trichromate	Trichromate
Genotypes	→	X^CY	X^CX^C
Gametes	→	(X^C) (Y)	(X^C)

Possible fertilization

	(X^c)
(X^c)	X^CX^C Normal
(Y)	X^CY Normal

The results justify that if both husband and wife have trichromatic vision, they cannot have colorblind son and daughter.

- xiv. If you found a road accident, unfortunately, the victims have got fractures in the bones of upper limb. How will you provide first aid treatment to the victims? Give any three key measures?

Ans: Three key measures for first aid treatment to the victims may be:

- (a) Immobilizing the fractured bone or dislocated joint but do not attempt to manipulate, pull or re-align the injured joint or bone. Leave this task to a professional
- (b) If possible; apply ice pack or cold pack over the affected part to reduce swelling.
- (c) Assist the victim to position of comfort.

- xv. Write the measures that a eukaryotic cell must adopt to protect its newly born mRNA from its own phosphatases and nucleases. (1.5+1.5)

Ans: A cap is in the form of 7-methyl GTP, which is linked from its 5' to the 5' end of mRNA. A modification also takes place at the opposite end of the RNA transcript in the form of a small chain of 30-500 adenine nucleotides, called poly-A tail, which is attached to the 3' end of the mRNA. These two modifications prevent the mRNA to be degraded by phosphatases.

xvi. If a population of certain plants which is in Hardy-Weinberg equilibrium consists of 1000 individuals, 64% of which are dominant homozygote and 32% are heterozygotes for a particular trait. Calculate the:

a. Genotype frequency of recessive homozygotes (1)

Ans:

Genotype frequency of recessive homozygotes = q^2

Where $p = q = 0.2$

So, $q^2 = (0.2)^2 = 0.04 = 4\% = 40$

b. Gene frequency of dominant gene and (1)

Ans: Gene frequency of dominant gene = $\sqrt{p^2} = \sqrt{0.64} = 0.8$

c. Gene frequency of recessive gene. (1)

Ans: Gene frequency of dominant gene = $\sqrt{q^2} = \sqrt{0.04} = 0.2$

xvii. What is productivity of an ecosystem? Differentiate the concept of gross primary productivity and net primary productivity. (1+2)

Ans: Only 1% of solar energy is incorporated into the ecosystem which is fixed into organic compounds. This is called productivity of the ecosystem.

The total amount of solar energy which is fixed by the producers during photosynthesis is called gross primary productivity (GPP).

On the other hand the amount of energy that remains available for plant growth after subtracting the fraction that plants use for respiration is termed as Net primary productivity (NPP) or biomass.

xviii. a. If a piece of 1 kilo base pairs of human DNA contains 10 restriction sites for an enzyme, how many fragments will be produced after complete digestion with that enzyme. (1)

Ans: 11 Fragments

b. Define palindromic sequence and draw a DNA fragment showing any two palindromic sequence and highlight them? (2)

Ans: A palindromic sequence is a four to eight base pairs in DNA in which nucleotides are arranged symmetrically in reverse order.

```
5'-ATTGTAC GTTAAC ACTATCGGTGAT GAATTC TCTA  
TG-3'  
3'-TAACATG CAATTG TGATAGCCACTA CTTAAG AGAT  
AC-5'
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xix. Threshold potentials in receptor cells can increase and decrease. Suggest the possible advantages of this change and define the concept of threshold stimulus.

Ans: A stimulus of minimum intensity that can initiate an impulse is called threshold stimulus.

Threshold potentials in receptor cells can be increased or decreased by changing the concentration of Na^+ gate in receptor plasma membrane. The possible advantage of this change is to reduce the response to a repeated stimulus and to conserve the loss of energy.

xx. Define Integrated Disease Management and give its procedure.

Ans: Integrated disease management is the effective control of a particular disastrous disease or all the common diseases of a population can be achieved by using all relevant,

appropriate methods of disease control such as:

- awareness of the community about the severity of the problem, its causes and its remedies
- preventive measures
- drug treatment
- vaccination and
- different kinds of therapies

SECTION – C (Marks 26)

Note: Attempt any **TWO** questions. All questions carry equal marks. (2×13 = 26)

- Q.3** a. Compare the structure and properties of Haemoglobin and Myoglobin. Also describe their role in human body. (5)

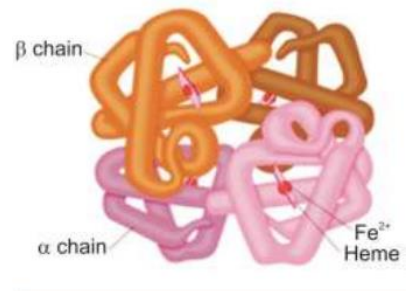
Ans: Respiratory pigments are coloured molecules, which act as oxygen carriers by binding reversibly to oxygen. All known respiratory pigments contain a coloured non-protein portion e.g., haem (heme) in haemoglobin. The two well-known respiratory pigments are haemoglobin and myoglobin.

Haemoglobin

It contains four globin protein chains; each associated with haem, (also hem and heme) an iron-containing group.

Function:

Iron combines loosely with oxygen, and in this way oxygen is carried in the blood. At high oxygen concentrations, the pigment combines with oxygen, whereas at low oxygen concentrations the oxygen is quickly released.

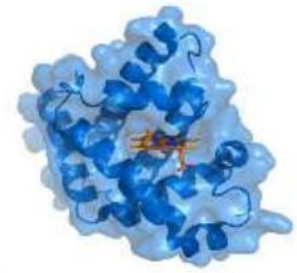


Myoglobin

It consists of one polypeptide chain. This chain is associated with an iron containing ring structure. This iron can bind with one molecule of oxygen.

Function:

It is found in skeletal muscles and is the main reason why meat appears red. It serves as an intermediate compound for the transfer of oxygen from haemoglobin to aerobic metabolic processes of the muscle cells. Myoglobin releases oxygen when the partial pressure of oxygen is below 20 mmHg. In this way it acts as a store of oxygen in resting muscle, only releasing it when supplies of oxyhaemoglobin have been exhausted.



- b. Describe role of foetal and maternal hormones in parturition and explain the stages of labor process. (8)

Ans:

Parturition means birth of the baby. Toward the end of pregnancy, the uterus becomes progressively more excitable, until finally it develops such strong rhythmical contractions that the baby is expelled. There are several factor involved in the onset of this excitation like increased ratio of estrogens to progesterone, foetal hormones and maternal hormones.

Role of Hormones in Controlling Birth

Increased ratio of estrogen to progesterone. Both progesterone and estrogen are secreted in progressively greater quantities throughout most of pregnancy, but from the

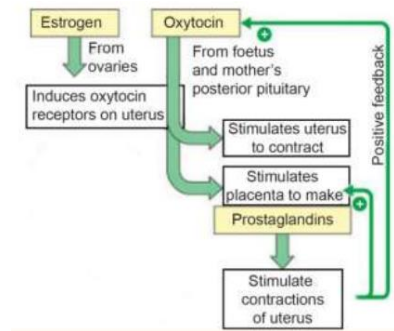
seventh month onward, estrogen secretion becomes greater than progesterone secretion therefore called increased ratio of estrogens to progesterone. It stimulates the myometrial cells of the uterus to form abundant oxytocin receptors. As a result, the myometrium becomes increasingly irritable, and weak, irregular uterine contractions begin to occur. These contractions are called Braxton Hicks contractions or false labour pains.

Role Of Foetal Hormones in Birth

As birth nears, two more chemical signals cooperate to convert these false labour pains into the real thing. The foetus pituitary gland secretes increasing quantities of oxytocin, which might play a role in exciting the uterus. Pituitary gland also secretes ACTH that stimulates the foetal adrenal gland to release corticosteroids which affect two regions, first they influence the placenta and cause a decrease in progesterone production and second they stimulate the foetal membranes to produce an increased secretion of prostaglandins. Both oxytocin and prostaglandins are powerful uterine muscle stimulants, oxytocin causes contraction of the smooth muscles of the myometrium and prostaglandins increase the power of the contractions

Role Of Maternal Oxytocin in Birth

At this point, the increasing emotional and physical stresses activate the mother's hypothalamus, which signals for oxytocin release by the posterior pituitary. Together the elevated levels of oxytocin and prostaglandins trigger the rhythmic expulsive contractions of true labour. Once the hypothalamus is involved, a positive feedback mechanism is propelled into action. The greater contractile force causes the release of more oxytocin, which causes greater contractile force, and so on. The release of oxytocin occurs in "waves" during labour.



Labour process:

Braxton Hicks contractions become progressively stronger toward the end of pregnancy; then they change suddenly, within hours, to become exceptionally strong contractions that start stretching the cervix and later force the baby through the birth canal, thereby causing parturition. This process is called labour, and the strong contractions that result in final parturition are called labour contractions. The process of labour has three stages. The first stage is the opening up and thinning of the cervix, ending with complete dilation. The second stage is the expulsion, or delivery, of the baby. Continuous strong contractions force the foetus down and out of the uterus and vagina. The final stage of the labour is delivery of the placenta, which normally follows the baby.

Clamping and cutting of umbilical cord:

After the delivery of the baby (second stage of the birth) the umbilical cord is still attached to the baby. The umbilical cord is clamped artificially as early as 1 to 5 minute after the birth of the child. Clamping is followed by cutting of the cord, which is painless due to the lack of any nerves.

Afterbirth:

Following the birth of the foetus, usually within 10-15 minutes, the placenta separates from the uterine wall and is expelled by uterine contractions through the birth canal. This expulsion is termed the 'afterbirth'.

- Q.4** a. In sweet-pea plants, the gene A/a controls flower colour. The dominant allele gives purple flowers and the recessive allele red flowers. A second gene, B/b, controls the shape of the pollen grains. The dominant allele gives elongated grains and the recessive allele spherical grains. A plant with the genotype AaBb was test-crossed by interbreeding it with a plant with red flowers and spherical pollen grains. Copy and complete the table to show the expected ratio of phenotypes of the offspring of this cross. The gametes from one parent are already in the table. (5)

Ans:

		Gametes of one parent							
		AB		Ab		aB		ab	
		Genotype	Phenotype	Genotype	Phenotype	Genotype	Phenotype	Genotype	Phenotype
Gamete of other parent	ab	AaBb	Purple flowers elongated grains	Aabb	Purple flowers spherical grains	aaBb	Red flowers elongated grains	aabb	Red flowers spherical grains

- b. Describe Meselson-Stahl experiment as an evidence of semiconservative replication of DNA. Also draw flow diagram of the experiment. (8)

Ans:

The three models of DNA replication were evaluated by Mathew Meselson and Franklin Stahl of the California Institute of technology in 1958. Later on, they were awarded Nobel Prize. In this experiment, it was concluded finally that the replication of DNA occurs according to semiconservative model.

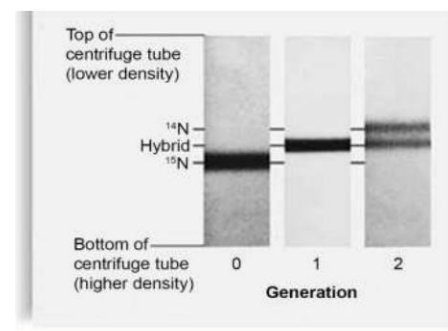
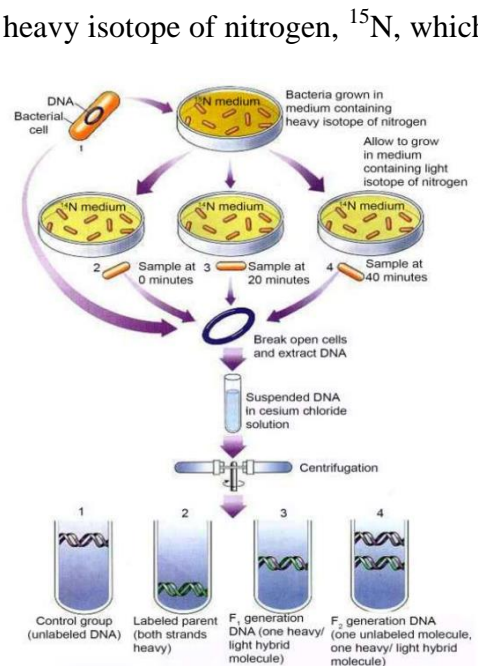
They grew bacteria in a medium containing heavy isotope of nitrogen, ^{15}N , which became incorporated into the bases of bacterial DNA. After several generations, the bacteria were shifted to three separate plates, which were already poured with medium containing ^{14}N .

Three DNA samples were taken from bacteria shifted from ^{15}N medium to the ^{14}N medium. First sample was obtained from first plate just after the transfer of culture; called sample at 0 minute, the second sample was taken from second plate after 20 minutes, called sample at 20 minutes, and third sample was taken from third plate after another 20 minute, called sample at 40 minute. In addition to these, a control sample was also taken from the bacteria which were grown separately in ^{14}N medium.

The DNA samples were dissolved in cesium chloride (CsCl) solution and then spun at a very high speed in an ultra-centrifuge for many hours. The cesium and chloride ions tend to be pushed by centrifugal force towards the bottom of the tube. Ultimately a gradient of Cs^+ and Cl^- ions was established in the tube. Molecules of DNA were settled down and formed sediments to the level of their appropriate densities in test tubes.

DNA of control sample appeared red lightest as it formed sediment at the top of test tube, while DNA of sample at 0 minute appeared heaviest as it formed sediment at the bottom of test tube. The DNA of sample at 20 minute formed sediment intermediate level to that of control sample and sample at 0 minute whereas sample at 40 minute had two sediments, one at the top and other at intermediate level.

Meselson-Stahl interpreted their results as it follows: the DNA of control sample appeared lightest because it had both strands of ^{14}N , whereas DNA of sample at 0 minute appeared heaviest because it had both strand of ^{15}N , but after first round of replication each daughter duplex was a hybrid possessing one strand of ^{14}N and one of ^{15}N , so it formed sediment at intermediate level. When this hybrid duplex replicated in second round of replication, it contributed ^{15}N strand to form another hybrid



duplex and ^{14}N strand to form a light duplex containing both ^{14}N strands that is why this sample formed two sediments. On the basis of above mentioned results, they claimed that the DNA replication is semi conservative.

- Q.5** a. Describe the mechanism of Polymerase Chain Reaction and draw its labelled diagram. (8)

Ans: The technique, which is used to amplify (clone) a single gene or a piece of DNA into thousands to millions of copies by means of in vitro replication process is called polymerase chain reaction (PCR). In this technique DNA polymerase is compelled to polymerize (polymerase reaction) a given piece of DNA again and again, so that multiple copies are produced, thus, the technique is known as polymerase chain reaction (PCR).

A special DNA polymerase, the Taq polymerase is used in PCR technique, which is specialized temperature-tolerant enzyme isolated from *Thermus aquaticus*, a bacterium found in hot springs. This enzyme is stable and active at near-boiling temperatures.

In order to perform PCR, template DNA (DNA to be amplified), free nucleotides (deoxyribo-nucleoside triphosphates or dNTPs), primers and Taq polymerase are dissolved in suitable buffer to make PCR mixture or reaction mixture. The PCR mixture is placed in an instrument called thermocycler or PCR machine. Thermocycler regulates the temperature during various steps of PCR reaction according to the need.

Mechanism of PCR Reaction

PCR cycle consists of three steps: denaturation, primer annealing, and extension or polymerization each requires a specific temperature. The time duration, temperature and sequence of the steps have to be programmed in the thermocycler.

Denaturation

In the denaturation step, the template is heated to 94°C for one minute. At this high temperature the DNA undergoes complete denaturation and the double-stranded DNA (dsDNA) becomes single-stranded DNA (ssDNA). Each single ssDNA can act as the template for the in vitro DNA synthesis.

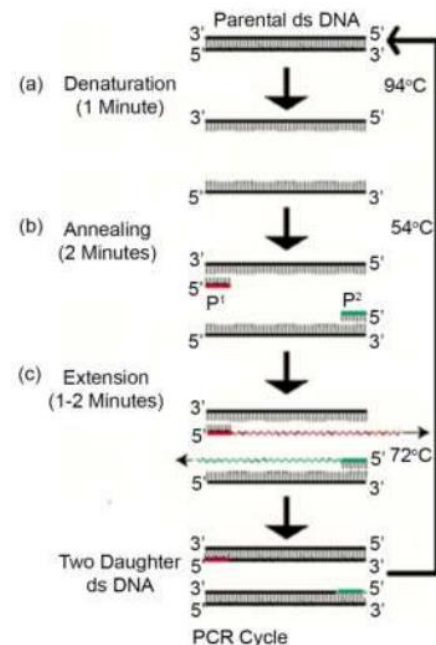
Primer annealing

The next step is the primer annealing. In this step the two primers, the forward primers and the backward primers, anneal or hybridize to the single-stranded template DNA at its complementary regions. Annealing is usually carried out at a lower temperature depending on the length and sequence of the primers. In standard cases it is 54°C and approximate time required for this step is 2 minutes.

Extension or Polymerization

The final step in each cycle is the primer extension or polymerization in which the Taq polymerase synthesizes new DNA strands to the 3' ends of primers using dNTPs. The optimum temperature for carrying out the primer extension reaction or polymerization of dNTPs is standardized at 72°C . This step takes just one minute to be completed.

At the end of first cycle one target DNA molecule is converted into two molecules. The second cycle immediately starts with the denaturation by heating at 94°C , so that all the newly synthesized DNA are also denatured to single strands, which again act as templates. It will again be followed by the primer annealing and extension and thus the cycle of denaturation, primer annealing, and extension continues resulting in the amplification of the selected DNA sequence at an exponential rate i.e., the number of existing DNA molecules become doubled after each cycle.



- b. Discuss how Darwin's theory of evolution by natural selection explains the origin of new species. (5)

Ans: In his book 'The origin of species' Darwin developed two main points i.e.

- (i) Descent with modification
- (ii) Natural selection and adaptation.

Descent with modification

Darwin believed and perceived unity in life, with all organisms related through descent from some common ancestors and that adaptation to various environments results diversity. In the Darwinian view, the history of life is like a tree, with multiple branching and re-branching from a common trunk all the way from the tips of the living twigs, symbolic of current diversity of organisms. At each fork of the evolutionary tree is an ancestor to all line of evolution branching from that fork.

Natural selection and adaptations

Natural selection refers to the differential reproductive capacities among the individuals of a population which indicates that some individuals of a population are capable to reproduce while others are not. Darwin's mechanism of evolution by natural selection consists of four observations about natural world

Over production:

Each species has the capacity to produce more offspring than will survive to maturity. Through reproduction, natural populations may exponentially increase in number over time.

Variations:

The individuals in a population exhibit variation in their traits. Some of these traits improve the chances of an individual's survival and reproductive success, whereas other traits do not.

Struggle for existence:

Over production leads to the competition among the individuals of a population for the limited resources food, water light, growing space. Because there are more individual than the environment can support, not all will survive to reproductive age. Other limits on population growth include predators and disease causing organisms. The struggle may be interspecific, intraspecific and environmental.

Survival of the fittest:

Those individuals that possess the most favourable combination of characteristics are most likely to survive and reproduce, passing their heritable traits on to the next generation. For example if there is sudden flood only those organisms that can swim or respire in water, have a better chance to survive and other will die or if there is an earthquake, the flying animals have a better chance of survival. This is called natural selection. It is also referred as the survival of the fittest. The fittest individuals are those that reproduce most successfully in the environment.

The processes of natural selection thus cause an increase of favourable alleles and a decrease of unfavourable alleles within the population. Over succeeding generations, individual members become better adapted to local conditions, thus, leading to the evolution of new species.

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