BIOLOGY PAPER 2
SECTION B
COMPULSORY QUESTION
GRAPHS & DATA ANALYSIS



GRAPHS AND DATA ANALYSIS

- There is always a **compulsory question which involves a graph or a graph related question**.

(20 marks out of 80 marks)

Graphs/data analysis questions are made compulsory because

The data analysis /**graphs questions test the candidates;**

- **understanding, interpreting, manipulation of data and applying of knowledge and facts of biology.**
- *Thus data analysis /graphs help to* ***identify good students*** *who know the subject well and also those who are weak in the subject.*

WHAT IS A GRAPH?

- A graph is a diagram consisting of a line or smooth curve representing the change of two or more factors,
- e.g. change of temperature every two hours.

TYPES OF QUESTIONS USING GRAPHS

- Where data or figures are given and the candidate is asked to plot a CURVE or two CURVES on the same axes and answer questions from the plotted curve(s).
- Where an already drawn graph(s) is provided and the questions asked from the graph(s).

WHAT TO OBSERVE WHEN DRAWING GRAPHS

The title

- Given by the question wording like “Graph of germination rate against temperature”

Axes drawn using a pencil & Ruler

- There are usually two axes (singular axis), namely Vertical (Y) axis and Horizontal (X) axis.
- Each axis should be correctly labeled with units shown,

e.g. temperature in ^{0}C, time in hours, mass in grammes, rate of reaction in grammes produced per minute,

- The calibrations/markings on the axes are done using a pencil
- the values written using a blue/black pen.

continued

- Write the quantities on both axes along with their units used e.g. Temperature in ^{o}C ,Time in minutes
- ***Which quantity should be placed on which axis?***

(a) Independent vs Dependent factors

Independent factor is allocated the x axis ALWAYS, see y=mx +C

- Independent factor is any parameter or input the experiment had control or determined before the experiment started e.g. pH in each solution, number of rats in each cage, time interval between readings
- If time is one of the two quantities given, it must always be placed on the horizontal (x) axis. This is because time is an independent factor.

continued

Dependent factor is allocated the y axis ALWAYS, see y=mx +C

- All the other factors are dependent on time and are placed on the vertical (y) axis. Dependent factors are all observation or results of a study or experiment include temperature, distance, height, population growth etc.
- Any factor that depends on time must always go the vertical axis.
- Never plot time on the vertical axis. This is known as reversing or exchanging of the axes and will result into loss of both marks for the axes.

(b) Factor Mentioned first in the question

- Where time is not one of the quantities given the **first factor mentioned** in the question should be plotted on the vertical axis and the other ones on the horizontal axis.
- **For example;** Plot quantity Q against quantity R. Here Q goes on the vertical axis and R on the horizontal axis. Never reverse the axes.

The origin

- **The origin** is a point where the two axes meet, usually has a single value of zero.
- However a graph where there are two numbers at the origin, happens if the two quantities being plotted are far apart to warrant a common number at the origin.
- The two types of quantities given are too far apart which makes it impossible to have one number at the origin to represent the two scales. Therefore two numbers at the origin like 5000 for vertical scale and 0 for horizontal scale are used.

The scale

- **The scale** is required for producing the correct graph on the given graph paper.
- The scale should be;
  - correct to have the curve use 75% of the space provided,
  - suitable i.e. even,
  - workable
  - convenient,
  - Starting at the origin where the two axis meet,

Continued/ explaination

- Must be even throughout, workable and *must start at the origin*, where the two axes meet.
- Choose a scale that will give a curve(s) covering over ¾ of the graph page given.
- Never choose a scale that will give a small curve(s) of less than ½ of the page.
- Spread out your scale but make sure not to exaggerate the scale that will produce an oversize curve.
- Similarly don’t use such a small scale that will produce an undersized curve.

Plotting of the points

- Points should be correctly plotted using large dots or cross and use a pencil.

BUT NOTE;

- *The points must be correctly plotted from data using x and only use a large dark dot when plotting two curves on the same axes to avoid confusion.*
- ***This is because dots may be so faint as not to be seen during marking. X** symbol is easily seen and should always be used for plotting the points when plotting one curve.*

Joining of the plotted points

- Using a pencil join the plotted points using a free hand, and not a ruler, to form a smooth continuous curve unless clearly stated otherwise.
- NOTE; *A ruler may be used only if the plotted points all lie on a straight line.*
- *EXTRAPOLATION is a situation where the curve is extended beyond the last plotted point.* ***Make sure that this does not happen.***

continued

- *Extrapolation will head to loss of your marks unless you are instructed to make a reading beyond the plotted point.*
- *Your curve should stop at the last plotted point and not extended beyond the point.*
- *Curve must not be wavy, must not be broken anywhere, must not be dotted, and must be drawn in a pencil that is sharp and must be clearly visible.*

Labeling the curves

- Where two or more curves are plotted on the same axis they must be labelled using a blue/black pen.

Examples of graphs

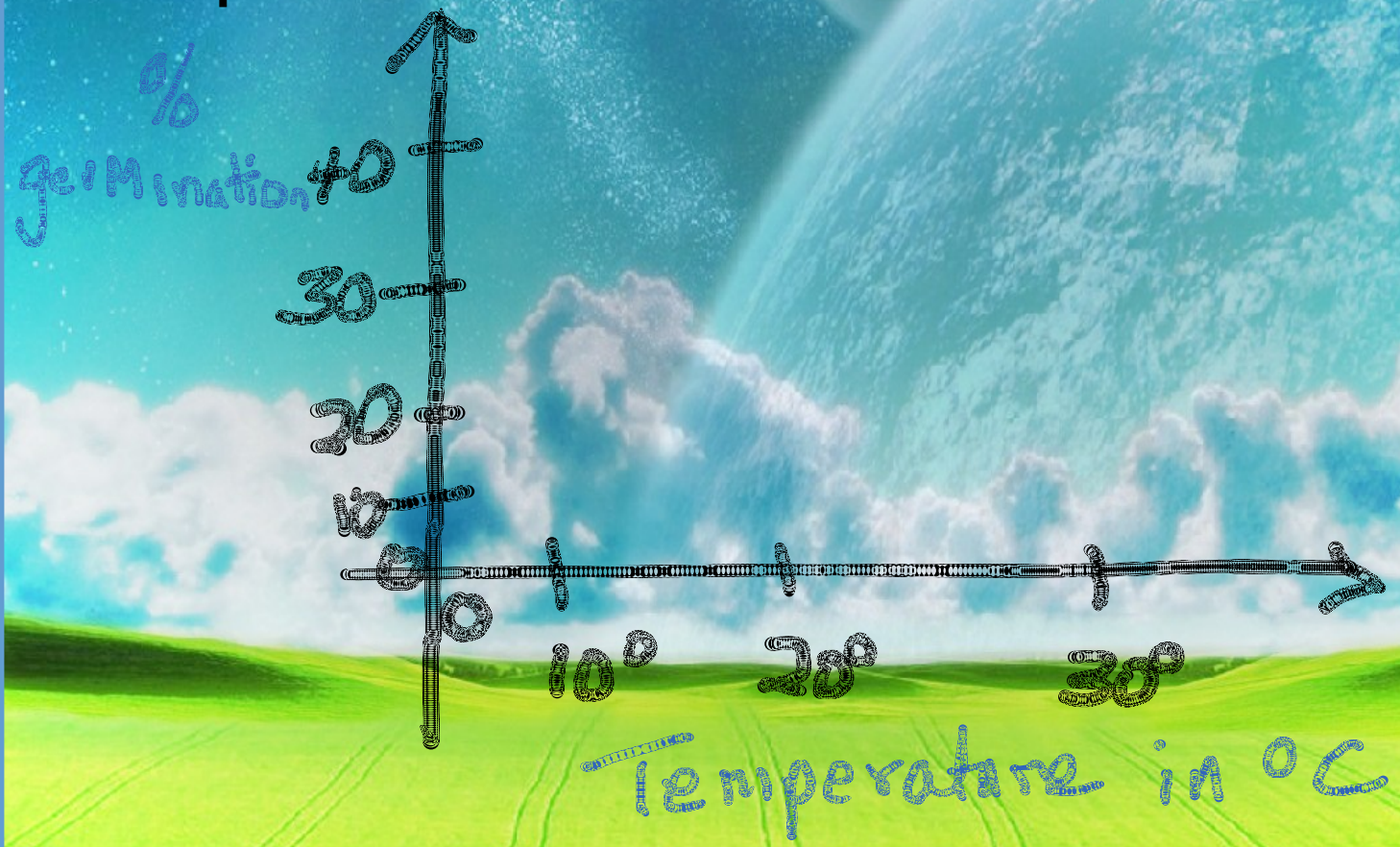
Examples

Using a suitable scale drawn a graph of percentage germination of seeds against time in days.



Example 2

Using a suitable scale draw a graph of percentage germination of seeds against temperature.



N.B Ensure the following;

- **To spend enough time to find the correct scale**
- **To ensure that the axes are not inter-exchanged**
- **The origin is always numbered**

PROCEDURE OF HANDLING A GRAPH QUESTION

- Step 1.Determine the origin
- Step 2.Choosing the scale
- Step 3.Determine the axes
- Step 4.Plotting the points
- Step 5.Drawing the curve(s)

Step 1. Determine the origin

- First read through the data to find out the following information.
- How many graphs are you required to plot?
- Do the quantities given agree to have only one number at the origin for both axes or there is need to have two numbers at the origin to represent each scale.

Step 2.Choosing the scale

- Check the figures given in each quantity, find the smallest figure and the highest figure,
- check on the interval that is used increasing from one figure to the other, from the interval that is used you can now choose your scale to use ¾ of the space provided.

Step 3. Determine the axes

- Check on the factors you are given for plotting.
- Is time one of those quantities?
- If time is one of them put it on the horizontal axis.
- If time is not one of the two quantities then put the first one mentioned or the independent factor on the vertical axis and the remaining on the horizontal axis.
- Draw and mark the intervals using a pencil, as given in the data provided.
- Write the values of the intervals using a blue/black pen.
- The axes should be correctly labeled.
- Take care not to inter- exchange axes.

Step 4. Plotting the points

- Once you have chosen the scale, use the figures to plot the points. Make sure to plot the points correctly.
- If there are two or more graphs to be plotted using a sharp HB pencil, they must be plotted on the same axes and each curve labeled along using a blue/black pen.
- NB; avoid a KEY (this is not your exam do not set your own questions)
- Do not plot the graphs on different axes each.

Step 5.Drawing the curve(s)

- Ensure to use a free hand to join the plotted points
- Avoid extrapolation
- The curve must be smooth and continuous.
- The curve must not be wavy, wooly or broken anywhere.

NOTE; “CHANGING PENS IS ILLEGAL”

- ***In ANY exam you care ONLY use one Colour of a pen per paper.***
- ***If you start writing your responses using black keep it black throughout that paper.***
- ***Change of pen Colour may mean CHEATING!!!!!.***
- ***And cancelled exam results.***

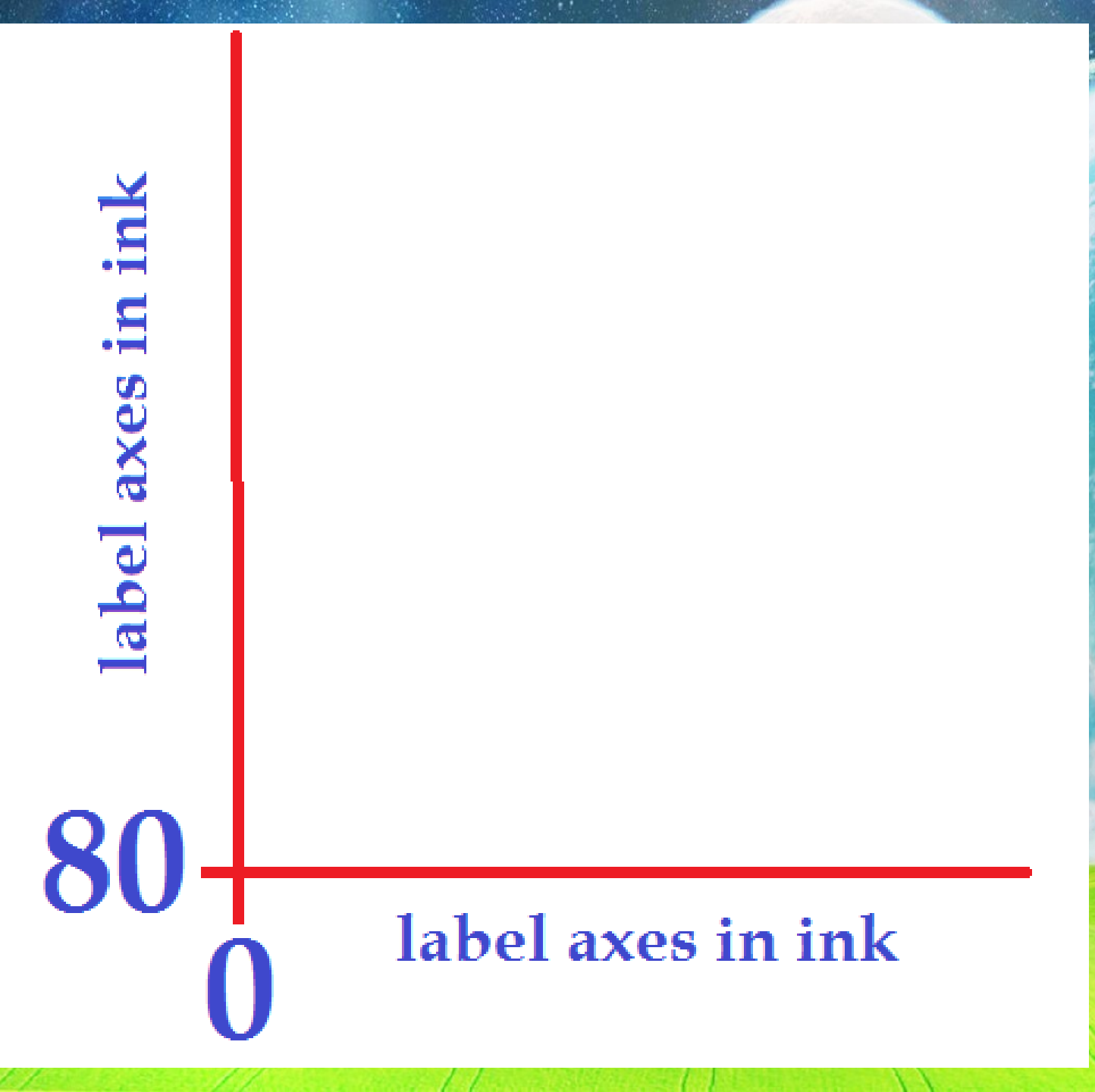
YOU MUST ATTEMPT THE FOLLOWING

PRACTICAL ONE

Two persons X and Y drunk volumes of concentrated solution of glucose. The amount of glucose in their blood was determined at intervals. The results are shown in the table below. On the same axes plot the two curves, use the graph paper provided.

Data table

Time (minutes)	Glucose level in blood (mg / 1000cm^3)	
	X	Y
0	87	84
15	112	123
30	139	170
45	116	188
60	100	208
90	95	202
120	92	144
150	88	123


label axes in ink
80
0
label axes in ink

From the data above the following information is obtained

- Time is one of the factor, therefore will be put on the horizontal – X axis
- The least figure is zero minutes for time and 84 **mg / 1000cm^3** for glucose level in the blood.
- The two figures are far apart , therefore each scale will have its own number at the origin.
- The two numbers at origin are zero(o) for time and 80 for glucose level.

Practical TWO

Two boiling tubes A and B were filled with hot water. The temperature of water in the tubes was taken at the start of the experiment and then at 5 minutes interval. The surface of tube A was continuously wiped with a piece of cotton wool soaked in methylated spirit. The results obtained are shown in the table below. Use the data to plot the curves of boiling tube A & B on the same axes.

Data table

Time (minutes)	Temperature ºC in tubes	
	A	B
0	80	80
5	54	67
10	40	59
15	29	52
20	21	47
25	18	46

Points to observe

- Time is one of the factor, therefore it is placed on the horizontal scale.
- The least figure for time is zero and the least value for temperature ^{o}C is 18. This then means the two figures are near enough, therefore only one value at the origin representing both scales (Zero number).
- The interval for time is regularly taken after 5 minutes.
- The interval for temperature in both tubes fluctuates.

PRACTICAL THREE

Average temperature of a group of students, toads and environment were taken at intervals of four hours and recorded as shown in the table below. Study the table below and answer the questions that follow.

(a). Plot the curves of students, toads, and environment on the grid provided.

Time in hours		07.00	11.00	15.00	19.00	23.00	03.00	07.00
Temperature in °C	Students	36.9	37.0	36.6	36.8	38.0	37.0	37.0
	Toads	13.4	17.4	26.0	19.2	16.0	13.0	13.4
	Environment	16.4	20.0	27.8	22.0	19.2	15.8	16.0

Example FOUR

- Use the figures in the table below to answer the questions.

Age in years Birth	Height in cm 50.4	Weight in Kg 3.3
1	75.0	10.3
2	87.2	12.6
3	96.0	14.5
4	104.0	16.0
5	111.0	18.6
6	115.5	22.0
7	123.5	25.0
8	130.0	27.3
9	135.5	30.0
10	141.0	33.0

Continued

- The table above shows measurements of height and weight of individuals of different ages. Study it and;
- (a) Draw two graphs using the same axes to show height and weight against different ages.

Continued

(b) Calculate the percentage growth in height between:

(i) Birth in1 year

(ii) Year 1-2

(iii) Year 2-3

(iv) Year 3-4

(v) Year 4-5

(c) In which period is there the highest growth percentage rate?

(d) What factors affect the rate of growth?

The marking of graphs in KCSE Examination

Graph marks are usually around 6, 7 or 8 depending on;

- **The number of graphs to be plotted**
- **Identification of two or more curves drawn**

Distribution of graphs marks usually follows this trend

- **Correct scales i.e. y & x- axes scales = 2 marks or 1 mark**
- **Correctly plotted points = 1 or 2 marks**
- **Correctly labeled axes = 2 marks or 1 mark**
- **Smooth curve = 1 or 2 marks**

  Total = 6, 7 or 8 marks
- **NB***; where two curves are drawn there is always 1 or 2 marks for labeling of the curves*
- *Labeling of curves must be indicated on the curves drawn e.g. curve of A, curve of B.*
- *Failure to identify the curves will lead to loss of labeling marks.*

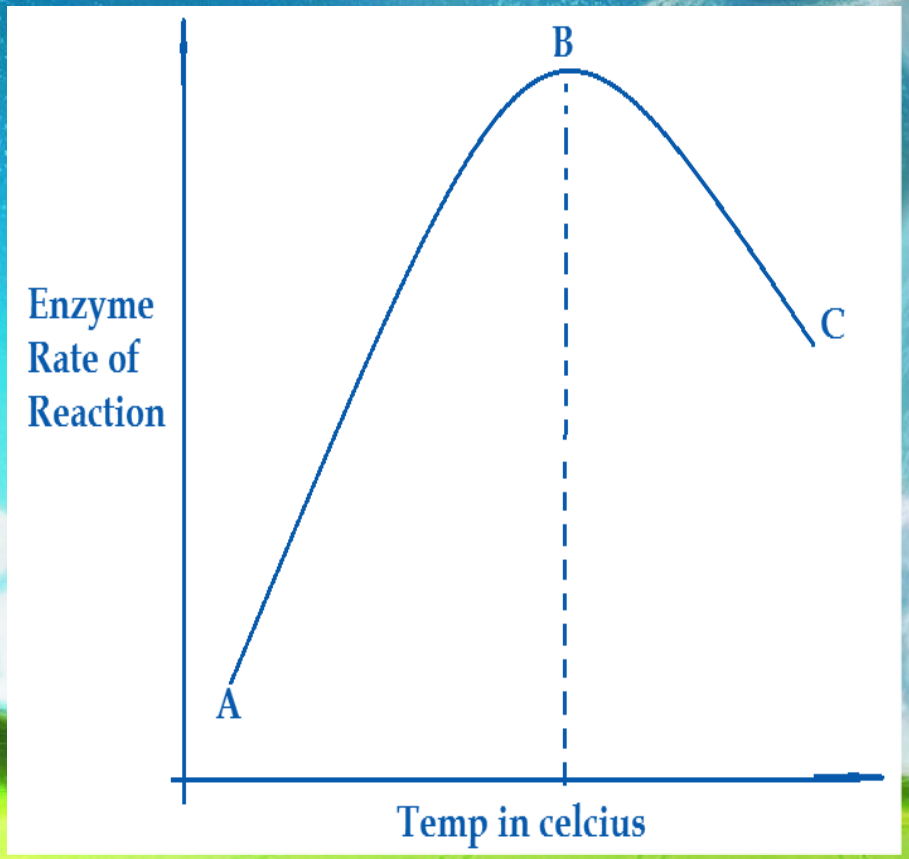
Where marks are lost on graphs

- *Reversing the axes,*
- *drawing a small graph,*
- *failure to label the two or more curves along the curves, (NO KEY)*
- *drawing separate curves on separate axes instead of drawing them on the same axes as instructed,*
- *drawing a wavy or woolly curve(s),*
- *extension of the curve beyond the last plotted point (extrapolation),*
- *incorrect plotting of some points,*
- *uneven scale,*
- *failure to label the axes or wrong labeling axes,*
- *Failure include units*

HOW TO INTERPRET & ACCOUNT GRAPHS IN BIOLOGY

- **Interpretation of biology graphs simply is to observe what happens to the vertical quantities as changes come about on the horizontal quantities**
- **e.g. what happens to enzyme activity as temperature increases.**

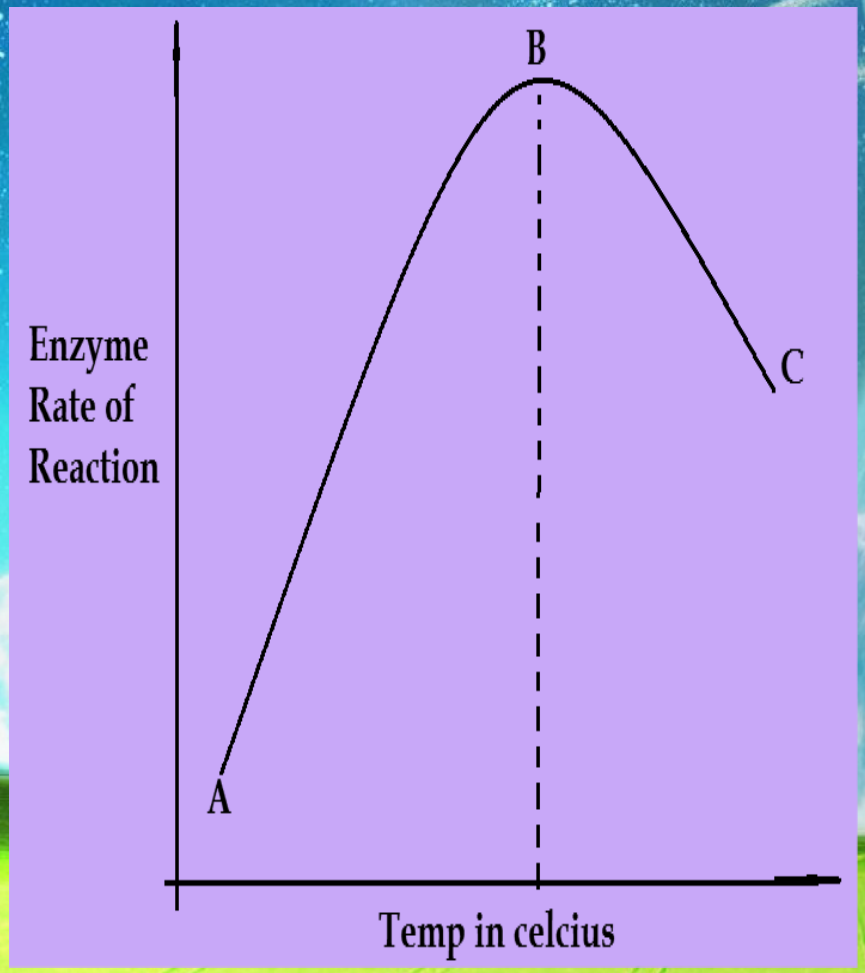
EXAMPLE ONE



Interpretation

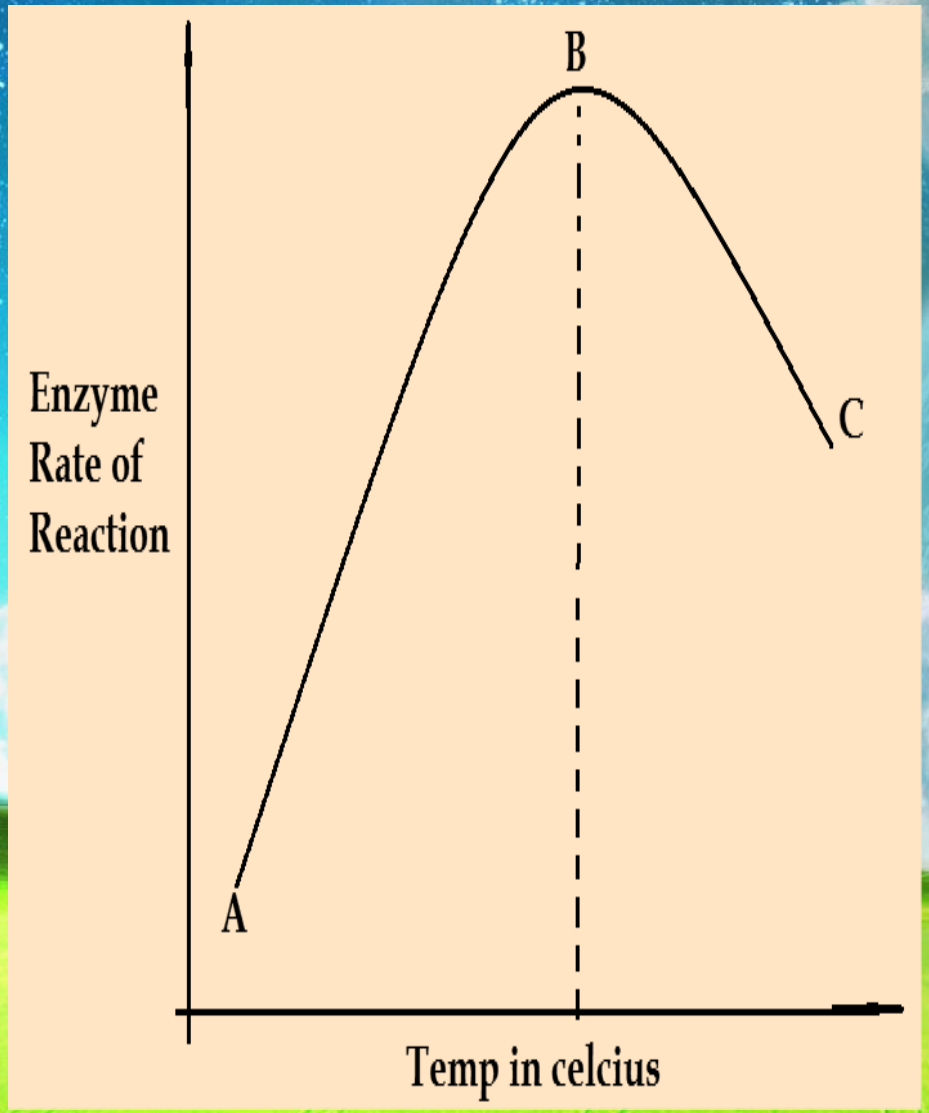
- **As the temperature increases the enzyme action also increases up to a maximum at point B.**
- **On further increase in temperature the enzyme activity decreases (BC),**

Accounting =Observation + REASON(S)



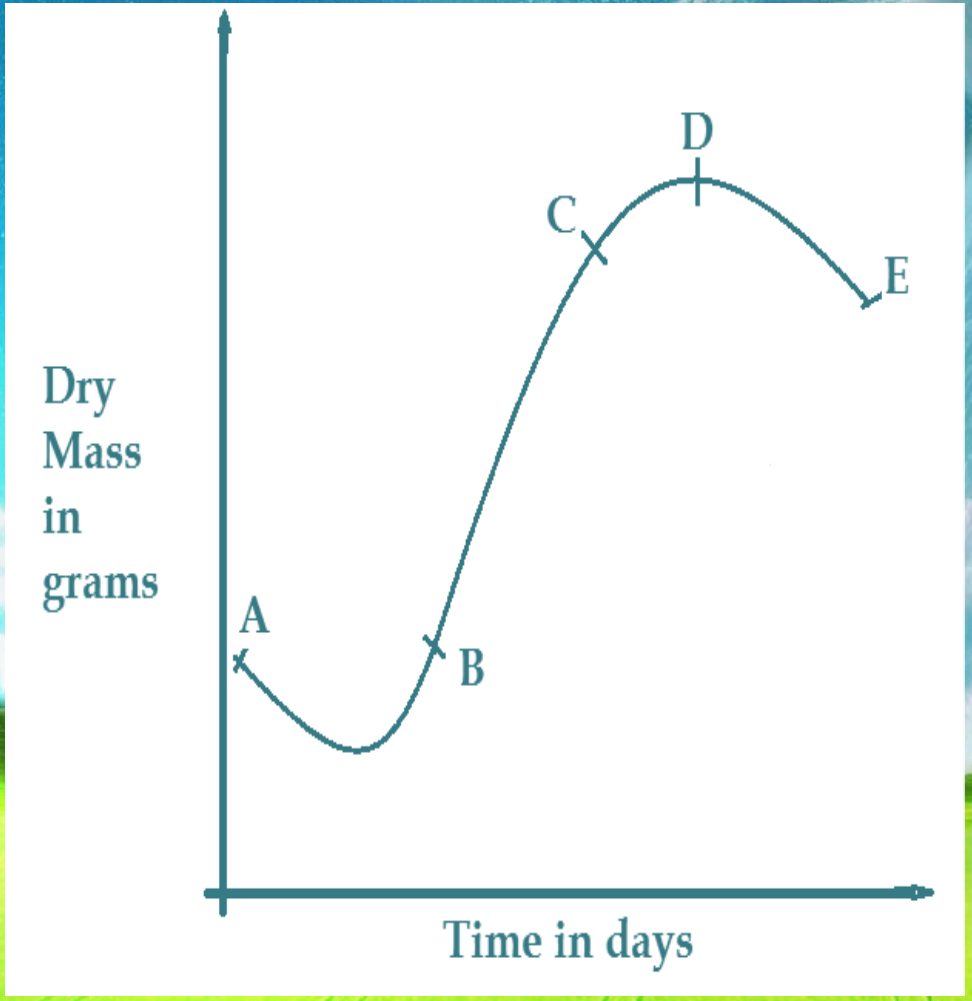
- **Between A and B the increase in temperature increased the rate of reaction because the enzyme is activated as the substrate kinetic energy increases.**
- **At B the enzyme is at its highest activity because this is the optimum temperature,**

continued



- **Between B and C the increase in temperature leads to the rate of reaction decreasing because the enzyme active site is denatured by the high temperatures above optimum temperature,**

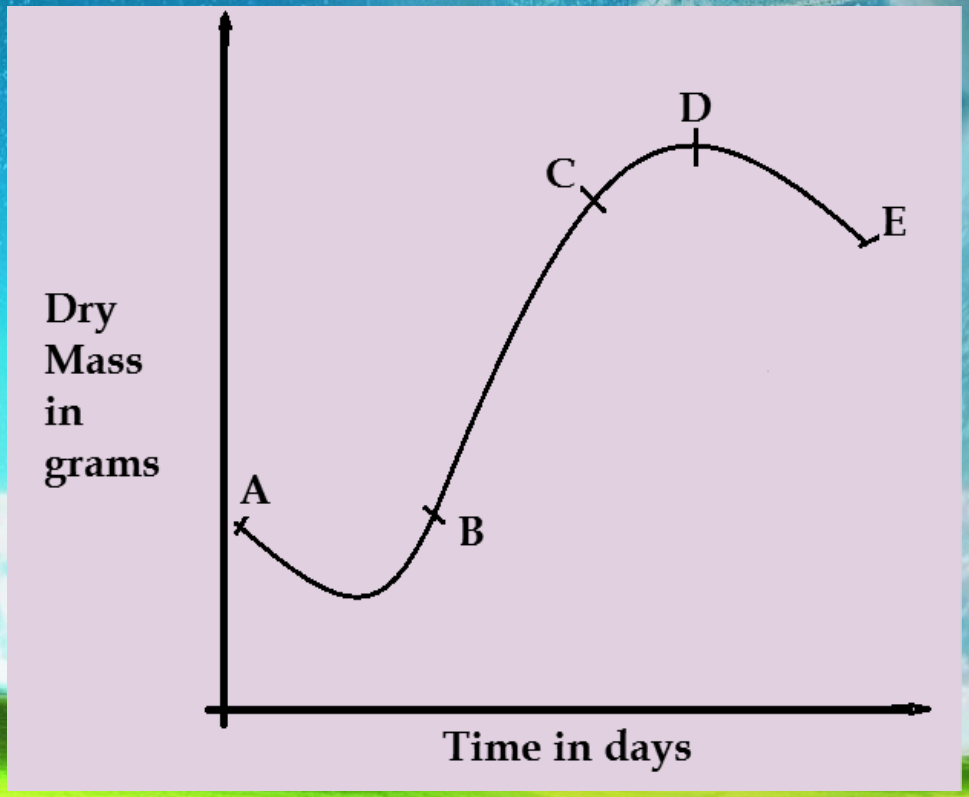
Sigmoid Curve; Dry Mass of germinating bean seedling



Interpretation

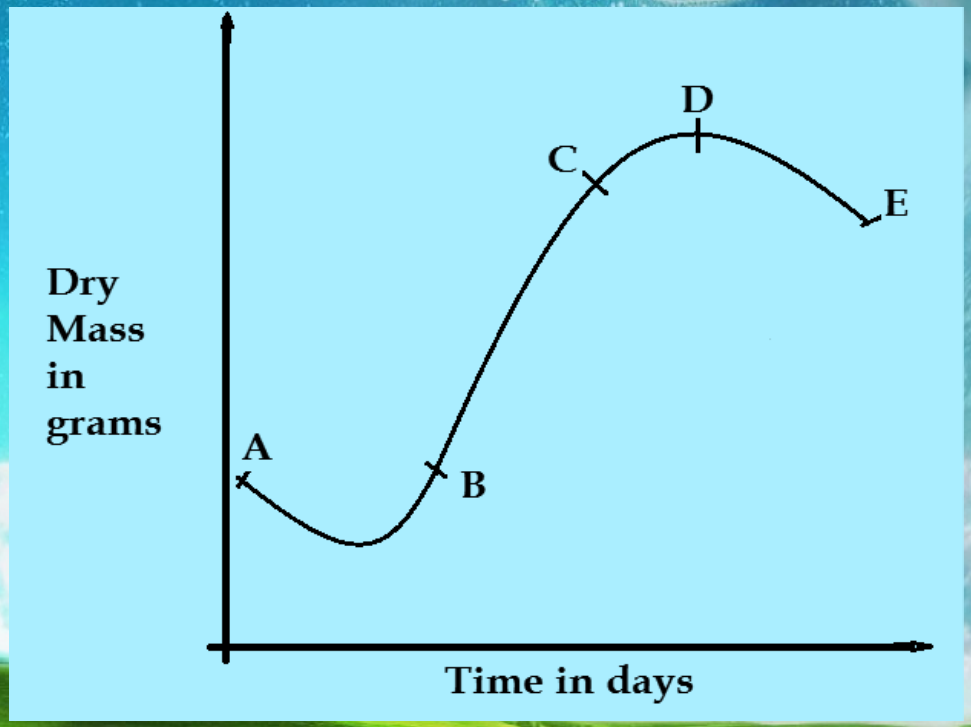
- **As time increases the dry mass decreases at first (AB) and on further increases of time the dry mass increases exponentially / rapidly up to a maximum point after which the dry mass decreases with increase in time,**

Accounting for the changes in dry mass



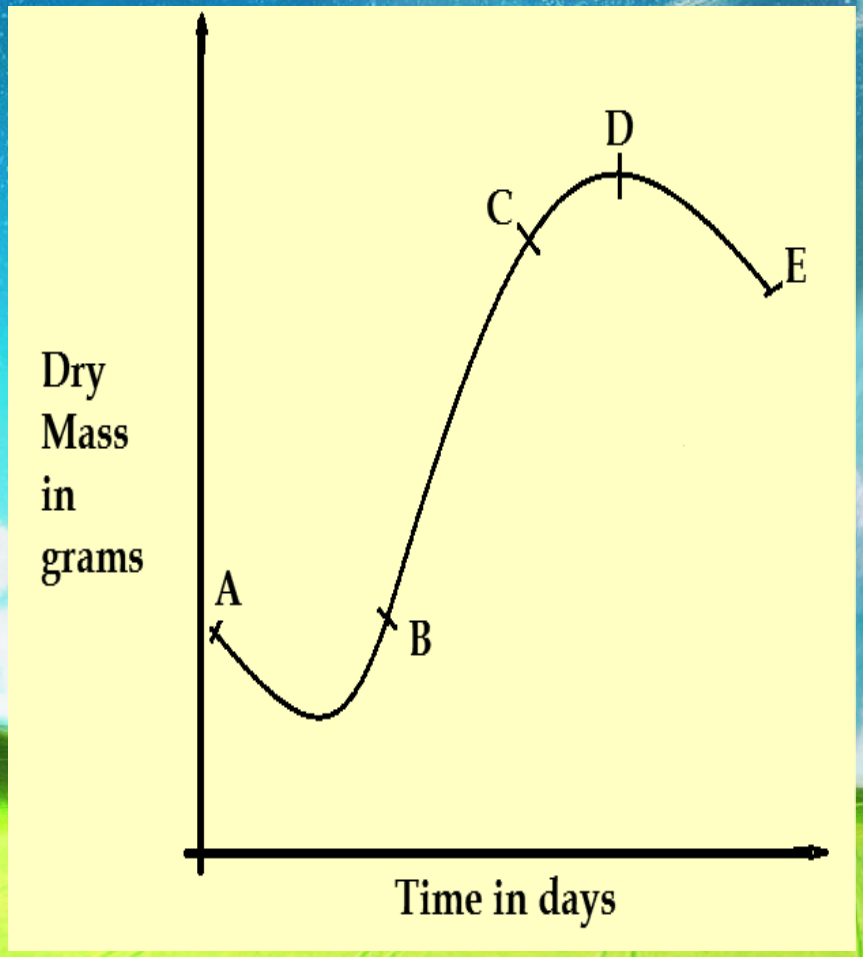
- **Between A and B there was a decrease in dry mass initially because the stored food was being used in respiration to provide energy and for growth in the seedling.**

Continued



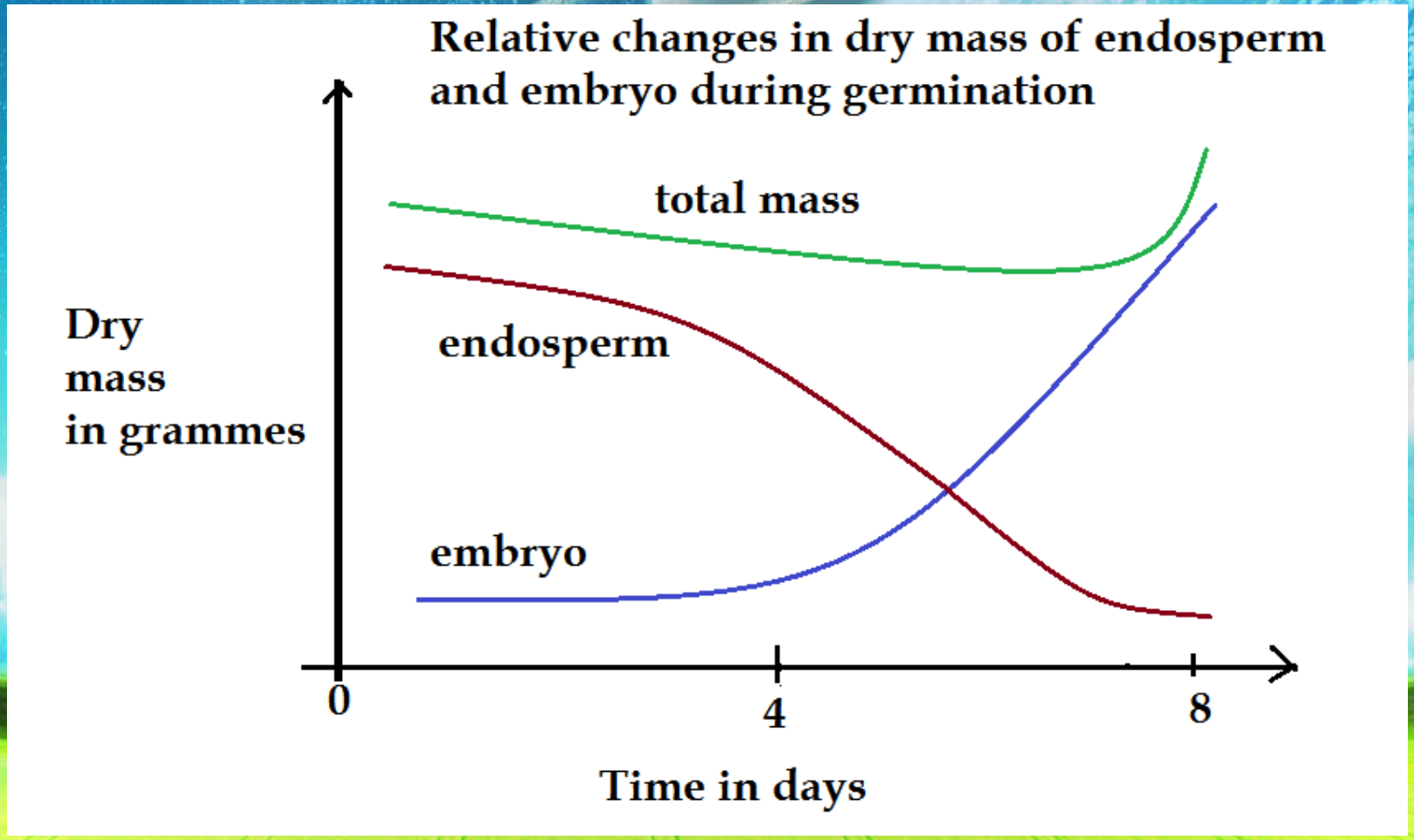
- **Between B and C the dry mass increased rapidly because of the formation of foliage leaves lead to photosynthesis and produce food used in tissue formation which results in rapid increased in mass.**
- **Between C and D the rate of dry mass increase is decreasing because the anabolic**

Continued

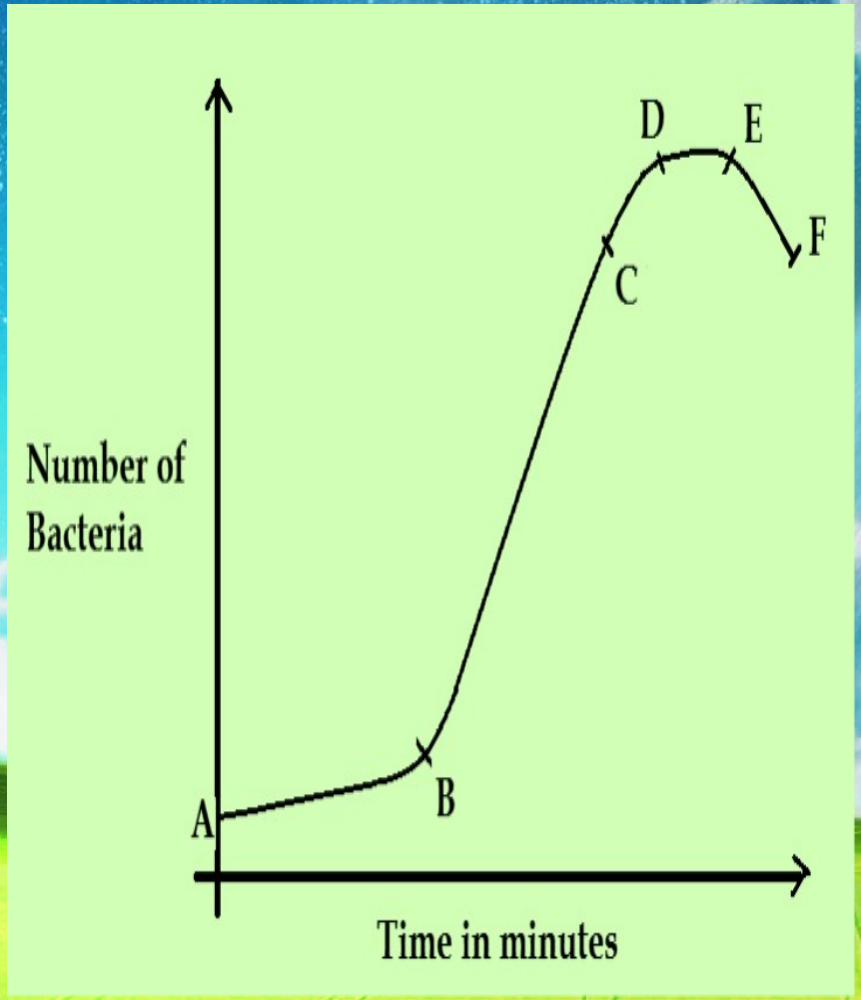


- **At D the dry mass is constant because the rate of anabolic reactions e.g. tissue formation and photosynthesis is equal to the catabolic reactions i.e. respiration.**
- **Between D and E the dry mass decreases because the rate of respiration is faster than the anabolic reaction as the leaves mature and turn yellow and brown.**

Graphs of germination



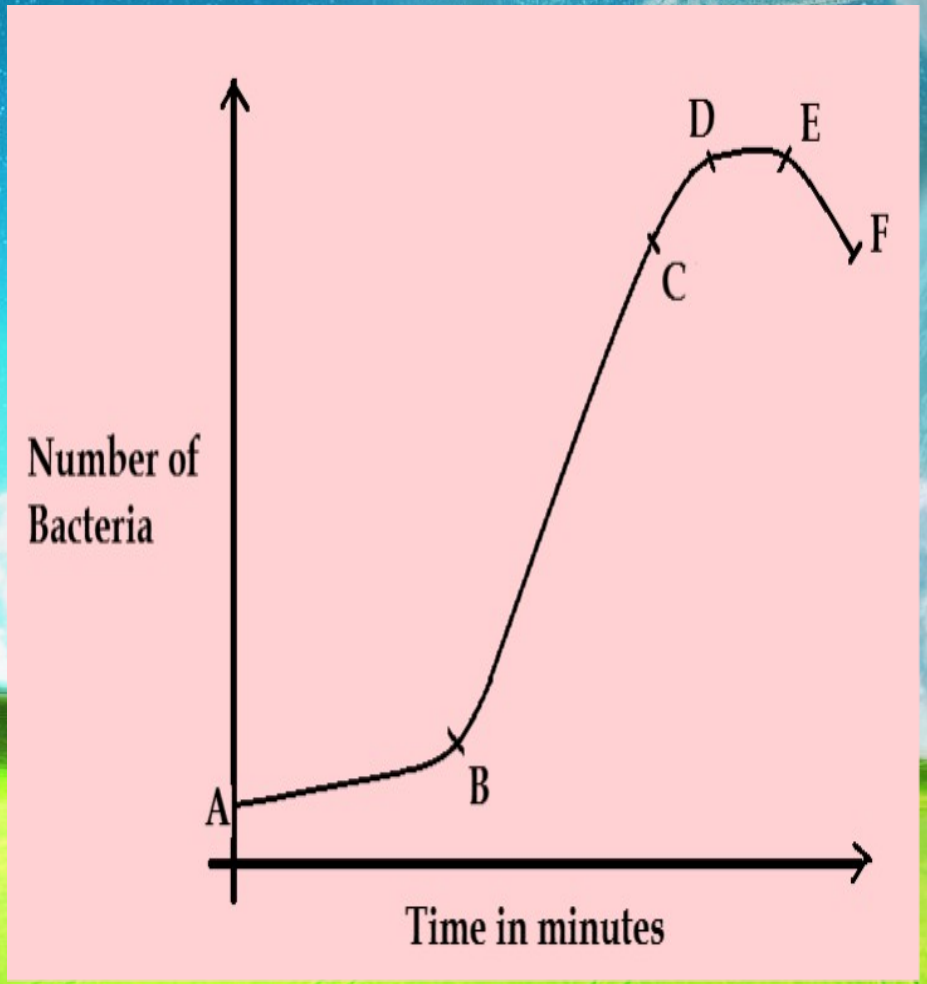
Sigmoid curve; Bacteria culture growth



Interpretation

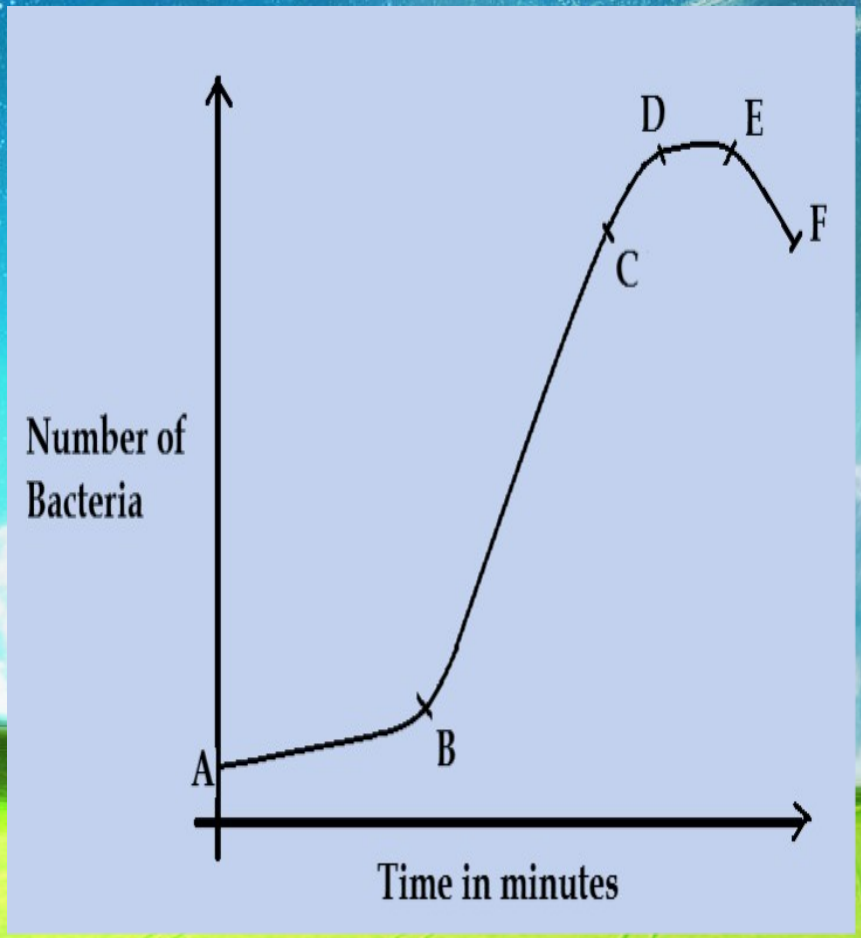
- As time increases population growth of bacteria is slow at first (AB) in the lag phase and then gradually increase at first slowly then increase rapidly / exponentially (BD) in the log phase before reaching the plateau (DE) and then decreases with increase in time (EF) in the decline phase,

Accounting



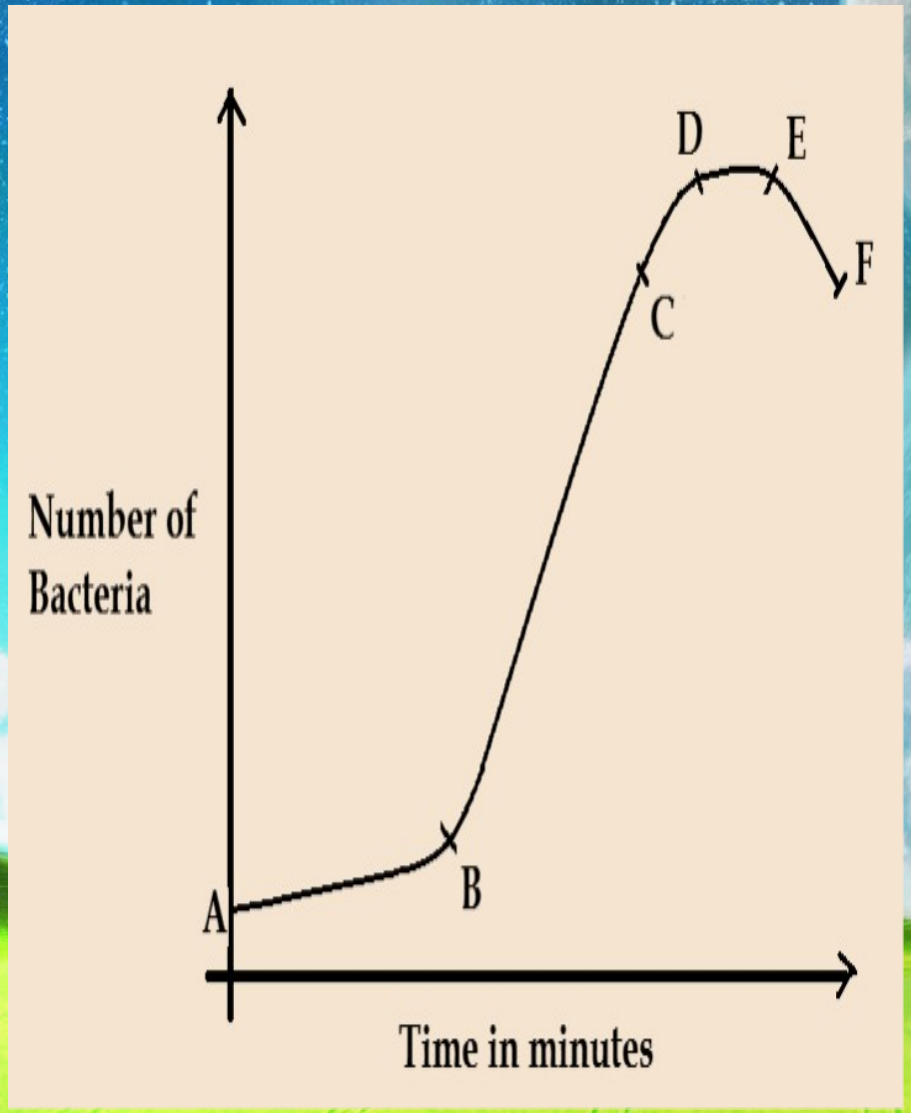
- Between A and B; has slow population growth; because the bacteria are adjusting to the new environment,

Accounting



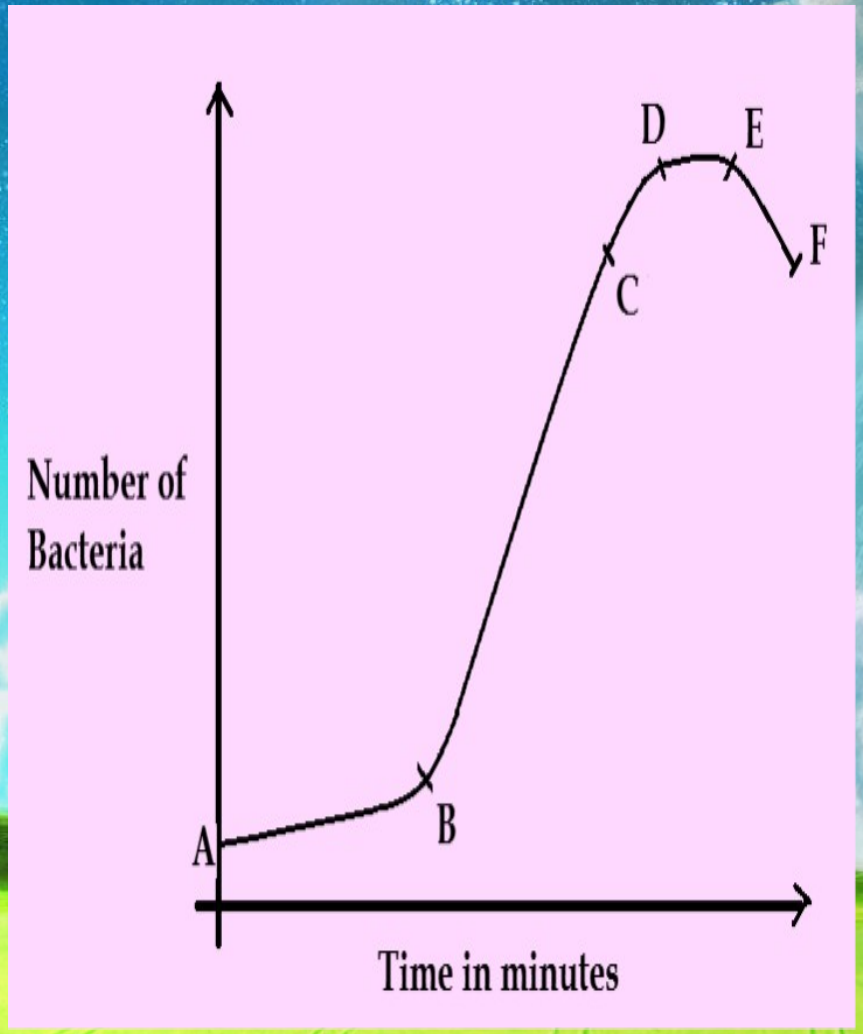
- Between B and C; rapid increase in bacteria numbers **because** Bacteria have adjusted to the existing conditions and are now dividing rapidly due to the abundance of food, the suitable pH & temperature, low amount of metabolic wastes and absence of limiting factors.

Accounting



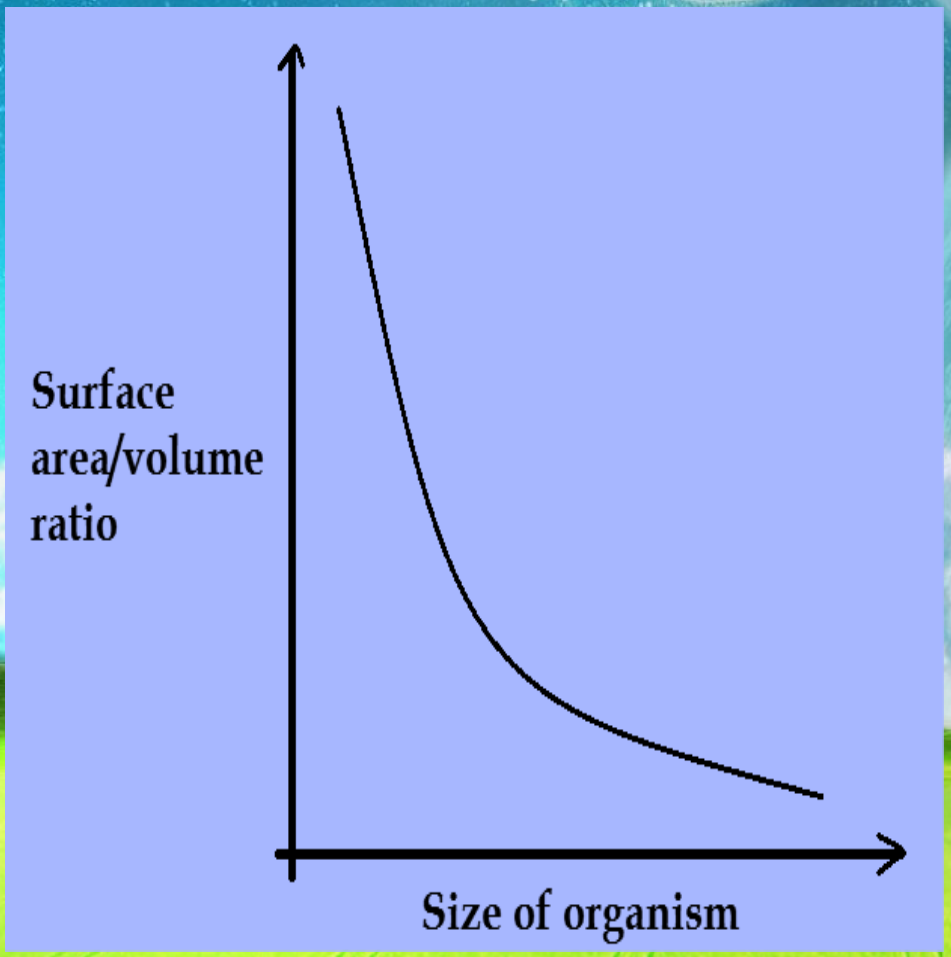
- Between C and D; Population increases at decreasing rate **because** the limiting conditions begin to set in.
- Between D and E; the population growth is stationary **because** the rate bacteria cell death is equal to rate of bacteria cell division,

Accounting



- Between E and F; population declines **because the** conditions become unfavourable, Accumulation of metabolic wastes leads unsuitable pH and temperature leading to more cell deaths than cell divisions.

INVERSELY PROPORTIONAL GRAPH

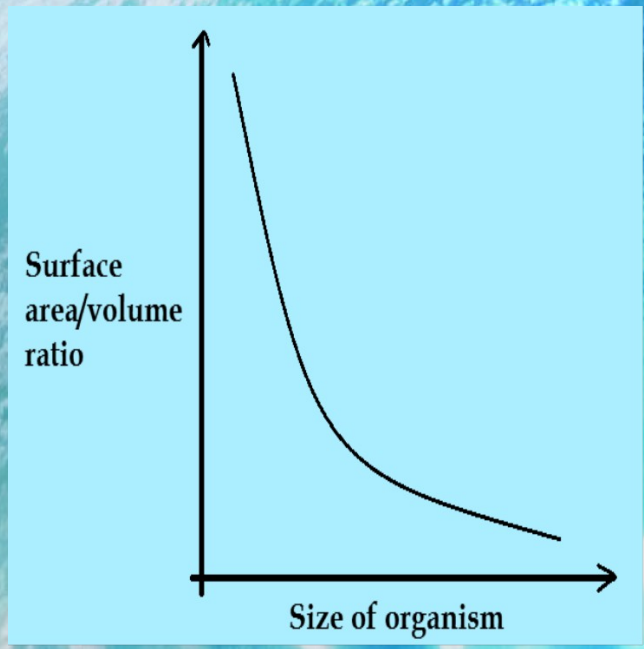


Interpretation

- As the size of the organism increases the surface area to volume ratio decreases and as the size of the organism decreases the surface area to volume ratio increases,

Accounting for Surface area volume ratio decrease explains;

- Decrease in rate of heat loss as the body size increases therefore need less insulation, need more air currents in hot weather, use less food to maintain a constant body temperature.
- Diffusion of gases in single celled organisms because the have a large surface area to volume ratio.

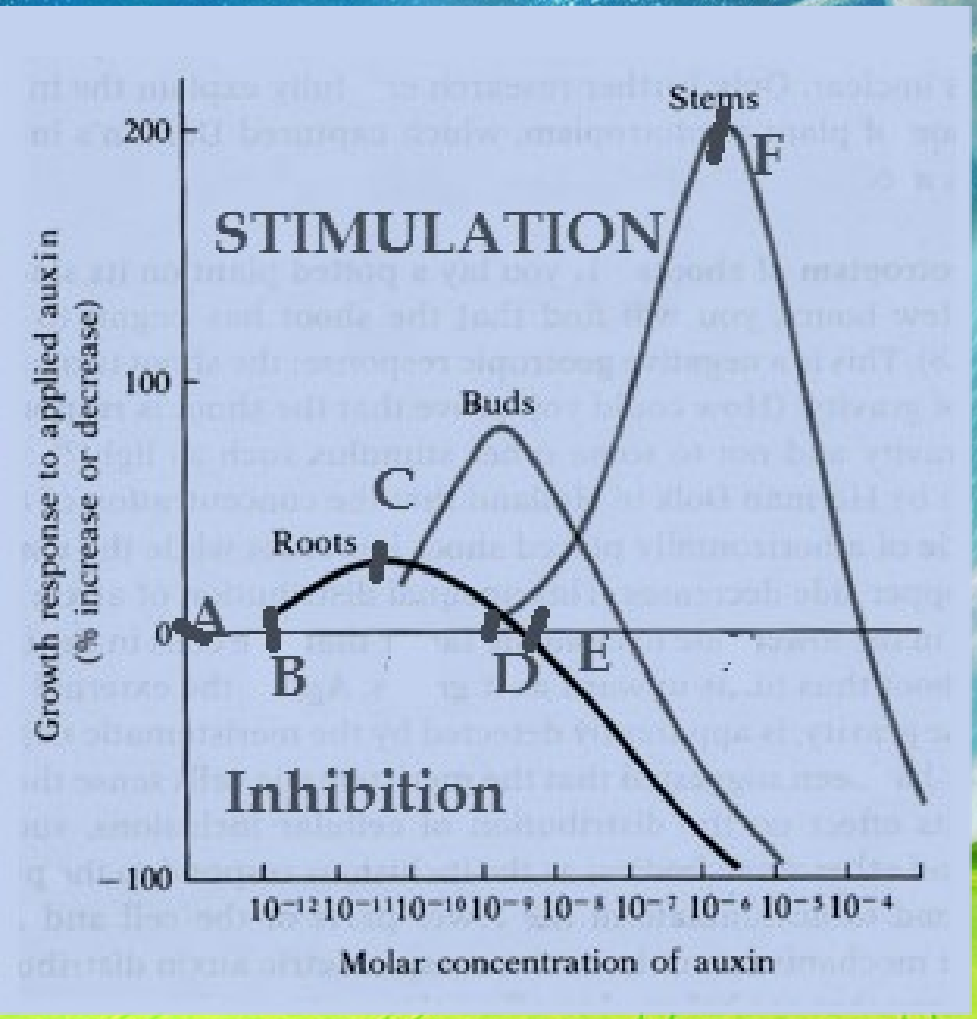


African fox vs Artic fox



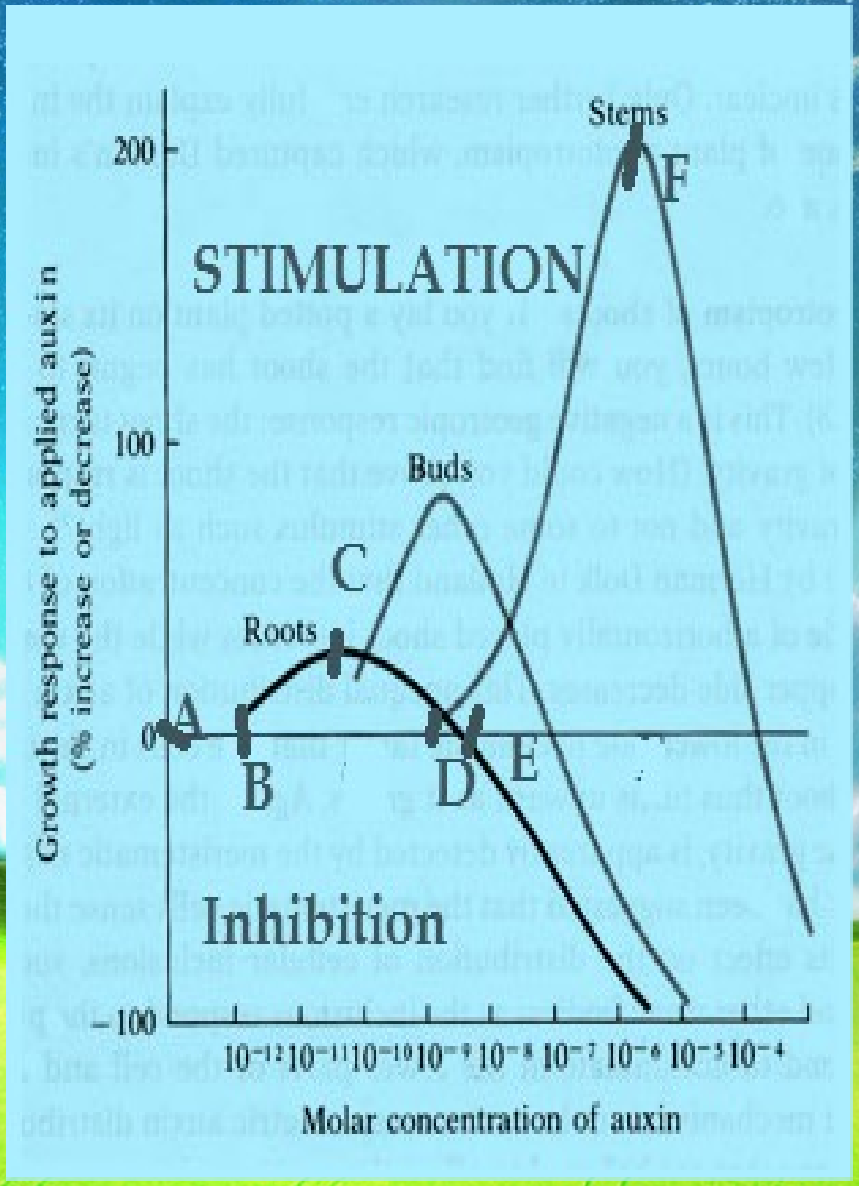


Effects of auxins to roots & shoots



- Interpretation
- Increase in auxins concentration causes increase in growth first in the roots then the shoots.

Accounting



- Between B & C increase in auxins concentration cause increase in root growth while no growth in the shoot **because shoot cells respond to higher auxins concentration than root cells.**

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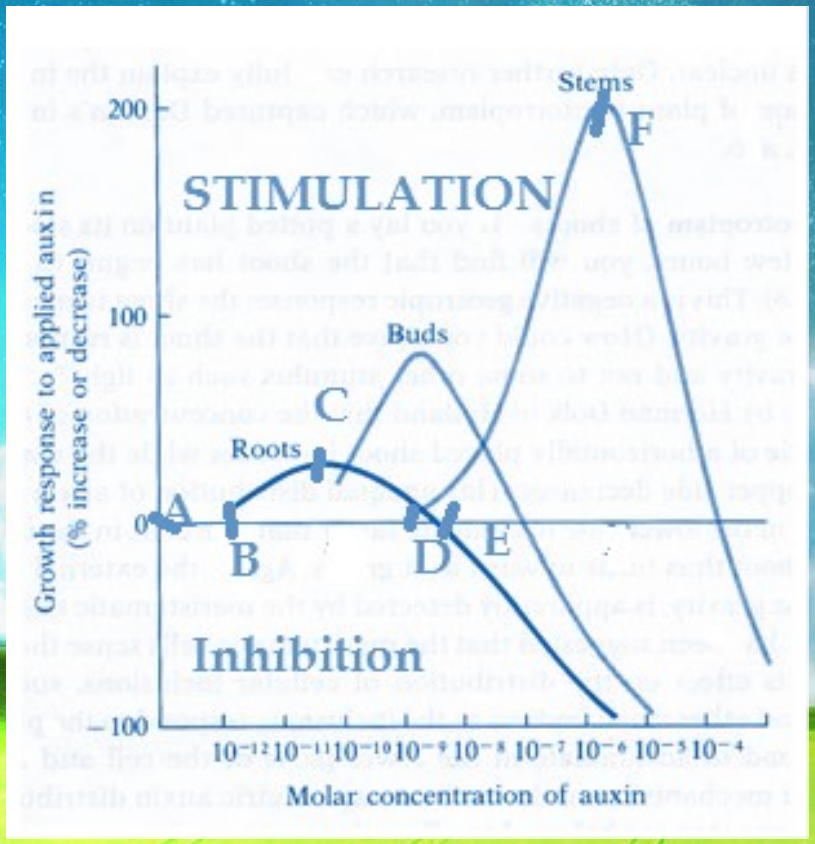
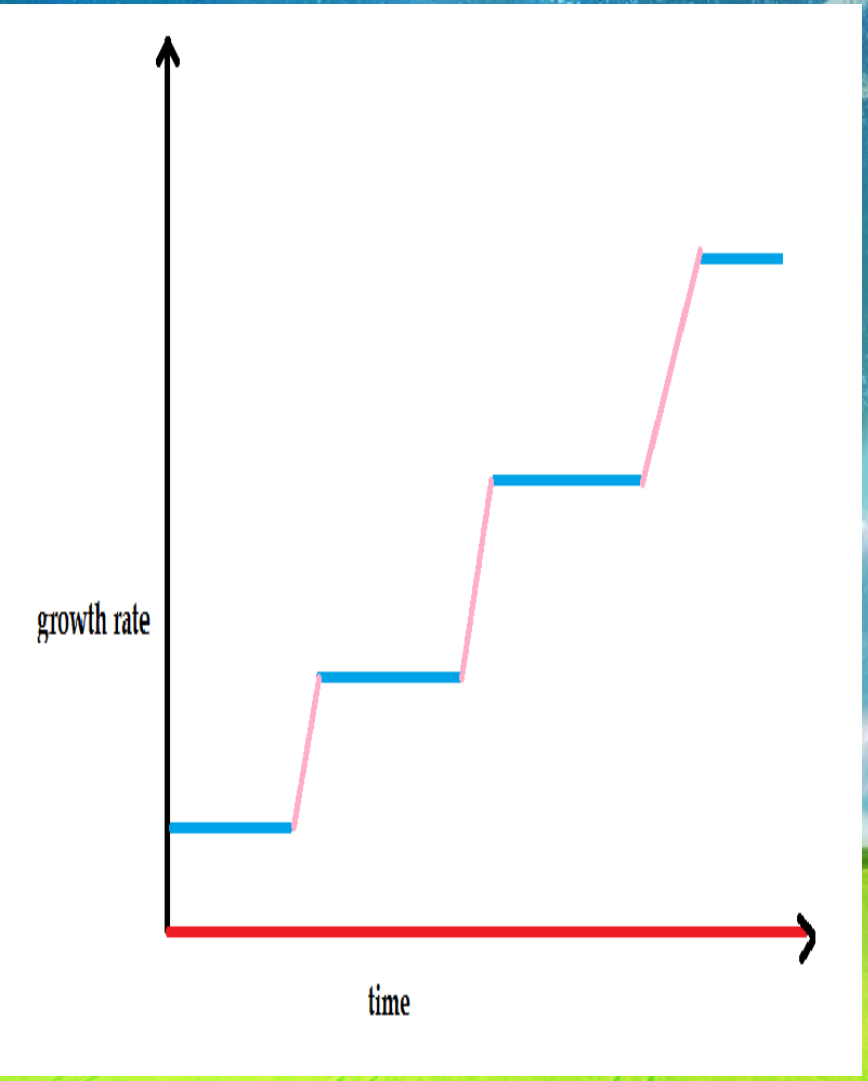


- Between C & E further increase in auxins concentration leads to decrease in root growth rate while the same concentration stimulates growth in buds and the shoot, **because roots growth is inhibited by high auxins concentrations that stimulate growth in shoots.**

Discontinuous growth curve in incomplete metamorphosis e.g. grasshopper



- As the insect moults occurs it is followed by rapid expansion of the body tissues before the exoskeleton hardens resulting into staircase or zig zag curve,
- Shows 4 instars stages and three


THANK YOU
FOR YOUR
TIME