THE UNITED REPUBLIC OF TANZANIA
PRESIDENT'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

FORM SIX-EXAMINATION MARKING GUIDE

CODE: 133/2 BIOLOGY 2 February 2025

1. (a) Introduction

Adaptation of yeast to their mode of life

- They store carbohydrates in the form of glycogen
- They have permeable cell walls to allow entry of nutrients that are obtained from extracellular digestion
- They secrete extracellular enzymes such as sucrase, proteases, and cellulase for digestion
- They have a high reproduction rate through budding to produce new cells hence increasing in number
- Spores can remain dormant in unfavourable conditions to ensure their survival
- Some saccharomyces are facultative. They can respire aerobically which ensures their survival

Any 4 points @ 1 mark = 04 marks

(b) Viruses pose a problem in identification among biologists because they have both living and non-living characteristics.

Introduction

Characteristics of viruses as living things

- They possess genetic material either DNA or RNA
- They can replicate only inside a living cell. Therefore, all viruses are obligate endoparasites
- They can mutate
- They penetrate through a host cell with the help of enzymes derived from the protein cost on the surface of the membrane of the host cell
- They show specificity to hosts and they can infect the host cell and take over the genetic machinery of the host cell.

Any 4 points @ 2 marks = 08 marks

Characteristics of viruses as non-living things

- They are non-cellular structures i.e. do not have membranes or any cell organelles
- They possess either DNA or RNA but not both
- They do not carry out metabolic reactions on their own – require the organelles and enzymes of a host to carry out such reactions.
- They do not have a life of their own i.e. they depend on the host cells for reproduction
- They exist in a dormant state outside of the living cells (hosts)
- They are resistant to very high temperatures due to a lack of enzymes
- Don't respond to external stimuli

- They are filterable; therefore, they can pass through a bacteria-proof filter paper

Any 4 points @ 2 marks = 08 marks

Total = 20 marks

2. (a) The Law of Independent Assortment states that; " two pairs of contrasting characteristics of living organisms are controlled by a pair factors/genes/alleles and during the formation of gamete in each sex, either one of a pair of alleles may combine randomly with either of another pair"

OR

" in a dihybrid cross, the factors responsible for the two pairs of contrasting characters stay together in the F1 generation, but assort independently during the formation of gametes"

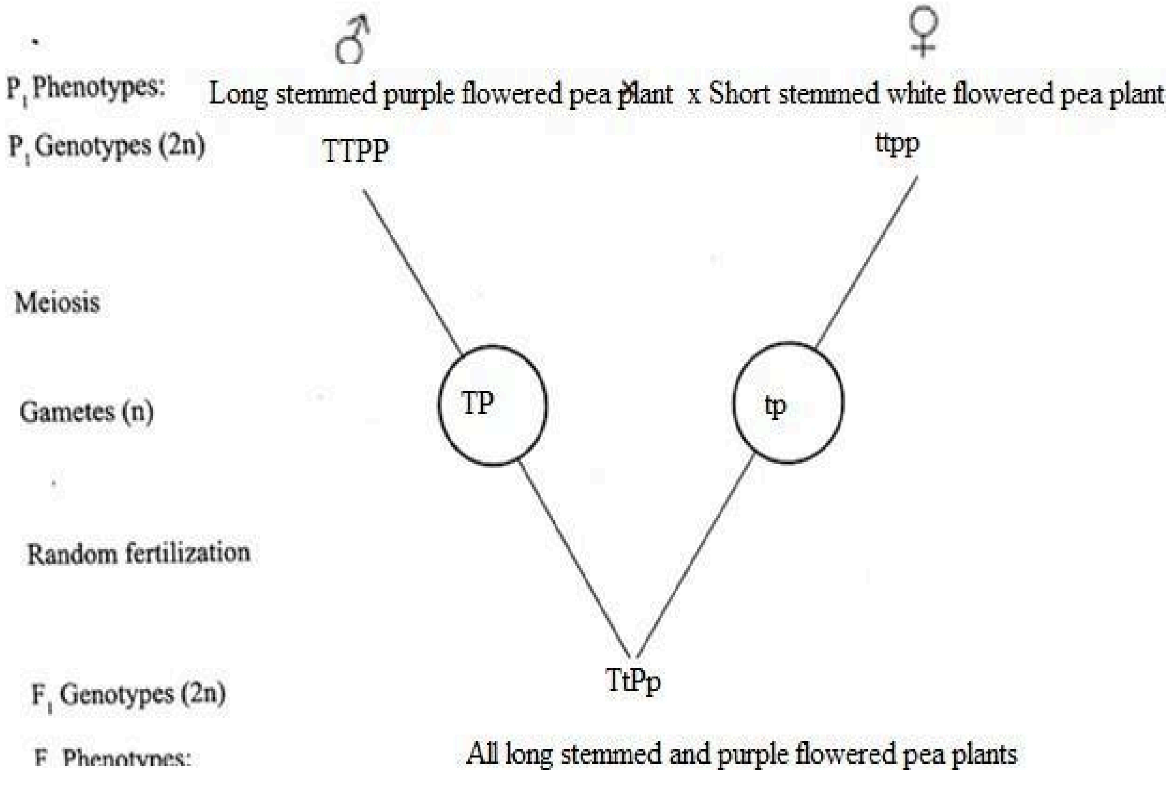
b) (i) Let

T – an allele for long-stemmed plant t – an allele for short-stemmed plant
P – an allele for purple-coloured flowers p – an allele for white-coloured flowers
T and P are dominant over t and p respectively

@ ½ marks = 03 marks

Illustration

A genetic cross between a pure long-stemmed and purple-flowered pea plant with a pure short-white pea plant



@ ½ marks = 02 marks

Selfing F1

	♂		♀
P_2 Phenotypes:	Long stemmed purple flowered	x	Long stemmed pruple flowered
P_2 Genotypes (2n)	TtPp	x	TtPp
Meiosis	↓		↓
Gametes (n)	TP Tp tP tp	x	TP Tp tP tp

@ ½ marks = 01½ marks

A punnet showing a cross between white fruits and yellow fruits

	♀ gamete			
♂ -gametes	TP	Tp	tP	tp
TP	TTPP Tall and purple	TTPp Tall and purple	TtPP Tall and purple	TtPp Tall and purple
Tp	TTPp Tall and purple	TTpp Tall and white	TtPp Tall and purple	Ttpp Tall and white
tP	TtPP Tall and purple	TtPp Tall and purple	ttPP Short and purple	ttPp Short and purple
tp	TtPp Tall and purple	Ttpp Tall and white	ttPp Short and purple	ttpp Short and white

@ ½ marks = 08 marks

Results in F2 generation

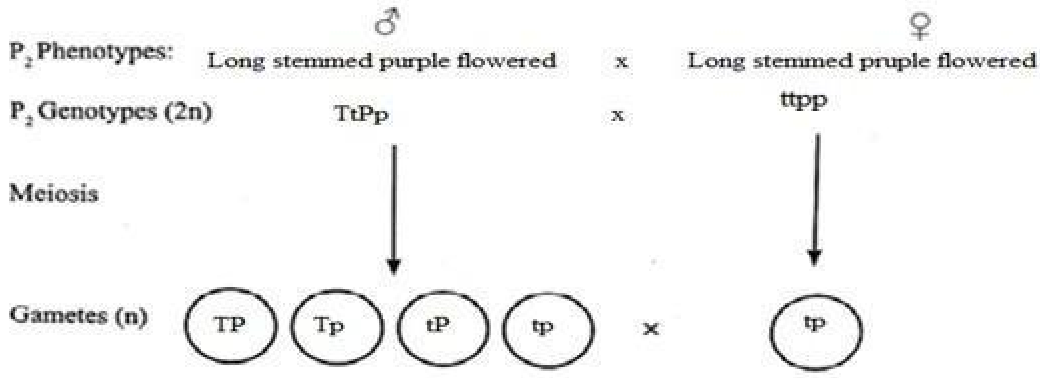
Phenotypes

Tall and purple flowered plants = 9
Tall and white flowered plants = 3

Short and purple flowered plants = 3
Short and purple flowered plants = 1

@ ½ marks = 02 marks

(ii) The test done was back cross Illustration



01 mark

A punnet square showing genetic cross between an F_1 and a homozygous recessive parent

	♀ gamete			
♂ -gametes	TP	Tp	tP	tp
tp	TtPp Long and purple	Ttpp Long and white	ttPp Short and purple	ttpp Short and white

@ ¼ mark = 01 mark
Total = 20 marks

Results

Results in F_2 generation

Phenotypes

Tall and purple flowered plants = 1
Tall and white flowered plants = 1
Short and purple flowered plants = 1
Short and purple flowered plants = 1

3. (a) Describe any two biomes found in East and Central Africa siting, temperature, precipitation, location, fauna, and flora found.
   (b) About a third of the entire ecosystem was wiped out in the Amazon forest in 2021 after a wildfire outbreak, as a young biologist suggested six stages/phases for the stabilization of this ecosystem.

Answer

a) A biome is a large geographical area of distinctive plant and animal groups, which are adapted to that particular environment.

(i) Tropical rain forest

- o In Central Africa; the tropical rainforest biome is located around the belt at the equator in the Congo basin

Characteristics of tropical rainforest biome

i. The tropical rain forests have the highest annual rainfall, which exceeds 2000 to 2250 mm, and are generally evenly distributed throughout the year.

ii. It is characterized by temperature, ranging between 20^0C and 38^0C and the humidity is relatively high throughout the year.

iii. It consists of tall trees which form canopies that block sunlight from reaching the ground. The various trees of the tropical rain forests are closely spaced together and form a thick continuous canopy some 25 to 35 metres tall.

iv. Tropical rainforests have the highest biodiversity compared to other biomes in the world. For example, one square kilometer may contain as many as 100 different tree species as compared to 3 or 4 in the temperate zone.

(ii) Savanna

Tropical grasslands are located near the equator, between the Tropic of Cancer and the Tropic of Capricorn. In East and Central it is found extending from Kenya, through Tanzania, Mozambique to South Africa.

Characteristics of the savanna biome

This biome is characterized by

i. Grassland with scattered open canopy trees and shrubs with extended dry periods or droughts

ii. The alternation between two distinct seasons, that is, the rainy and dry seasons - Savannas have two distinct seasons in regards to precipitation. Tropical savannas generally border rainforests and receive a yearly total of 40 to 60 inches of rainfall.

iii. There are large herds of grazing animals on the savanna that thrive on the abundance of grass and trees. Tropical grassland animals (which do not all occur in the same area) include **giraffes**, **zebras**, buffaloes, **kangaroos**, mice, moles, gophers, ground squirrels, **snakes**, worms, termites, beetles, **lions**, **leopards**, hyenas, and **elephants**. The world's greatest diversity of ungulates (hoofed mammals) is found in the savannas of Africa. The antelopes are especially diverse and include eland, impalas, gazelles, oryx, gerenuk, and kudu. Buffalo, wildebeest, plains zebra, **rhinos**, giraffes, elephants, and warthogs are among other herbivores of the African savanna. Carnivores include lions, leopards, cheetahs, jackals, wild dogs, and hyenas. Termites are especially abundant in the tropical grasslands of the world.

b)

Secondary succession

Secondary succession occurs when an area that was previously occupied by living things is disturbed, and then re-colonized following the disturbance that kills much or all of its community.

For example, secondary succession occurs in forests cleared by wildfire like what happened in the Amazon forest. Their nutrients, however, are returned to the ground in the form of ash. Since a disturbed area already has nutrient-rich soil, it can be recolonized much more quickly than the bare rock of primary succession.

Stages of secondary succession

Secondary succession in the Amazon forest.follows a fire and it involves the following stages of secondary succession are:-

i. Fires:
The initial stage involves a fire that destroys the existing vegetation, and many trees do not sprout in the aftermath.
ii. Fast-growing grasses develop:
After the fire, fast-growing grasses and other herbaceous plants are the first to develop in the cleared area.
iii. Grasses and shrubs develop:
Over time, the area sees the development of grasses, shrubs, and small trees, marking the progression of the ecosystem towards a more complex state.
iv. Grasses, shrubs, and small trees:
As grasses and similar species thrive over several years, they cause environmental changes that favor the growth of shrubs and small trees.
v. Tall trees emerging and increasing in number:
The ecosystem continues to evolve, and tall trees begin to emerge and increase in number. Shade-tolerant trees also develop in the understory.
vi. Mature trees with a dense canopy develop:
The final stage involves the development of mature trees with a dense canopy, resembling the original state of the ecosystem. This indicates the completion of the secondary succession process.

4. i) Show how the modern view of natural selection modifies the theory put forward by Charles Darwin.

Charles Darwin's original theory of natural selection, presented in *On the Origin of Species* (1859), emphasized the gradual process by which organisms with traits better suited to their environment survive and reproduce more successfully, leading to changes in populations over generations. While this framework remains foundational, the **modern synthesis** of evolutionary biology, which integrates Darwin's ideas with genetics and molecular biology, has significantly refined and expanded the original theory.

Below is an explanation of how the modern view of natural selection modifies Darwin's theory.

1. Integration of Genetics

- **Darwin's View:**
  Darwin did not know the mechanism by which traits were inherited. He speculated about "blending inheritance" and "pangenesis," which have since been disproven.
- **Modern View:**
  The discovery of **Mendelian genetics** provided a mechanism for inheritance, showing that traits are passed through discrete units (genes). The modern view incorporates mutations, genetic recombination, and allelic variation as sources of genetic diversity.
  - **Example:** Mutations in the **gene** affect fur color in rock pocket mice, allowing populations to adapt to light or dark environments.

2. Role of Mutations

- **Darwin's View:**
  Darwin recognized variation but could not explain its origin.
- **Modern View:**
  Mutations in DNA are now understood to be the ultimate source of genetic variation. These mutations may create new alleles, which, if beneficial, can be acted upon by natural selection.

- **Example:** Antibiotic resistance in bacteria often arises from mutations that provide a survival advantage in the presence of antibiotics.

3. Population Genetics

- **Darwin's View:**
  Darwin focused on individual organisms and their traits but did not address how entire populations evolve.
- **Modern View:**
  Evolution is now studied at the population level, emphasizing changes in **allele frequencies** over time due to natural selection, genetic drift, gene flow, and mutation. The **Hardy-Weinberg equilibrium** provides a mathematical framework for understanding these changes.
  - **Example:** The change in allele frequencies for sickle-cell anemia in regions with malaria demonstrates the influence of selection on populations.

4. Expanded Understanding of Selection Pressures

- **Darwin's View:**
  Darwin emphasized competition for resources and survival as the primary drivers of natural selection.
- **Modern View:**
  Modern biology recognizes a broader range of selection pressures, including:
  - **Sexual selection:** Traits that increase mating success may be favored even if they reduce survival.
    - Example: Peacock tails are costly to maintain but improve reproductive success.
  - **Kin selection and inclusive fitness:** Altruistic behaviors can evolve if they benefit genetic relatives.
    - Example: Worker bees forgo reproduction to help their queen.

5. Incorporation of Molecular Evidence

- **Darwin's View:**
  Darwin relied on observable traits (phenotypes) but had no knowledge of the molecular basis of inheritance.
- **Modern View:**
  Molecular biology has revealed the role of DNA, RNA, and proteins in heredity. Genomics, epigenetics, and molecular pathways now provide insights into how traits evolve at a molecular level.
  - **Example:** The evolution of hemoglobin variants in humans is linked to specific genetic changes that confer resistance to malaria.

6. Recognition of Non-Adaptive Evolutionary Forces

- **Darwin's View:**
  Darwin focused primarily on natural selection as the driver of evolution.

- **Modern View:**
  Other forces, such as genetic drift (random changes in allele frequencies) and gene flow (movement of genes between populations), also play critical roles in evolution, particularly in small populations.
    - **Example:** The founder effect in island populations, like the high prevalence of certain genetic disorders in the Amish community, is due to genetic drift rather than selection.

7. Acknowledgment of Rapid Evolution

- **Darwin's View:**
  Darwin envisioned evolution as a slow, gradual process (gradualism).
- **Modern View:**
  Evolution can occur rapidly under strong selection pressures or environmental changes (e.g., punctuated equilibrium).
    - **Example:** Rapid changes in beak size among Darwin's finches during drought years demonstrate that evolution can happen in observable timeframes.

Conclusion, the modern synthesis has enriched Darwin's theory of natural selection by integrating genetic, molecular, and ecological insights. While Darwin laid the groundwork, the modern view recognizes additional mechanisms, molecular evidence, and the importance of population dynamics, offering a more comprehensive understanding of evolution.

Any 5 points @ 03 marks =15 marks

ii) Explain the evolution of Plasmodia which are resistant to certain anti-malarial drugs such as chloroquine.

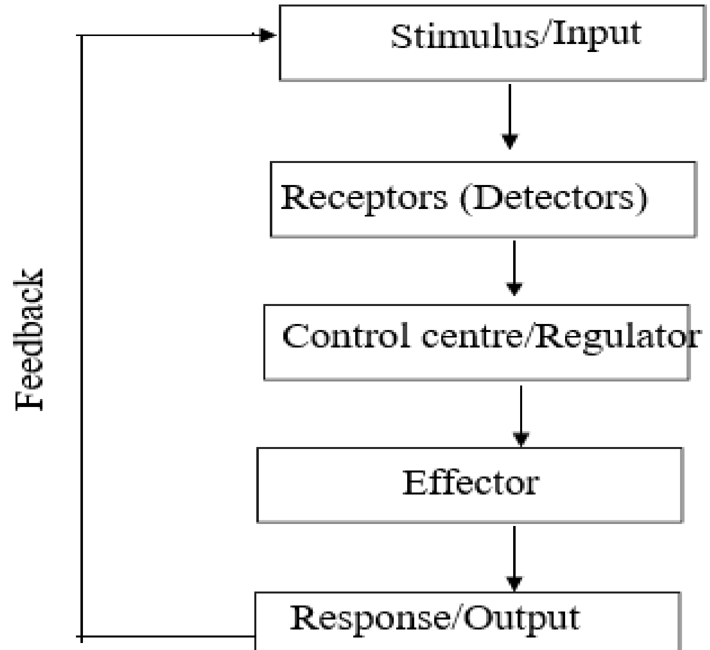
- The evolution of **Plasmodium species** (e.g., *Plasmodium falciparum*), which are resistant to anti-malarial drugs like chloroquine, is a prime example of natural selection and adaptation at the molecular level. Resistance arises due to genetic mutations that confer a survival advantage in the presence of the drug.

05 marks

5. Giving examples of a homeostatic mechanism, draw a diagram showing how the body can balance its contents through a negative feedback mechanism under the following criteria:
   (i) Blood sugar regulation
   (ii) Osmotic pressure

Alternative 1

Below is a simplified diagrammatic representation of how the body maintains homeostasis through negative feedback mechanisms for blood sugar regulation and osmotic pressure:



A diagram showing how the body can balance its contents through the negative feedback mechanism

Explanation in both cases

(i) Blood sugar regulation

Blood sugar, or blood glucose, is tightly regulated to ensure that it remains within a narrow range. When blood sugar levels rise above the normal range (e.g., after eating), the body uses a negative feedback mechanism to bring them back to normalize

Mechanisms of blood sugar regulation as follows

a. Stimulus:
After a meal, blood sugar levels rise due to the ingestion of carbohydrates.
b. Receptor:
Specialized cells in the pancreas, known as beta cells, sense the increase in blood sugar levels.
c. Control centre:
The pancreas acts as the control centre and releases insulin into the bloodstream.
d. Effector:
Insulin travels to target cells, primarily in the liver, muscle, and fat tissues.
e. Response:
Insulin promotes the uptake of glucose by these target cells, where it can be stored as glycogen or used for energy. This causes a decrease in blood sugar levels.
f. Negative Feedback: As blood sugar levels drop back to normal, the stimulus for insulin release decreases, and the pancreas reduces insulin secretion. This negative feedback loop helps maintain blood sugar within a narrow range.

Osmotic pressure:

Osmotic pressure is regulated in the body to ensure that the concentration of solutes (such as ions and proteins) in bodily fluids remains balanced.

a) Stimulus:
Changes in the concentration of solutes in body fluids, such as an increase in blood solute concentration.
b) Receptor:
Specialized cells, such as osmoreceptors, in the hypothalamus of the brain, detect changes in osmotic pressure.
c) Control centre:
The hypothalamus acts as the control centre and stimulates the posterior pituitary gland to release antidiuretic hormone (ADH).
d) Effector:
ADH travels through the bloodstream to the kidneys.
e) Response:
In the kidneys, ADH increases the reabsorption of water from the distal convoluted tubule and collecting tubule, reducing the concentration of solutes in the urine and increasing the concentration of water in the blood.
f) Negative Feedback:
As the concentration of solutes in the blood returns to normal, the stimulus for ADH release decreases, and the hypothalamus reduces its production. This negative feedback mechanism helps maintain osmotic pressure within a balanced range.

Answer

(i) Regulation of blood sugar (glucose)

Blood sugar (glucose) is controlled by the insulin hormone. It is a good example of a negative feedback mechanism.

- o When blood sugar rises, receptors in the body sense a change. In turn, the control centre (pancreas) secretes insulin into the blood effectively lowering blood sugar levels. Once blood sugar levels reach homeostasis, the pancreas stops releasing insulin.
- o However, when the blood glucose levels decrease, this is sensed in a different group of cells in the pancreas: the hormone glucagon is released, causing glucose levels to increase. This is still a negative feedback loop.

(ii)

Osmotic pressure is regulated by a hormone called antidiuretic hormone (ADH). It is also known as vasopressin, and it plays a role in the negative feedback control of osmotic pressure (osmoregulation) in the body.

Its primary function is to regulate the reabsorption of water by the kidneys in response to changes in blood osmolality.

Mechanism

- o In the brain, there are specialized cells called osmoreceptors which are located in the hypothalamus and continuously monitor the osmotic pressure of the blood and other bodily fluids. They sense changes in the concentration of solutes (e.g., ions) and water.
- o When osmoreceptors detect an increase in blood (higher solute concentration),
- o The hypothalamus stimulates the release of ADH from the posterior pituitary gland into the bloodstream. ADH is then transported to the kidneys.
- o Antidiuretic hormone (ADH) acts on the collecting ducts and distal convoluted tubules thereby increasing the permeability of these tubules to water. This allows more water to be reabsorbed from the urine into the bloodstream.
- o Reabsorption of water concentrates the urine, making it more concentrated with solutes and conserving water.
- o The increased water reabsorption from the urine into the bloodstream dilutes the blood's solute concentration, helping to restore the osmotic balance.
- o When ADH levels are reduced, the collecting ducts become less permeable to water, leading to less water reabsorption
- o Osmoreceptors in the hypothalamus continually monitor blood osmolarity. When osmolarity deviates from the set point (around 300 milliosmoles per litre), the release of ADH is adjusted accordingly to maintain osmotic balance. ADH operates in a negative feedback system, meaning that it works to counteract changes in blood osmolarity and return it to the desired level.

6. (a) Mitosis is a type of cell division in which the cell divides into two identical daughter cells. During development and growth, mitosis increases the cells, and throughout an organism’s life, it replaces old, worn-out cells with new ones.

Mitosis plays a critical role in growth, tissue repair, regeneration, and reproduction in multicellular organisms as follows;

(i) Growth

Mitosis increases the number of cells within an organism. This is the basis of the development of a multicellular body from a single cell, i.e., a zygote, and also the basis of the growth of a multicellular body.

(ii) Tissue repair

Mitosis is the basis of the replacement of old and worn-out tissues as well as wound healing. When cells become damaged in any way or die, the body produces new cells to replace them.

(iii) Regeneration

Some organisms can regenerate body parts. The production of new cells in such instances is achieved by mitosis, for example, starfish regenerate lost arms through mitosis. Other examples include tail regeneration in lizard and tissue regeneration in salamanders and planaria

(iv) Reproduction

Some organisms produce genetically similar offspring through asexual reproduction. For example, in unicellular organisms, cell division is the means of asexual reproduction, which produces two or more new individuals from the mother cell. The group of such identical individuals is known as a clone and vegetative propagation.

(b) (i) The growth curve is sigmoid Stag

(ii)

e

A

- This stage shows a small reduction in dry mass in the initial part of growth, due to seed germination.
- During germination, food stored in the cotyledons is usually used up before the first leaves undergo photosynthesis. This loss of mass is later replaced when the first leaves develop and start photosynthesis to produce food, making use of some of it and storing some of it.

Stage B

- Stage B shows increasing dry mass. At this stage, photosynthesis is at its maximum the rate of anabolism is greater than the rate of catabolism, and there is rapid growth.
- This leads to an exponential increase in the dry mass and, consequently exponential growth of a plant.

Stage C

- At this stage when the plant is fully matured the rate of anabolism is equal to the rate of catabolism and therefore the growth remains constant.
- There is no increase in the dry mass.

Stage D

- After maturity, negative growth or senescence occurs during which the rate of catabolism exceeds the rate of anabolism until growth becomes zero.
- At this stage, the cell deaths are very high
- The decrease in the dry mass is due to seed dispersal.

(iii)Examples are. Garden pea and bean plant (any other annual plants)