1. **FIGURE 1** shows the stages in cell division.

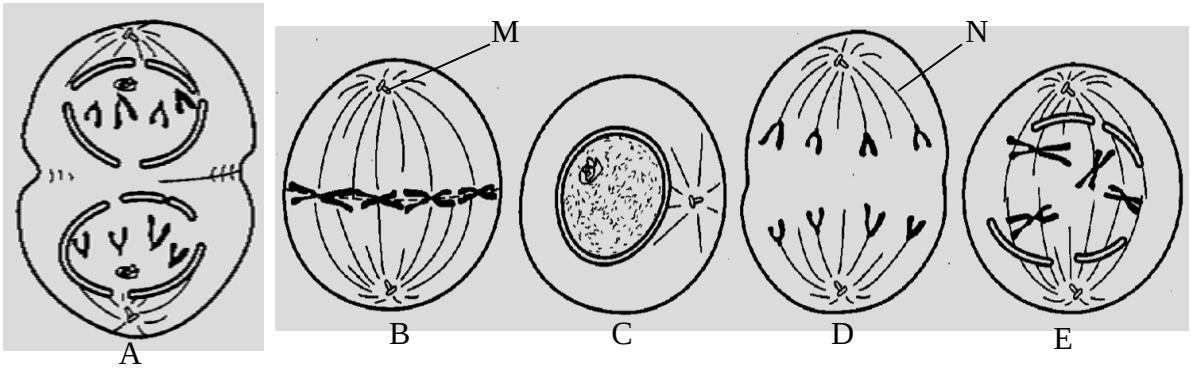


FIGURE 1

a) Name the structure **M** and **N**. [2 marks]

M : **(Pair of) centriole**

N : **Spindle fibers/apparatus**

b) Arrange the correct sequence of stage **A** to **E** beginning the earliest stage. [1 mark]

C,E,B,D,A

c) Briefly explain the difference between stage **D** and anaphase I. [2 marks]

In stage D sister chromatids separate and daughter chromosome move to the opposite pole while in anaphase I homologous chromosome separate and sister chromatids move to the opposite pole.

In stage D, centromere split/ divide while in anaphase I centromere do not split/divide.

d) The chromosome number of *Drosophila* sp. is 8.

(i) How many chromosome does the *Drosophila* sp. inherit from each parent? [1 mark]

4/four

(ii) How many chromosome found in gamete of *Drosophila* sp.? [1 mark]

4/four

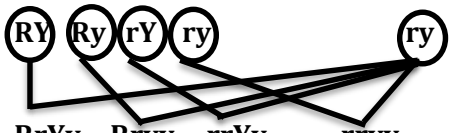
2. A dihybrid cross between two pea plants with phenotype round seeds and yellow colour but unknown genotype was cross with pea plant of double recessive genotype for wrinkled seed and green colour where R represents the gene for round seeds and Y represents the gene for yellow colour. The cross produced the following results:

72 plant with round and yellow seed
75 plant with round and green seed
78 plants with wrinkled and yellow seed
81 plants with wrinkled and green seed

a) Using the symbols given, draw a genetic diagram to explain this cross. [3 marks]

P : RrYy x rryy **1m**

G : **RY Ry rY ry** **ry** **1m**



F_1 genotype: RrYy Rryy rrYy rryy **1m**
F_1 Phenotype: round round wrinkled wrinkled
yellow green yellow green

b) State how can many possible alleles combination produced in dihybrid inheritance? [1 mark]

Independent assortment

c) Suggest the two parental genotype that can produce only round and green plant. [2 mark]

RRyy x RRyy
RRyy x Rryy

d) If the gene is linked without crossing over, what is the expected number of individuals of each phenotype in F_1 generation? [1 mark]

306/2 = 153

e) A test cross is a genetic cross used to determine the genotype of an individual showing a dominant phenotype. Explain the determination of genotype in dominant round (R) and yellow (Y) seed in garden pea plant (*Pisum sativum*) using test cross. [6 marks]

(The purpose of test cross is to) determine/predicting whether the dominant phenotype individual is a homozygous dominant genotype or a heterozygous genotype // whether the dominant phenotype individual have genotype of RRYY or RrYy. **---- 1m**

The dominant phenotype individual/with round and yellow seed is crossed with a homozygous recessive individual /rryy.

---- 1m

If all the offspring exhibit the dominant phenotype (with round and yellow seed), therefore the dominant phenotype parent is likely homozygous dominant /RRYY genotype. ---- 1m

Because the homozygous dominant individual only produces one type of gamete RY //Gamete RY fertilize with gamete ry from homozygous recessive parent // Gamete RY will fertilize with gamete ry and produce all progeny with dominant phenotype. ---- 1m

If the F1 progeny shows (four different phenotypes) which are round with smooth seed, round with yellow seed, wrinkled with yellow seed and wrinkled with green seed, therefore the dominant individual is likely heterozygous /RrYy.

---- 1m

Because the heterozygous parent produces four type of gametes RY, Ry, Ry and ry // Gametes RY, Ry, Ry and ry fertilize with gamete ry from homozygous recessive parent // All types of gametes fertilize with gamete ry from homozygous recessive parent and produce progeny four different phenotype.

---- 1m

3. In population, the ability of tongue rolling is controlled by dominant allele T. 56% of individual in that population are able to roll their tongue.

i) What is the frequency of **T** allele in population? [2 marks]

q^2 = 44/100

q = 0.663

p+q = 1
p = 0.337

ii) What is the frequency and amount of individual with TT, Tt and tt genotypes if the population consists of 500 people. [3 marks]

Frequency and amount TT, Tt and tt in 500 people:

TT (p^2) = (0.337)2 = 0.114 so amount 0.114 X 500 = 57 people

Tt (2pq) = 2 (0.337) (0.663) = 0.446 so amount 0.446 X 500 = 223 people

tt (q^2) = (0.663)2 = 0.440 so amount 0.440X 500 = 220 people

iii) If all non-rolling tongue individual are killed, what is the frequency of non-rolling tongue individual in the next generation. [2 marks]

New gene pool
= 2 [57 (TT) + 114 (Tt)] + 114 (Tt)
= 560

	No of individual			No of allele T	No of allele t
TT	**57**	**114**	**-**		
Tt	**223**	**223**	**223**		
tt	**-**	**-**	**-**		
TOTAL NEW ALLELE				**337**	**223**

Frequency of allele t (q) = 223/560
= 0.398

Frequency of non-rolling tongue, q^2 = (0.398)2
= 0.158

4. **FIGURE 2** shows the process of protein synthesis in animal cell.

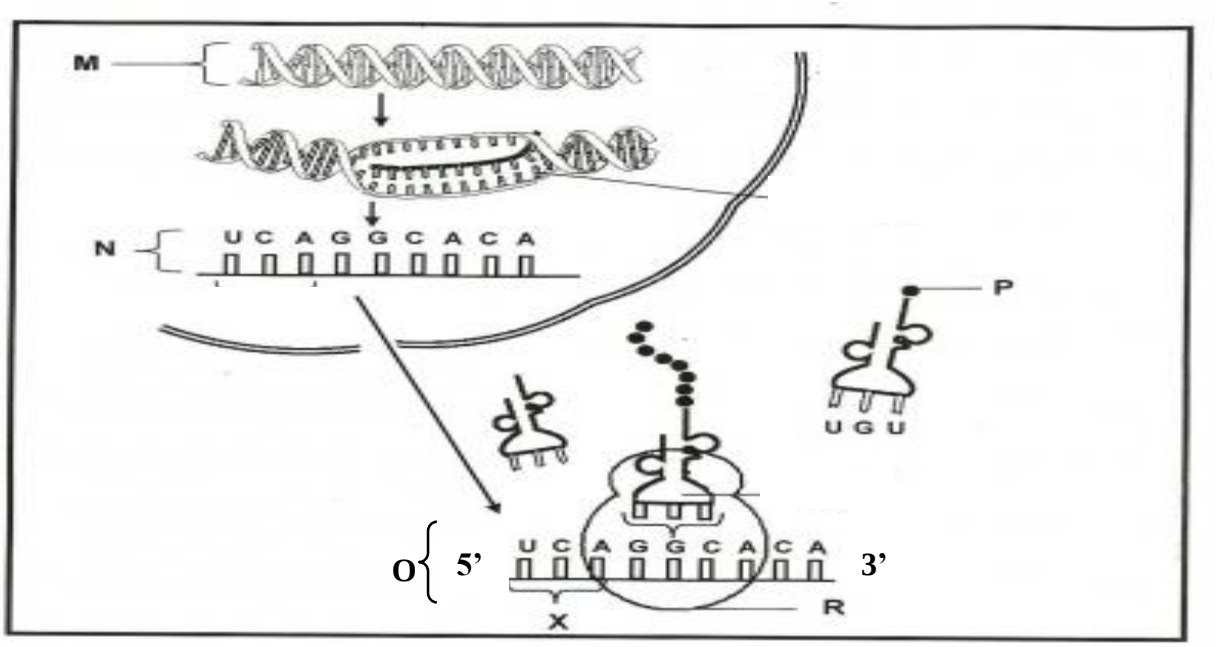


FIGURE 2

a) What is the anticodon sequence for **X**? [1 mark]

3' AGU 5'

b) State the enzyme that catalyses the binding of **P**? [1 mark]

Aminoacyl-tRNA synthetase

c) Give **ONE** reason why **M** is not used directly by **R** for synthesis of protein. [1 mark]

Less chance damage of DNA
Transcription

d) Briefly describe what happen to **N** before enter cytoplasm. [4 marks]

N Undergo RNA processing
Addition of 5' cap to the 5'end and addition of poly-A tail to 3'end undergo RNA splicing by removed intron and exon joined together involve spliceosome.

e) Explain the mechanism of the *lac* operon when someone drinks cow milk. [7 marks]

Suggested answer	Mark
1. Lactose is present in cow milk, causes some lactose is converted into allolactose (an isomer of lactose).	**1**
2. Allolactose binds to *lac* repressor and alters its shape causes *lac* repressor to be inactive.	**1**
3. so the *lac* repressor cannot bind to the *lac* operator.	**1**
4. *lac* operon switch on.	**1**
5. RNA polymerase binds to *lac* promoter.	**1**
6. Structural genes of *lac* operon are transcribed into mRNA.	**1**
7. *lacZ* codes for β–galactosidase to hydrolyze lactose into glucose and galactose	**1**
***8.* *lacY* codes for permease to transport lactose into the cell and**	**1**
***9.* *lacA* codes for transacetylase to detoxify other molecules entering the cell via the permease / transfer an acetyl group from acetyl CoA to β-galactosidase**	**1**

5. **FIGURE 3** shows a karyotype of an individual.

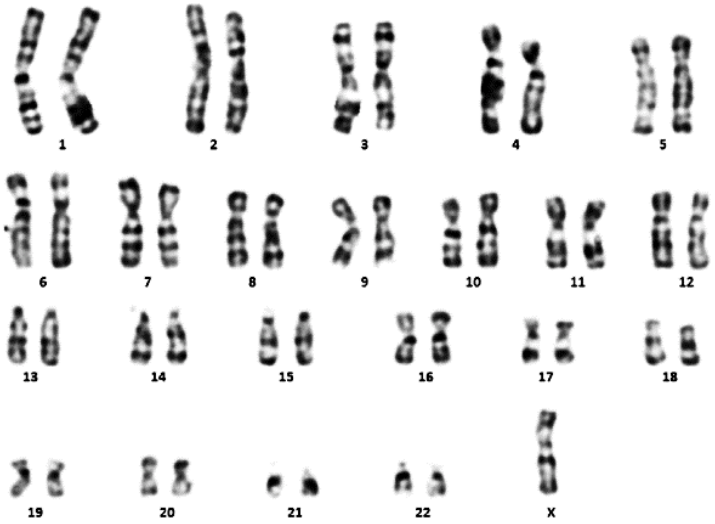


FIGURE 3

a) State the type of chromosomal mutation shown in **FIGURE 3.** [1 mark]

Chromosomal number alteration // changes in chromosomal number

b) i) Name the genetic disorder shown in **FIGURE 3**. [1 mark]

Turner syndrome

ii) Give a reason for your answer in b (i). [1 mark]

Only one X chromosome present in chromosome number 23

iii) Briefly describe how the genetic disease shown in **FIGURE 3** may be produced if the mutation occurs in the mother during meiosis II of oogenesis. [2 marks]

- **During oogenesis, sister chromatids for X chromosome fail to move apart properly / separate and move to opposite poles during anaphase II, thus producing abnormal female gamete / ovum with XX chromosome / extra X chromosome (22+XX), ovum without X chromosome (22+O) and normal ovum (22+X).**
- **When the normal male gamete / sperm with X chromosome (22+X) fertilizes with abnormal ovum without X chromosome (22+O), an aneuploid zygote with XO chromosome (44+XO) is produced which called Turner syndrome.**

c) If individual with karyotype above get married, what are the probability for this couple to have offspring with the same genetic disease? [1 mark]

0%

d) Philadelphia chromosome is produced due to reciprocal translocation between chromosome number 22 and chromosome number 9. Briefly explain how this mutation occurs and its effect. [5 marks]

Answer	Marks
• **Large portion of chromosome 22 breakoff**	**1**
• **Small fragment at a tip of Chromosome 9 breakoff**	**1**
• **Both chromosomes exchange their fragments**	**1**
• **Produced shortened chromosome 22 (Philadelphia chromosome)**	**1**
	Any 3
• **This will lead to uncontrolled white blood cell division // uncontrolled cell cycle progression**	**1 or**
• **This promotes cancer**	**1**
• **The diseases is Chronic Myelogenous Leukemia**	**1**

6. **FIGURE 4** shows the initial process of insulin production using gene technology.

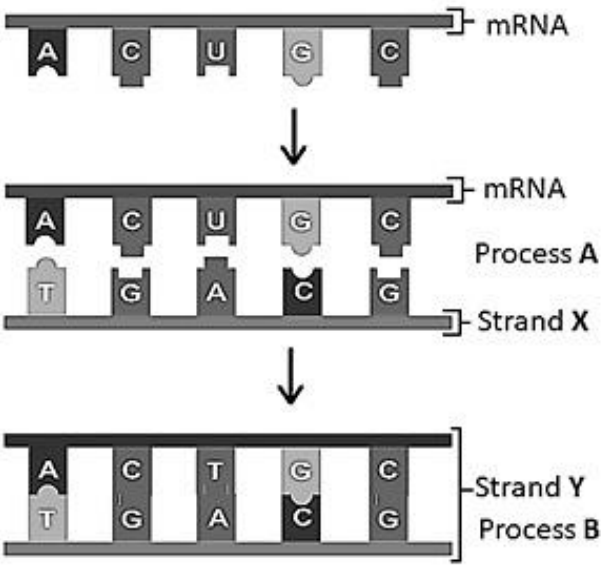


FIGURE 4

(a) State the source of mRNA used for insulin production. [1 mark]

Pancreatic cells// β-cell of pancreas

(b) State the enzymes that are involved in process **A** and process **B**. State their function. [2 marks]

	Enzyme	Function
Process **A**	**Reverse transcriptase**	**to synthesize the first DNA strand (using mRNA as the template)**
Process **B**	**DNA polymerase**	**to synthesize the double/ second strand of cDNA (using first DNA strand as template)**

(c) What is stand **Y**? State the benefit of strand **Y** compared to mRNA. [2 marks]
cDNA

cDNA carries complete coding sequence/ exons of the gene without introns

(d) State the consequence if human insulin cannot be produced using gene technology. [2 marks]
Must use insulin from other source like animals that may cause allergic

Patients must pay high price for diabetic treatment

(e) Briefly describe the steps involved in Polymerase Chain Reaction (PCR). [6 marks]

Answer	Mark
Denaturation/ separation of double stranded DNA	**1**
By heating at high temperature / 94 – 98 C	**1**
Annealing of the primer to the target region/ sequence/ single stranded/ denatured DNA/ template	**1**
By cooling/ lowering the temperature to 50 – 65 C	**1**
Primer extension to produce complementary DNA strand	**1**
Catalyzed by (heat stable) *Taq* polymerase	**1**
The cycle is repeated many times/ 30 to 40 times	**1**
To amplify / multiple/ many copies identical DNA molecules	**1**
TOTAL	**8**
MAXIMUM	**6**

7. (a) **FIGURE 5A** shows a secondary oocyte in fallopian tube.

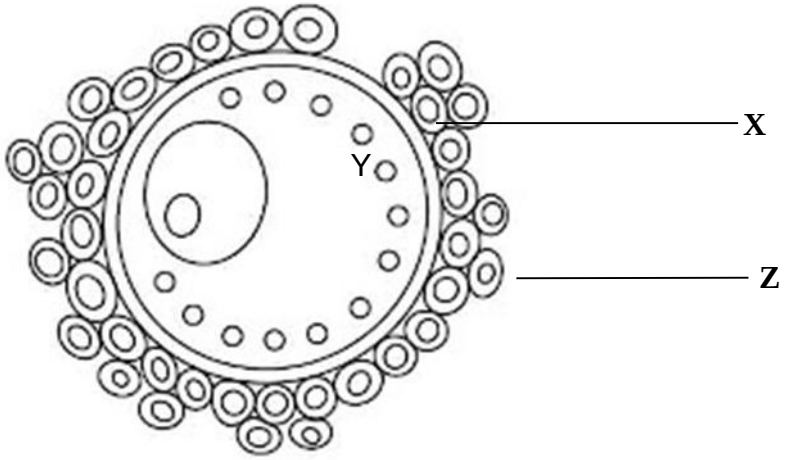


FIGURE 5A

(i) State structure **X** and cell **Z**. [2 marks]

Zona pellucida
Corona radiata

(ii) Briefly explain what happen to structure **Y** once the secondary oocyte is fertilized. [2 marks]

Structure Y/Corticol granules release lysosomal enzyme by exocytosis and alters sperm receptor
Other sperm cannot penetrate the secondary oocytes

(iii) What happen if there is no functional enzymes in granule **Y**? [1 mark]

Polyspermy occurs

(b) **FIGURE 5B** shows hormonal control during parturition.

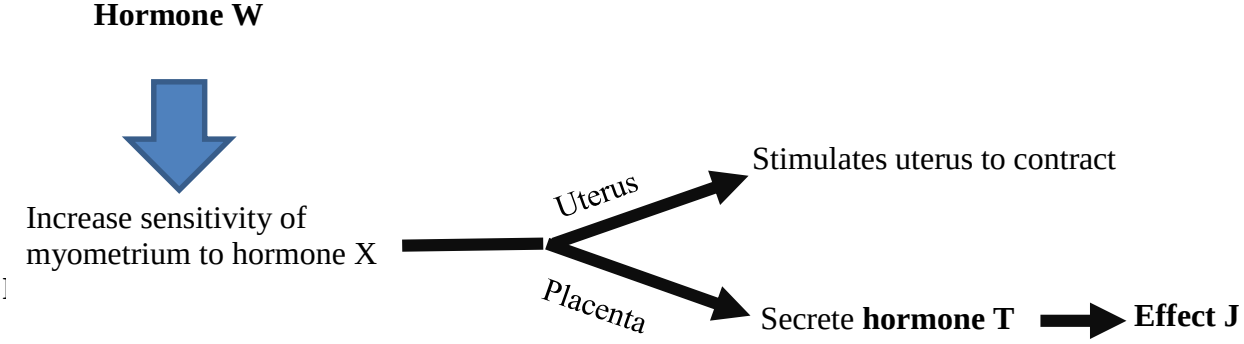


FIGURE 5B

(i) Name hormone **W** [1 mark]

Estrogen

(ii) During parturition, the mother is in emotional and physical stress and hormone **T** secreted. State hormone **T** and Effect **J**. [2 marks]

Hormone T –Prostaglandin
Effect J: Stimulate more vigorous contraction of uterus

c) Describe the structure of secondary oocyte. [6 marks]

Size around 100 - 120 µm diameter.
Consists of plasma membrane, cytoplasm, and nucleus.
The haploid nuclei (arrested at metaphase II) sits inside a cell with a large volume of cytoplasm.
The secondary oocyte is produced along with the first polar body as a result of the first meiotic division.
There are cortical granules just beneath the plasma membrane that serves a critical function during fertilisation (contain enzyme that prevent polyspermy during fertilisation).
Secondary oocyte cover by a thick glycoprotein shell called the zona pellucida (jelly-like coat).
First polar body is located in zona pellucida.
Around the outside are the follicular cells called corona radiata.
Corona radiata is made up of the granulosa cells of the follicle.
Cells of corona radiate protect the secondary oocyte as it passes through the ruptured follicular wall.

(any 6)

d) **FIGURE 6** below shows human growth curve. Describe the difference in growth between male and female during phase **C**. [2 marks]

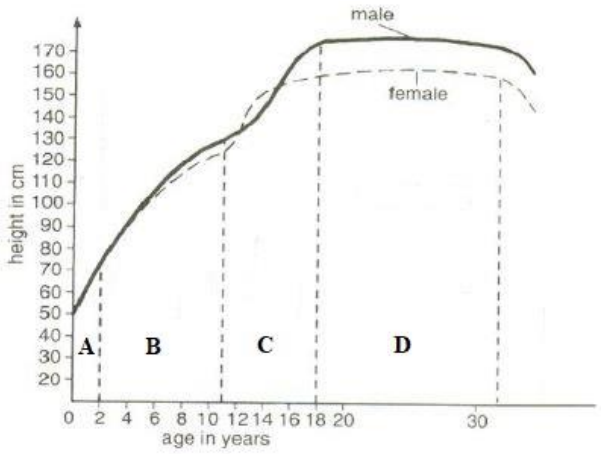


FIGURE 6

Starting at age 12, female has more rapid growth rate because female reach puberty earlier than male
Later, male growth rate increases and becomes higher than female

END OF QUESTION