BIOLOGY UNIT
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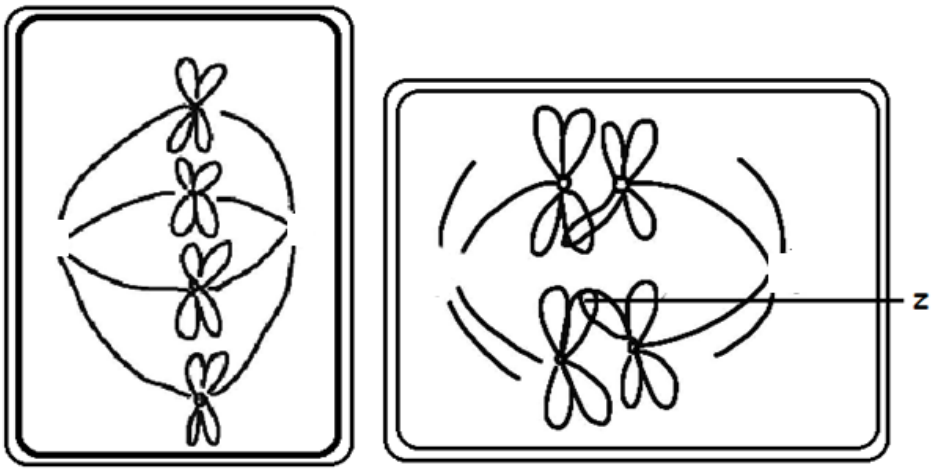
BIOBOOSTER
SEMESTER I SESSION 2023/2024
ANSWER SCHEME

TOTAL MARKS: 80

INSTRUCTION: ANSWER ALL QUESTIONS

1. Cell **A** and cell **B** are two different cells that are found in different part of the same plant.



Cell A Cell B

FIGURE 1

a) Name the example for Cell **B.** [1 *mark*]

Microspore mother cell // Megaspore mother cell// Microsporocyte // Megasporocyte

b) Differentiate the chromosome behavior for cell A and cell B in the stage before the stage in **FIGURE 1.** [2 *marks*]

Note: students are now allowed to answer this question in table form. This table for examiners use only.

No.	Cell A	Cell B	Mark
1.	• Synapsis does not occur (in prophase of mitosis)	• Synapsis occur (in prophase I)	1
2.	• No chiasmata formed (in prophase of mitosis)	• Chiasmata form between non sister chromatids/ between the chromatids of homologous chromosomes (in prophase I)	1
3.	• No crossing over occurs (in prophase of mitosis)	• Crossing over occurs (in prophase I)	1

c) After cell division is completed, how many chromosomes are present in Cell A and Cell **B**? [2 *marks*]

Cell A : 4
Cell B : 2

d) Name the process that occurs at **Z** and state its importance. [2 *marks*]

Process : Crossing over
Importance : Increase the genetic recombination // increase genetic variation

2. a) In rabbits, short hair is controlled by a dominant allele (*L)* while long hair is controlled by its recessive allele (*l)*. On the other chromosome, black hair is controlled by a dominant allele (*B)* while brown hair is controlled by its recessive allele (*b)*. By using Punnett square, draw the genetic diagram to determine the genotypic and phenotypic ratio for F_1 progeny if the heterozygous rabbit is test-crossed. [4 *marks*]

(P phenotype) : (Short and black hair) (Long and brown hair)
P (genotype) : LlBb X llbb
Gamete : (LB) (Lb) (lB) (lb) (lb) **1/0**

F_1 (by using Punnett square):

Gametes	**(LB)**	**(Lb)**	**(lB)**	**(lb)**
(lb)	**LlBb Short and black hair**	**Llbb Short and brown hair**	**llBb Long and black hair**	**llbb Long and brown hair**

1/0

F_1 genotypic ratio : 1 LlBb : 1 Llbb : 1 llBb : 1 llbb **1/0**

F_1 phenotypic ratio : 1 short and black hair, : 1 short and brown hair, : 1 long and black hair, : 1 long and brown hair, **1/0**

b) In the pea plant, the purple flower (*P*) is dominant over the red flower (*p*), and the long pollen shape (*L*) is dominant over the round pollen shape (*l*). A cross was done between a homozygous purple flower long pollen plant and a homozygous red flower round pollen plant. The F_1 generation was then crossed with a red and round pollen plant, producing the following progenies:

Phenotypes	No. of progeny
Purple flower, long pollen	48
Purple flower, round pollen	13
Red flower, long pollen	12
Red flower, round pollen	46

TABLE 1

i. Does the above cross follow the Mendelian ratio. [1 *mark*]

No

ii. Explain how the situation in (b)(i) occurs. [2 *marks*]

Genes (encoding for flower colour and seed shape) are linked
Crossing over occurs

iii. Draw the genetic diagram for the test cross of the F_1 generation.

[4 *marks*]

(F_1 Phenotype) : (Purple flower, long pollen) (Red flower, round pollen)

F_1 : PL/pl X pl/pl 1/0
Test cross

Gamete: PL pL Pl pl pl 1/0

F_2 : PL/pl pL/pl Pl/pl pl/pl 1/0
Genotype

F_2 : Purple flower, long pollen (48) | red , flower long pollen (12) | Purple , flower round pollen (13) | red flower round pollen (46) 1/0
Phenotype

iv. Calculate the distance between the genes. Show your calculation.

[2 *marks*]

Recombinant frequency/(COV) = $\frac{\text{Total no. of recombinants}}{\text{Total no. of all offspring}}$ X 100

= $\frac{25}{119}$ X 100

= 21%

1/0

Distance between genes = 21 map units / centiMorgan / cM 1/0

3. In the ladybug population, the spot color of the yellow ladybug was controlled by two alleles. The black spot (B) is dominant over the red spot (b). In a population of 600 ladybugs, the following data is recorded.

Phenotypes	Genotypes	Number of individuals
Black spot ladybugs	BB	350
Black spot ladybugs	Bb	130
Red spot ladybugs	bb	120

TABLE 2

a) Find the gene pool size for the spot color of the ladybug population. [1 *mark*]

600 x 2 =1200

b) Calculate the frequency of dominant allele, B. [1 *mark*]

Frequency of dominant allele:
[(350 x2) + 130] / 1200
= 830/1200
= 0.69

1 mark

c) Calculate the frequency of recessive allele, b. [1 *mark*]

Frequency of recessive allele:
[(120 x2) + 130] / 1200
= 370/1200
= 0.31

1 mark

d) If the ladybugs were left to breed randomly and the population remained in equilibrium, how many individuals are expected to be heterozygous in the next generation of 1500 ladybugs? [3 *marks*]

The expected frequency of heterozygous in the next generation; 2pq
Frequency of heterozygous, 2pq = 2 (0.69)(0.31)
= 0.428 ***1 mark***
Number of heterozygous = 2pq x total individuals = 0.428 x 1500 ***….. 1 mark***
= 642 ladybugs ***….. 1 mark***

4. a) **FIGURE 2** shows protein synthesis flow in a eukaryotic cell.

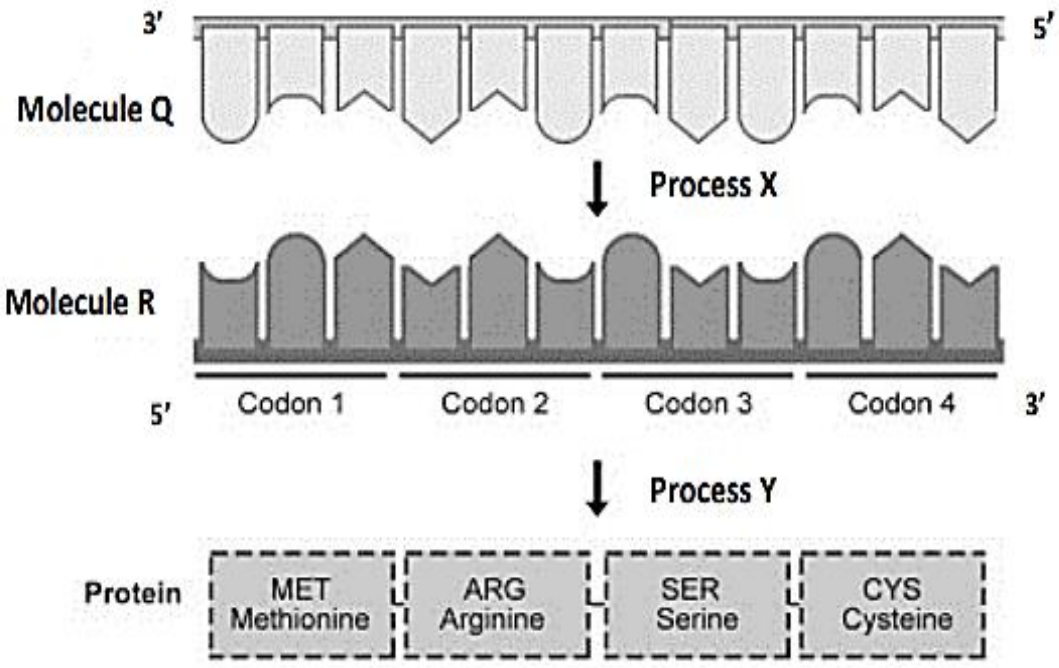


FIGURE 2

i. Name process **X** and **Y**. [2 *marks*]

Process X: Transcription
Process Y: Translation

ii. What is the base sequence of the Codon 1? [1 *mark*]

5' AUG 3'

iii. What is the anticodon sequence for 4(a)(ii)? [1 *mark*]

3' UAC 5'

iv. What happens if enzyme that invoved in process **X** is mutated and cannot perform its function? [1 *mark*]

R / mRNA will not produced // transcription will not occur // Q cannot be transcribed

v. Explain the formation of the initiation complex in process **Y**. [3 *marks*]

- **Small ribosomal subunit binds to 5' end of mRNA**
- **Initiator tRNA with anticodon 3' UAC 5' which carries amino acid methionine, binds to the start codon / 5'AUG 3' / codon 1**
- **Followed by the attachment of large ribosomal subunit**
- **Initiator tRNA is in the P site of ribosome and the empty A site is ready for the next aminoacyl-tRNA**

Any 3 points

b) **FIGURE 3** shows an operon model proposed by Jacob and Monod.

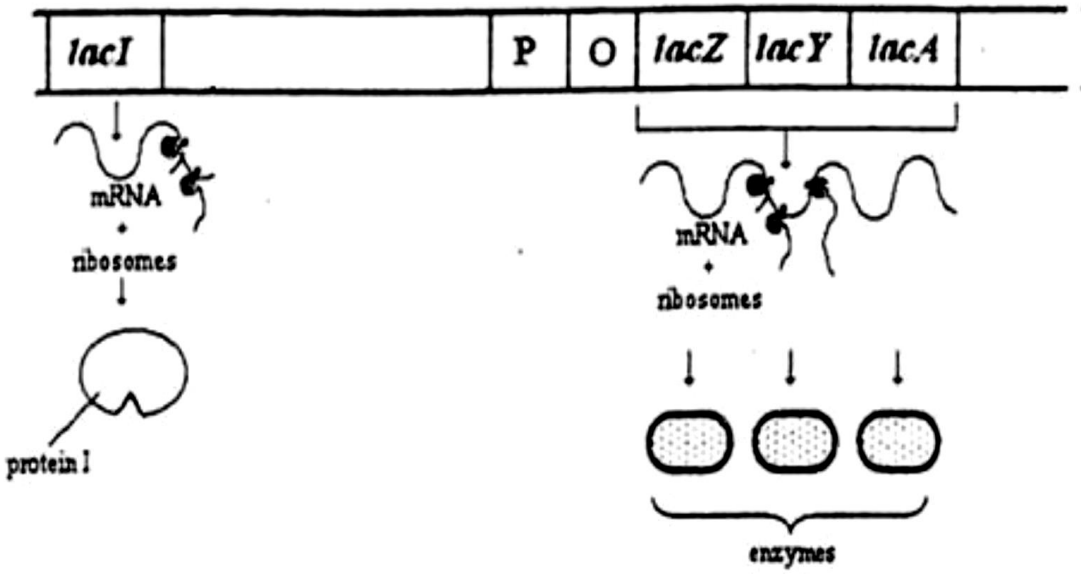


FIGURE 3

i. What is the function of **P** and ***lacZ***? [2 *marks*]

P : Binding site for RNA polymerase
***lacZ* : Encodes for β-galactosidase**

ii. Mutation can disrupt the normal regulatory mechanism of an operon. What will happen when the regulatory gene, ***lacI*** is mutated by radiation? [3 *marks*]

- **Produce non-functional protein I /repressor protein.**
- **No protein I/ repressor protein binds to the operator.**

- **RNA polymerase can bind to the promoter.**
- **In the presence or absence of lactose, structural genes are continuously transcribed /all enzymes are continuously produced.**

Any 3 points

iii. What is the effect of deficiency of enzyme encoded by ***lacY*** in lactose metabolism?

[1 *mark*]

- **Less lactose enters the cell // permeability of cell towards lactose decrease**
- **Lactose metabolism is reduce / low**

5. a) **FIGURE 4(a)** shows a segment of a normal DNA. Sequence **M** are the result of point mutation from normal DNA.

3'- G G C T A A C C G A T G G T A - 5'

Normal DNA

3'- G G C T A A C G G A T G G T A - 5

M

FIGURE 4(a)

i. By using genetic code table in **FIGURE 4(b),** what is the amino acid sequence for **M**. [1 *mark*]

UUU, UUC: Phe UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr UAA, UAG: Stop	UGU, UGC: Cys UGA: Stop UGG: Trp
CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg
AUU, AUC, AUA: Ile AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn AAA, AAG: Lys	AGU, AGC: Ser AGA, AGG: Arg
GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly

FIGURE 4(b)

Pro – Ile – Ala – Tyr – His

ii. Describe the effect of mutation occur in **M**. [2 *marks*]

- **Missense mutation**
- **A pair of nucleotide is replaced with another pair of nucleotide result in changes of one amino acid in polypeptide chain.**

b) **FIGURE 5** shows a karyotype of an individual suffering from a genetic disorder.

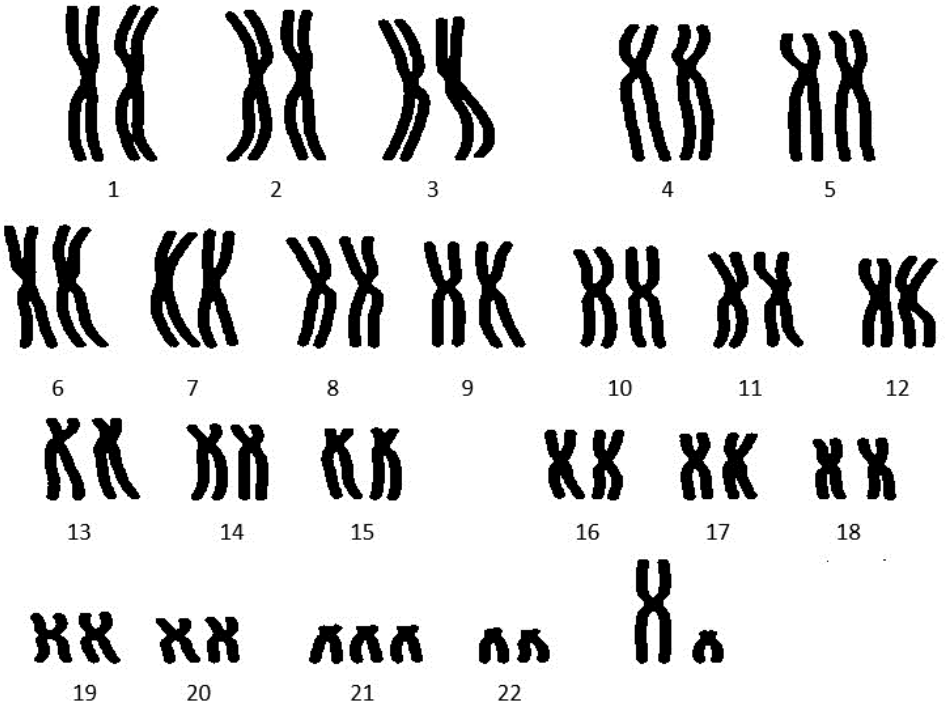


FIGURE 5

i. Based on **FIGURE 5**, name the disorder caused by the mutation? [1 *mark*]

Trisomy 21/ Down Syndrome

ii. How mutation in **FIGURE 5** arise? [3 *marks*]

- **Due to nondisjunction of chromosome 21 during meiosis I or meiosis II // anaphase 1 or anaphase II**
- **Results in the formation of abnormal gamete with extra one chromosome 21.**
- **Fertilization between normal /n gamete and abnormal/ n+1 gamete**
- **forming abormal zygote with 47 chromosomes/extra one chromosome 21/ 2n+1**

Any 3 points

c) **FIGURE 6** shows a karyotype of an individual suffering from a genetic disorder due to chromosomal aberration.

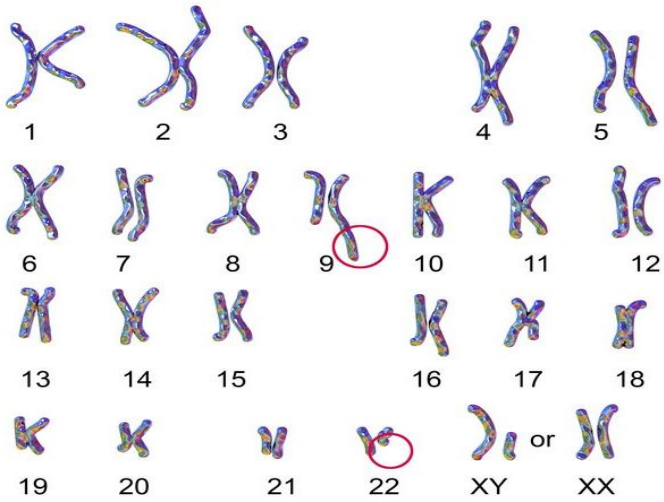


FIGURE 6

i. Name the genetic disorder shown in **FIGURE 6**. [1 *mark*]

Chronic Myelogenous Leukemia

ii. Identify the chromosomal aberration that leads to this genetic disorder. [1 *mark*]

Reciprocal translocation

iii. Explain the event in chromosomal aberration that leads to this disorder. [2 *marks*]

- **Segment of chromosomes number 9 and 22 breaks**
- **Exchange between the two non-homologous chromosomes.**

6. a) **FIGURE 7** shows steps in Polymerase Chain Reaction.

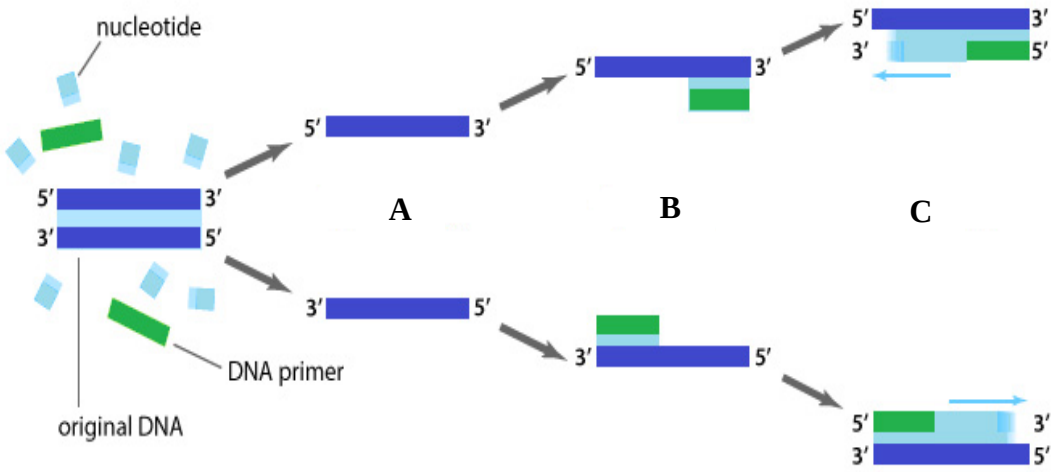


FIGURE 7

i. Identify step **A** and **B**. [2 *marks*]

A : Denaturation / Separation of double stranded DNA
B : Annealing of DNA Primer

ii. Describe the event that occur in stage **C**. [1 *mark*]
Strand elongation by DNA primer extension // Add free DNA nucleotide at 3' end DNA primer catalyze by *Taq* polymerase.

b) **FIGURE 8** shows part of general method in gene cloning.

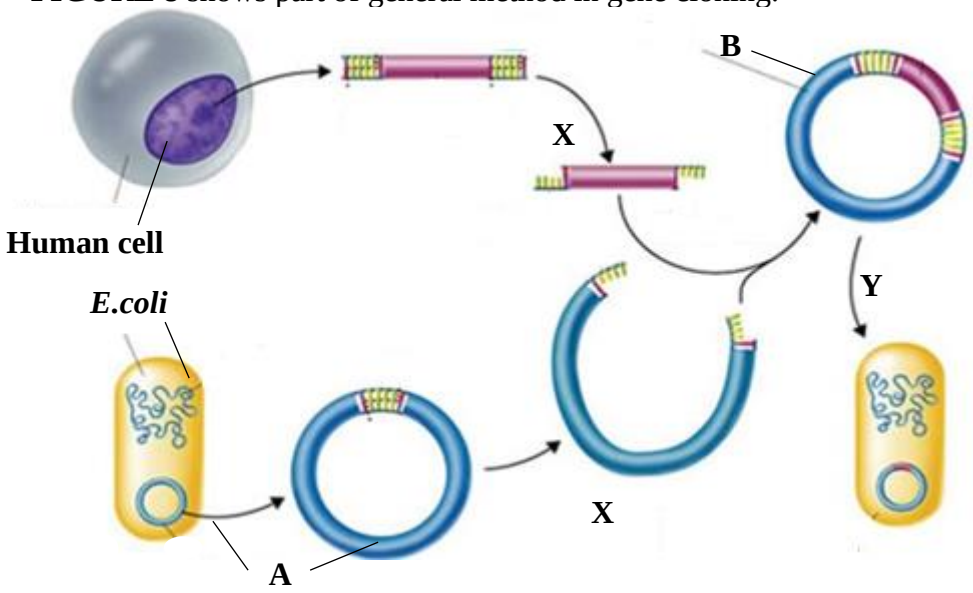


FIGURE 8

i. Give **TWO** characteristics of **A** as a cloning vector. [2 *marks*]

- **Able to accept foreign DNA in multiple cloning site (MCS)**
- **Able to replicate freely / independently in host cell**
- **Possess selectable genetic marker**
- **Able to express or amplify the cloned gene under suitable condition**

Any 2 points

ii. Explain the characteristics of ***E. coli*** as host cell. [2 *marks*]

- **Able to accept / receive the recombinant DNA through transformation.**
- **Able to maintain the recombinant DNA from one generation to another**
- **Able to amplify the gene product from the recombinant DNA**
- **Able to express gene of interest within recombinant DNA**

Any 2 points

iii. Name the structures label **B** and process **Y**. [2 *marks*]

Structure B : Recombinant DNA/ plasmid
Process Y : Transformation

iv. State the role of the enzyme **X**. [1 *mark*]
Recognize and cut DNA at restriction site.

v. Describe how structure **B** are formed. [3 *marks*]

- **Both plasmid and foreign DNA are cut using the same restriction enzyme to produce complementary / compatible sticky ends.**
- **Plasmid and DNA fragment are mixed to allow the formation of hydrogen bonds between the compatible /complementary sticky ends of both DNA molecules**
- **DNA ligase catalyze the joining of plasmid and DNA fragment by phosphodiester bond formation.**

7. a) **FIGURE 9** shows a process of spermatogenesis in human.

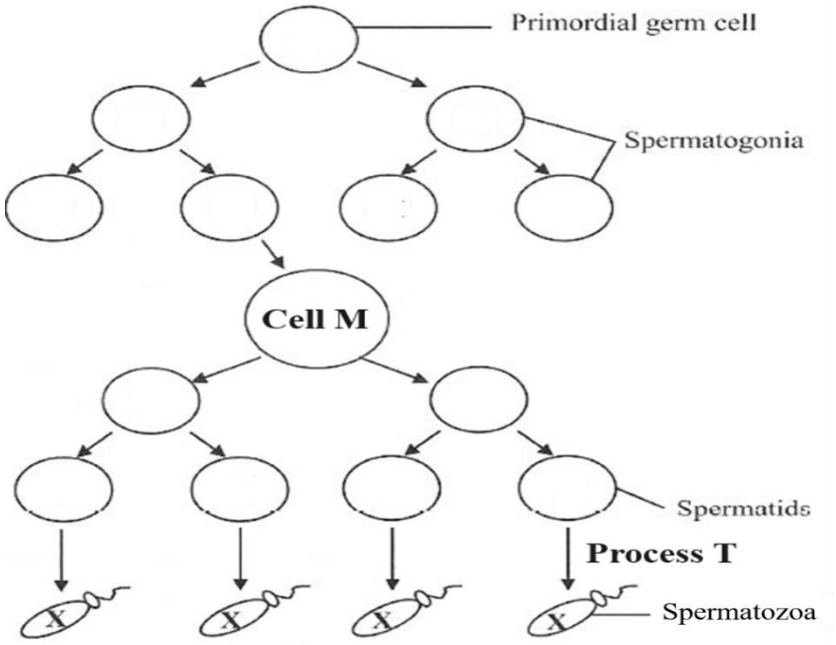


FIGURE 9

i. Name cell **M**. [1 *mark*]
Primary spermatocyte

ii. Describe the effects of process **T** if Sertoli cell is absent in seminiferous tubule? [2 *marks*]

- **Lack / no production of (mature) sperm / spermatozoa // no spermiogenesis // Incomplete spermatogenesis**
- **due to lack of nutrients for development of spermatids into (mature) sperm /spermatozoa.**

b) **FIGURE 10** shows the changes of hormone level in the reproductive cycle of a woman.

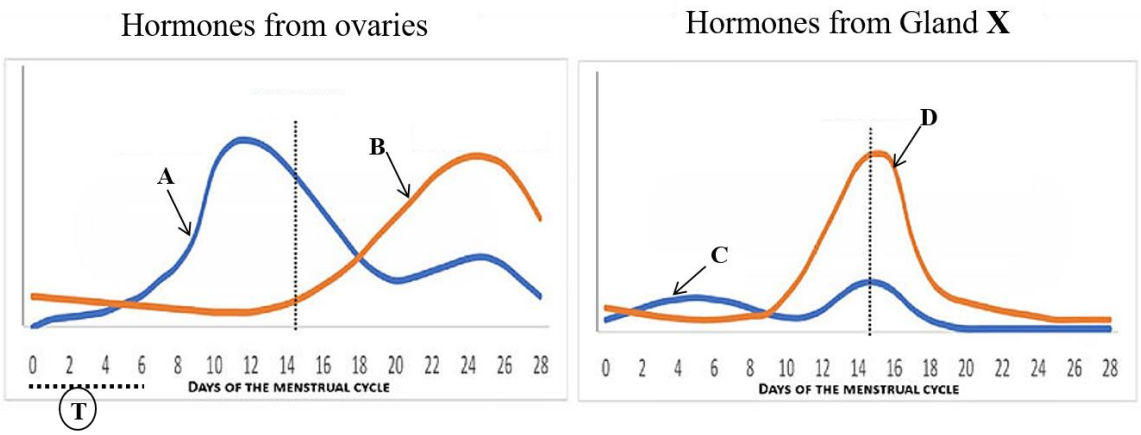


FIGURE 10

i. Name the hormones labelled **A** and **B**. [2 *marks*]

A: **Estrogen**
B: **Progesterone**

ii. What is the function of the hormones secreted by gland **X**? [2 *marks*]

- **Hormone C / Follicle stimulating hormone / FSH stimulates the development of follicles (in ovary)**
- **Hormone D / Luteinizing hormone / LH stimulates ovulation // stimulate transformation of ruptured Graafian follicle into corpus luteum.**

iii. Identify phase **T** which occurs in menstrual cycle. [1 *mark*]

Menstrual flow phase

iv. Explain the event that occur after phase **T** in menstrual cycle. [1 *mark*]

Estrogen stimulates repairing and development/thickening of endometrium.

v. Explain the effect of high peak of hormone **D** to the event occur in ovarian cycle. [3 *marks*]

- **Stimulate final maturation of follicle.**
- **Stimulate ovulation // Graafian follicle and adjacent wall of ovary to rupture releasing secondary oocyte into fallopian tube.**
- **Stimulate transformation of ruptured follicle into corpus luteum.**

c) **FIGURE 11** below shows different concentration of different hormones during pregnancy.

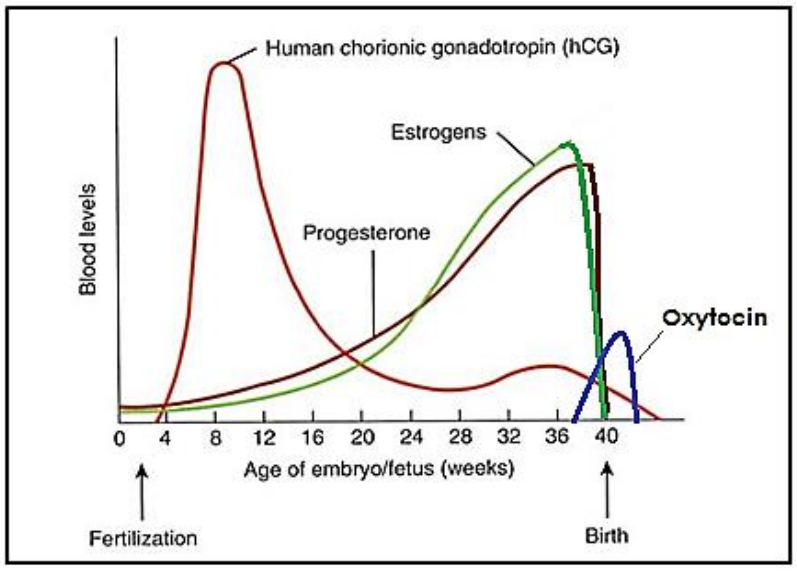


FIGURE 11

i. Explain the effects if hCG failed to be secreted during the first trimester. [2 *marks*]

- **Corpus luteum disintegrates**
- **Progesterone and estrogen level drop**
- **Resulting in miscarriage.**

Any 2 points

ii. Describe **TWO** roles of oxytocin during parturition. [2 *marks*]

- **Oxytocin stimulates uterus contraction/ powerful contraction on smooth muscle of uterus.**
- **Oxytocin stimulates placenta to secrete prostaglandins**