P530/2
S.6 BIOLOGY
Paper 2
2022
2½ hours

UNNASE JOINT MOCKS 2022 GUIDE

S.6 BIOLOGY
(THEORY)

Paper 2

2 hours 30 minutes

INSTRUCTIONS:

This paper consists of sections **A** *and* **B**.

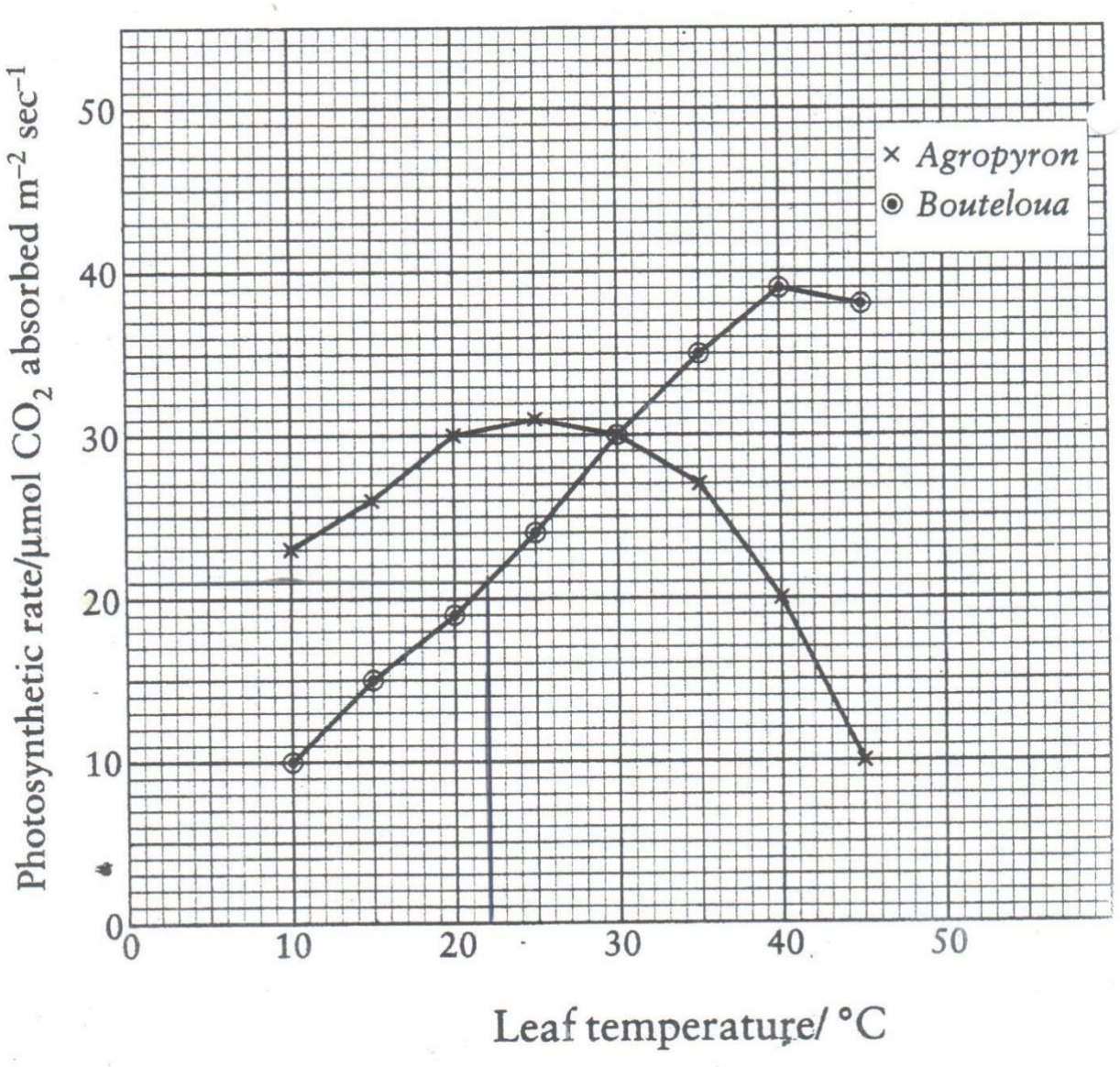
Answer question **one** *in section* **A** *plus* **three** *questions from section* **B**.

Candidates are advised to read the questions carefully, organize their answers and present them precisely and logically, illustrating with well labelled diagrams where necessary.

SECTION A: (40 MARKS)

*Question **1** is **compulsory.***

1. The graph below shows the effect of temperature on the rate of photosynthesis in two grasses, ***Agropyron*** and ***Bouteloua***



a) Compare the two curves. **(06 marks)**

Similarities:

From 10^0C to 25^0C both rates of photosynthesis increase. ;✓

At 30^0C the rate of photosynthesis for both is the same. ;✓

Both rates of photosynthesis attain a peak. ;✓ **(*Max* 03marks, so any 3)**

From 40^0C to 45^0C both rates of photosynthesis decrease. ;✓

Differences:

Photosynthesis rate for Agropyron	*Photosynthesis rate for Bouteloua*
Below 30^0C the rate of photosynthesis is higher	*lower rate of photosynthesis;*✓
From 20^0C to 25^0C the rate of photosynthesis increases gradually	*rate of photosynthesis increases rapidly. ;*✓
Rate of photosynthesis attains a peak at a lower temperature	*attains a peak at a higher temperature;*✓
Rate of photosynthesis attains a lower peak/maximum	*attains a higher peak/maximum;*✓
From 25^0C to 40^0C the rate of photosynthesis decreases	*rate of photosynthesis increases;*✓
Above 30^0C the rate of photosynthesis is lower	*rate of photosynthesis is higher;*✓
From 40^0C to 45^0C the rate of photosynthesis decreases rapidly,	*rate of photosynthesis decreases gradually;*✓ **(*Max* 03marks, so any 3)**

b) Account for the rate of photosynthesis of ***Agropyron*** from:

(i) **10 - 25°C.**

At the lowest temperature of 10^0C the rate of photosynthesis is low, ;✓ *because the photosynthetic enzymes are nearly inactivated/low activation, by near-freezing temperatures, below the optimum temperature. ;*✓

As temperature increases from 10^0C to 20^0C the rate of photosynthesis increases rapidly, ;✓ *due to rapid increase in activity of photosynthetic enzymes, ;*✓ *caused by rapid increase in kinetic energy of enzyme and substrate molecules, ;*✓ *causing rapid increase in the number of molecular collisions between the enzyme and substrate molecules, ;*✓ *hence rapid increase in the rate of formation of enzyme-substrate complexes, and thus rapid increase in catalysis. ;*✓

As temperature increases from 20^oC to 25^0C the rate of photosynthesis increases gradually, to a peak, ;✓ *because 25^0C is the optimum temperature for enzyme activity, ;*✓ *and as it is neared temperature begins to cease being a limiting factor, ;*✓ *and other factors, such as light intensity and carbon dioxide concentration, are become limiting. ;*✓ **(*Max* 10 marks)**

(ii) **25 - 45°C.**

As temperature increases from 25^0C to 35^0C, the rate of photosynthesis decreases gradually, ;✓ *as few enzymes become denatured, due to heating beyond the optimum temperature, causing slight breakage of the bonds determining the shape of the enzymes' active site. ;*✓

From 35^0C to 45^0C the rate of photosynthesis decreases rapidly, ;✓ as many enzymes are denatured, by excessive heating further beyond the optimum temperature due to severe breakage of the bonds determining the shape of the enzymes' active site. ;✓

In addition, at higher temperatures there is increased photorespiration, excessive water loss, and carbon dioxide concentration becomes limiting;✓ **(*Max* 04 marks)**

c) i) Describe the photosynthetic mechanism which is likely to occur in the cytoplasm of the mesophyll cells of ***Bouteloua***.

The mechanism occurring in the cytoplasm of the mesophyll cells of Bouteloua is the Hatch-Slack pathway, involving C_4 carbon dioxide fixation. ;✓

The carbon dioxide–acceptor Phosphoenol pyruvate/PEP reacts with carbon dioxide, to form Oxaloacetate, ;✓ under catalysis of Phosphoenol pyruvate carboxylase/PEP carboxylase. ;✓

Oxaloacetate is reduced by Hydrogen, donated by Reduced Nicotinamide Adenine Dinucleotide Phosphate/$NADPH_2$, ;✓ to form Malate, ;✓ and release Nicotinamide Adenine Dinucleotide Phosphate/NADP, under catalysis of Malate dehydrogenase enzyme. ;✓ **(*Max* 05 marks)**

ii) Explain the physiological significance of the mechanism described in (e) (i) above.

PEP carboxylase has a high affinity for carbon dioxide, leading to a high rate of carbon dioxide fixation and high photosynthetic efficiency. ;✓

PEP carboxylase does not accept oxygen, so photorespiration does not occur;✓ hence there is no wasteful loss of carbon and energy, increasing photosynthetic efficiency.

The Malate shunt functions as a carbon dioxide pump, ;✓ increasing the concentration of carbon dioxide in the Bundle sheath cells, thus increasing the efficiency with which Ribulose bisphosphate carboxylase/RuBP carboxylase works.

The Malate shunt functions as a hydrogen pump, ;✓ since Malate carries hydrogen from Reduced Nicotinamide Adenine Dinucleotide Phosphate/$NADPH_2$ in the mesophyll cells to Nicotinamide Adenine Dinucleotide Phosphate/NADP in the Bundle sheath cells, where $NADPH_2$ is regenerated, increasing the amount of Hydrogen in the Bundle sheath cells. **(*Max* 04 marks)**

d) Basing on the <u>data provided,</u> outline the physiological and ecological advantages of ***Bouteloua*** over ***Agropyron***.

Physiological advantages of Bouteloua over Agropyron

Bouteloua does not carry out photorespiration, while Agropyron undergoes photorespiration;✓

From 25^0C to 40^0C the rate of photosynthesis of Bouteloua increases, while that of Agropyron decreases.;✓

Bouteloua has a higher maximum rate of photosynthesis than Agropyron;✓

Bouteloua is more tolerant to higher temperatures than Agropyron. ;✓

Bouteloua is more efficient in food production at higher temperatures than Agropyron. ;✓

Bouteloua is more efficient in water conservation than Agropyron. ;✓

Light saturation in Bouteloua takes place at much higher light intensities than in Agropyron. ;✓

Bouteloua is more tolerant to low carbon dioxide concentrations than Agropyron. ;✓

Bouteloua is more tolerant to high oxygen concentrations than Agropyron. ;✓ **(*Max* 04 marks)**

Ecological advantages of Bouteloua over Agropyron

Bouteloua more efficiently exploits higher light intensities and higher temperatures of tropical regions than Agropyron. ;✓

Bouteloua is more tolerant of hot and dry conditions than Agropyron. ;✓

Bouteloua occurs in larger numbers at lower altitudes than Agropyron; since at lower altitudes oxygen tension is higher, light intensities and temperatures are higher, conditions which encourage photorespiration in Agropyron. ;✓ **(*Max* 02 marks)**

e) What is meant by **CAM**. **(05 marks)**

CAM is Crassulacean Acid Metabolism, ;✓ a type of metabolism occurring in succulents such as pineapples, stonecrops, and cacti, involving incorporation of carbon dioxide into organic compounds, such as citrate, and malate, in hours of darkness, when stomata are open. ;✓

In the light, when stomata are closed, ;✓ these compounds undergo decarboxylation, releasing carbon dioxide within the leaf for production of sugars in chloroplasts via the C_3/Melvin-Calvin pathway. ;✓

The Inverted stomatal rhythm reduces water loss, enabling CAM plants to survive in extremely dry conditions, ;✓ such as deserts where annual rainfall is very low, and days are hot, sunny and dry.

However, CAM photosynthesis is not very efficient, leading to very slow plant growth, ;✓ and so CAM plants cannot compete well with C_3 and C_4 in areas with plenty of water. **(*Max* 06 marks)**

SECTION B (60 MARKS)

2. a) Explain how variation in light intensity affects exchange of gases between the leaf cells and the atmosphere

Low light intensity causes low rate of exchange of gases;✓ because it stimulates opening of a few or no stomatal pores;✓ across which a small volume of carbondioxide diffuses from the atmosphere to the mesophyll cells. ;✓ It also leads to a low rate of photosynthesis, ;✓ thus little volume of oxygen is released as a biproduct. ;✓ Thus low rate of diffusion of oxygen from mesophyll cells to atmosphere via stomatal pores and low uptake of corbondioxide from the air to the palisade mesophyll cells. ;✓

High light intensity causes a high level of gaseous exchange ;✓between the mesophyll cells and the atmosphere by stimulating wide opening of many stomatal pores;✓ via which a large amount of carbon dioxide diffuses from the atmosphere to the mesophyll cells to meet the high demand of carbon dioxide to maintain a high rate of photosynthesis. ;✓ Since oxygen is a biproduct of photosynthesis, a high rate of photosynthesis leads into a high concentration of oxygen;✓ which diffuses from the mesophyll cells to the atmosphere via the stomatal pores. ;✓ **(*Max* 10marks)**

b) Describe how non specificity of photosynthetic enzymes affects plant productivity

Since Ribulose bisphosphate Carboxylase-Oxygenase enzyme;✓ involved in the Calvin cycle has a high affinity for both Oxygen and Carbon dioxide, ;✓ due to possession of non-specific active sites ;✓where it can catalyse the fixation of both carbon dioxide and oxygen by RuBP;✓ resulting into varying productivity. ;✓

Under conditions of high light intensity (High light intensity leads to high photosynthesis where biproduct oxygen accumulates in mesophyll cells competitively inhibiting carboxylation of RuBP), high temperature, and high oxygen concentration, ;✓RUBISCO catalyses the fixation of oxygen rather than carbon dioxide in C3 plants ;✓resulting into the formation of a 2C compound phosphoglycolate and little phosphoglycerate;✓ during photorespiration hence production of a small amount of carbohydrates, resulting into low productivity. ;✓

But at low light intensity, low temperature and low carbondioxide concentration, ;✓RUBISCO catalyses fixation of carbon dioxide instead of oxygen ;✓resulting into formation of only phosphogycerate;✓ and hence a large amount of carbohydrates resulting in high productivity. ;✓ **(*Max* 10marks)**

3. a) Compare the spores of a moss plant with the pollen grains of angiosperms.

Similarities

Both are haploid; ;✓ nucleated; ;✓ produced by meiosis; ;✓ produced in large quantities: ;✓ reproductive units;✓ and both can remain dormant for longer periods;✓ **(*Max* 05 marks)**

Differences:

Spore of a moss	*Pollen grain of angiosperm*
Has one nucleus	*has two nuclei;✓*
Produced inside sporangia	*produced inside anthers;✓*
Grows anywhere damp and moist	*germinates only on stigma of compatible species;✓*
Thin outer covering	*thick outer covering;✓*

Only dispersed by wind	*both wind and insects are agents;*✓
Relatively smaller	*relatively larger;*✓
Single covering	*double covering;*✓
Non ruptured outer most covering	*Ruptured outer most covering;*✓ **(*Max* 05 marks)**

b) Explain how the formation of a seed in angiosperms has contributed to their evolutionary success

The seed has a rich store of food; on which the embryo is nourished; ;✓*until it becomes self supportive; after germination;*✓*. This increases survival and hence evolutionary potential.*

Seeds have embryo protective structures like cotyledons and seed coat;✓ *which enhances embryo survival ;*✓*promoting evolutionary success over generations.*

Seeds are modified in a number of ways to aid dispersal; ;✓ *for plants to colourise new areas; ;*✓ *hence increasing chances of survival and evolution.*

Fertilization which forms seeds does not require water;✓ *a rare resource on land hence easily formed on land;*✓*which increase evolutionary success.*

Seeds are hardy in nature;✓ *hence not easily destroyed by the harsh terrestrial condition;*✓*swhich enhances evolutionary survival.*

Maturation of seeds requires minimal water; ;✓*this supports angiosperms to live a successful life in a terrestrial environment; ;*✓

Seeds can remain dormant; ;✓*to allow angiosperms survive harsh weather conditions;*✓*which increases evolutionary survival*

Seed formation involves fertilization which is associated with gene mixing;✓*which increases variations and vigour;*✓ *promoting evolutionary success.* **(*Max* 10 marks)**

4. a) Explain the glowing eyes of the cat at night, when shone with light.

The eyes have a layer called tapetum lucidum;✓ *(reflecting layer) behind the retina;*✓*, which reflects light back into the eyeball;*✓ *for its maximum absorption by the rods;*✓ *in order to improve vision in dim light. ;*✓ **(05 marks)**

b) Account for the sensitivity of rods towards light.

The rods have a high sensitivity towards light because their photosensitive pigment of rhodopsin is easily and readily decomposed;✓ *by even low intensity light scotopsin and retinene.*

The rhodopsin is also rapidly regenerated;✓ in dim light after bleaching which makes the rods gain the high sensitivity.

The rods also exhibit the high sensitivity because they undergo convergence and summation, ;✓ such that once simultaneously stimulated by low intensity light, each of them develops a generator potential below a threshold but which generator potentials are summed up to raise the threshold generator potential and firing of impulses to the brain.

The even distribution of the rods along the retina;✓ increases chances of light landing on the rods hence increasing their sensitivity.

The rods also contain more mitochondria and vesicles;✓ for more ATP and rhodopsin synthesis respectively which increase their sensitivity. **(05 marks)**

c) Describe the physiological behavior of a rod in darkness. **(10 marks)**

The photoreceptor rod is not stimulated; ✓ and there is no photo decomposition of the rhodopsin due to lack of light. ;✓

The Na+ pump of the inner segment of the rod actively pumps out sodium ions;✓ of the rod cell thereby creating a sodium gradient between the inside and the outside of the cell. ;✓

Since the surface membrane of the outer segment is permeable to the Na+,;✓ some Na+ diffuse back into the rod cell ;✓ thereby reducing the negative potential of the inside rod cell. ;✓

This leads to maximum release of the excitation neurotransmitter substance, ;✓ mainly glutamate, at the terminal end ;✓ which maintain the resting potential of the bipolar neuron and ganglion cell, ;✓ hence no impulses firing to the brain;✓ **(Max 10 marks)**

5. a) Describe the changes in the;

i) pressure potential, of the plasmolysed plant cell when inserted in a hypotonic solution

Pressure potential is inward pressure exerted by the cell wall against the protoplast due to osmotic influx of water into the plant cell. ;✓ Since the protoplast of the plasmolysed plant cell is not pressing against the cell wall, the pressure potential is zero. ;✓

With osmotic influx of water into the cell, the protoplast expands until it begins to press against the cell wall. ;✓

The pressure potential increases due to inward pressure exerted by the cell wall to resist the protoplast expansion ;✓ until maximum pressure potential is reached when no more water is allowed to enter;✓ because the protoplast can no longer be allowed to expand anymore by the tough, rigid cellulose cell wall at full turgor. ;✓ **(Max 06 marks)**

ii) water potential of the plasmolysed plant cell when inserted in a hypotonic solution

Water potential is the tendency of water molecules to move from one place to another. ;✓Since the plasmolysed cell is not pressed against the cell wall, pressure potential is zero, it has low water potential ;✓ (more negative water potential).

Due to osmotic influx of water into the plant cell the protoplast expands, ;✓ increase in the amount of water molecules in the cell increases its water potential. ;✓

With further osmotic influx of water into the cell, the protoplast expands and exerts a force against the cell wall, thereby increasing the pressure potential of the cell. ;✓

Increase in the volume of water and pressure potential rapidly increases the water potential;✓ until it becomes zero; ;✓ (i.e the maximum of pure water due to maximum pressure potential) **(Max 06 marks)**

b) Account for the negative water potential of any solutions.

Since the maximum water potential of pure water is zero ;✓ addition of solutes to pure water to form a solution reduces the water potential to more negatives;✓ Since water is polar; ;✓ addition of solutes increases the electrostatic forces of attraction;✓ between its molecules and the solutes;✓ thereby reducing its kinetic energy;✓ and freedom of movement;✓ which reduces the water potential to more negative values. ;✓ **(08 marks)**

6. In cats, short hair is dominant over long hair. The gene involved is autosomal. Another gene which is sex linked produces hair colour, its alleles produce black or white coat colour and the heterozygote combination produces tortoise shell coat colour.

a) If a long haired black male is mated with a tortoise shelled female homozygous for short hair, what kind of off spring will be produced in F1?

Let XX represent the female sex Chromosome pair; ;✓
Let XY represent the male sex Chromosome pair

Let H represent the allele for short hair ;✓
Let h represent the allele for long hair

Let B represent the allele for black coat colour ;✓
Let W represent the allele for white coat colour

Parents: ♂ ♀

Parental phenotypes: ***long-haired, black male X tortoise-shelled, short-haired female*** ;✓

Parental genotypes (2n): ***X^BY hh or (hhX^BY)*** ***X^BX^WHH or (HHX^BX^W)*** ;✓

Meiosis:

Gametes (n): *all* ***X^B h*** ***Y h*** ***all*** ***X^B H*** ***X^WH*** ;✓

Random fertilization: ;✓

F1 genotypes (2n): ***X^BX^BHh*** ***X^BX^WHh*** ***X^BYHh*** ***X^WY Hh*** ;✓

F1 phenotypes: *1 short-haired, black female: 1 short-haired, tortoise-shelled female:*
1 short-haired, black male: 1 short-haired, white male ;✓

NB. If X sign missed, student just loses half mark, if instead of XX and XY xx and xy used ie small scale, the cross is not marked, X^BY hh or hhX^BY are okay, Gametes not genotypes to be circled, if genotypes circled, marking stops there. Other allele letters are ok. **(09 marks)**

b) i) If the F1 cats are allowed to interbreed freely among themselves, what are the chances of obtaining long haired males?

NB colour is not an issue in this question

Parents: ♂ ♀

Parental phenotypes: ***short-haired male X short-haired female*** ;✓

Parental genotypes (2n): ***XY Hh or (HhXY)*** ***XXHh or (HhXX)*** ;✓

Meiosis:

Gametes (n): ***XH*** ***Xh*** ***YH*** ***Y h*** ***all*** ***X H*** ***Xh*** ;✓

Random fertilization and offspring genotype

♂ / ♀	*XH*	*Xh*	*YH*	*Yh*
	XXHH	*XXHh*	*XYHH*	*XYHh*;✓

XH				
Xh	*XXHh*	*XXhh*	*XYHh*	*XYhh;*✓

F1 phenotypes: 3 short-haired females, one long haired female, 3 short haired males and 1 long haired male. ;✓

Chances of obtaining a long haired male are hence 1/8 ;✓ **(07 marks)**

ii) Using specific examples, describe the common effects of mutations.

Mutation is the sudden, spontaneous and unpredictable change in the amount, arrangement, or structure of the DNA of an organism. ;✓

Mutation leads to increased genetic variation in the gene pool of a population which increases chances of survival and evolution;✓

Somatic mutations occur in somatic cells that do not produce gametes and are only inherited by daughter cells produced by mitosis. They are lost when the organism dies, but cause many forms of cancers. ;✓

Diseases like sickle cell anaemia are a result of mutations distorting formation of essential body proteins. They mainly distort genes determining formation of the primary structure of proteins. ;✓

Disorders many disorders like Down syndrome, Klinefelter's syndrome and Turner's syndrome are a result of change in number of chromosomes mutation. ;✓

Since mutations form abrupt changes in the DNA, they often form new recessive genes which increase the number of heterozygotes in the population. ;✓

New traits arise from the abrupt changes in organisms' DNA;✓

Gene reshuffling which is rearrangement of genes into new gene combinations in gametes also may arise from the random changes in the DNA of an organism. ;✓

Forms polyploids which lead to increased yield, evolution potential, maturation, survival and increased resistance to diseases, drought, pests, weeds. ;✓

Mutations occurring in gamete cells and gamete-producing germ cells are inherited by subsequent generations, and contribute to evolution. ;✓

Mutations also lead to a change in allele frequency in the population gene pool from generation to generation. ;✓ **(Max 04 marks)**

⋆⋆⋆⋆**End**⋆⋆⋆⋆