AP Bio FRQ Fridays

2023 #2
Mitochondria, Data Analysis, & Effect of CO_2 levels

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Elevated levels of CO_2 increase the rate of photosynthesis and growth in plants. Scientists studying the mechanisms involved in these increases examined a variety of species and found that when plants are exposed to elevated levels of CO_2, there is an increase in the number of chloroplasts per cell. To investigate whether the elevated levels of CO_2 have a similar effect on the number of mitochondria in plant cells, the scientists then selected six of these species to quantify the number of mitochondria per cell when the plants were exposed to both normal and elevated levels of CO_2 (Table 1).

TABLE 1. AVERAGE NUMBER OF MITOCHONDRIA IN PLANTS EXPOSED TO NORMAL AND ELEVATED LEVELS OF CO_2

Species	Mitochondria at Normal CO_2 (per 100 μm^2 of cell area) $\pm 2SE_{\bar{x}}$	Mitochondria at Elevated CO_2 (per 100 μm^2 of cell area) $\pm 2SE_{\bar{x}}$
1	1.0 ± 0.10	1.6 ± 0.10
2	0.4 ± 0.05	0.9 ± 0.08
3	0.5 ± 0.07	0.9 ± 0.10
4	0.3 ± 0.03	0.6 ± 0.06
5	0.7 ± 0.06	1.5 ± 0.22
6	1.3 ± 0.15	2.4 ± 0.22

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(a) **Describe** the role of the inner mitochondrial membrane in cellular respiration.

Accept one of the following:

- It provides the location for the components of the electron transport chain/ATP synthase/oxidative phosphorylation.
- It separates (reactions in) the intermembrane space from (reactions in) the matrix.
- It allows the establishment of a proton gradient.

a) The inner mitochondrial membrane (cristae) is used for the electron transport chain, which is essential to create the proton concentration gradient for the production of ATP.

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(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. **Determine** which species show(s) a difference in the number of mitochondria between normal and elevated levels of CO_2.

TABLE 1. AVERAGE NUMBER OF MITOCHONDRIA IN PLANTS EXPOSED TO NORMAL AND ELEVATED LEVELS OF CO_2

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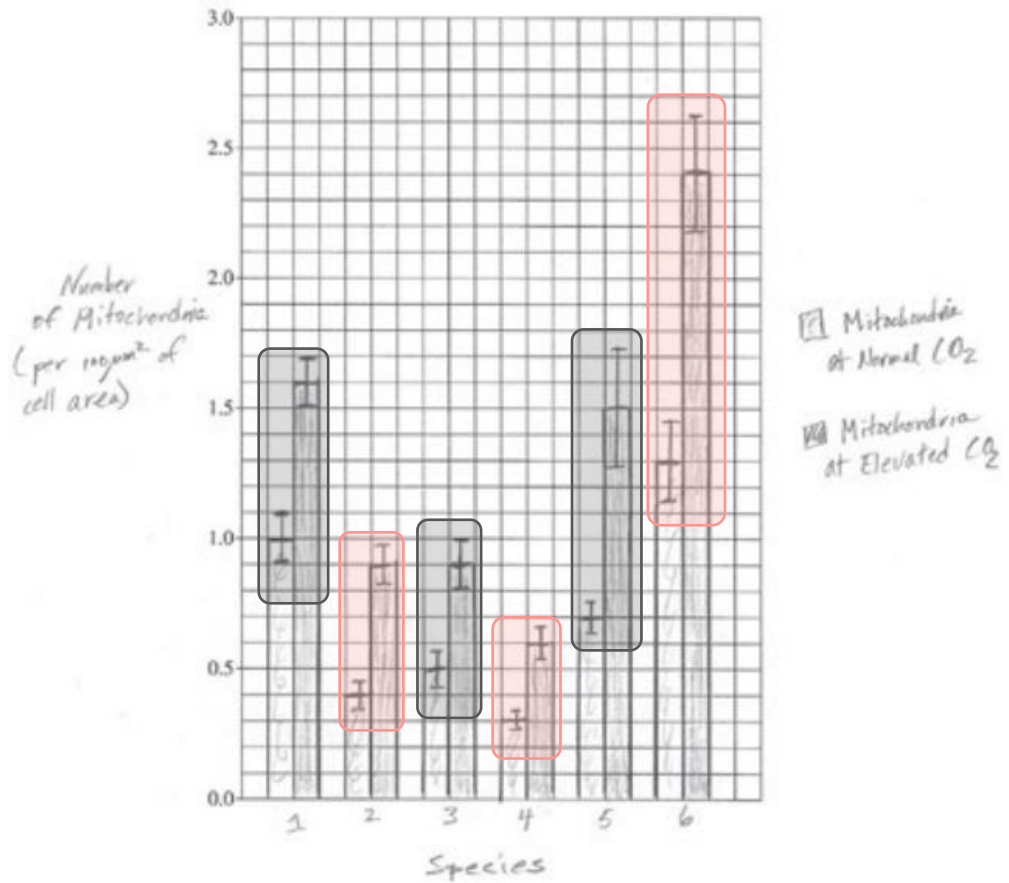
(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. **Determine** which species show(s) a difference in the number of mitochondria between normal and elevated levels of CO_2.



- Appropriate labelling
- Data are represented in a bar/modified bar graph.
- Data points and error bars are correctly plotted.

- All of the species

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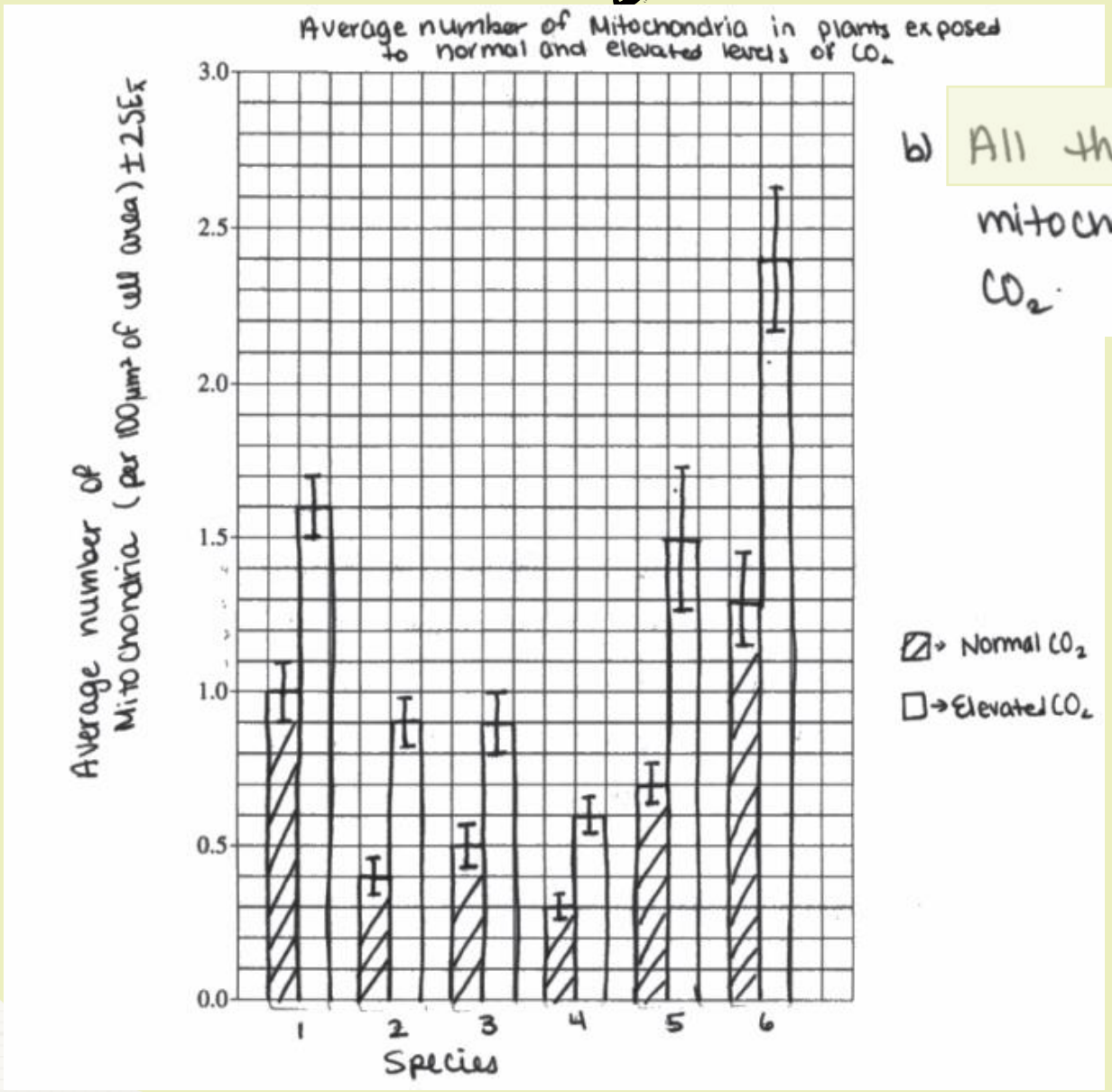

b) All the species show significant difference in the number of mitochondria between normal and elevated levels of CO_2.

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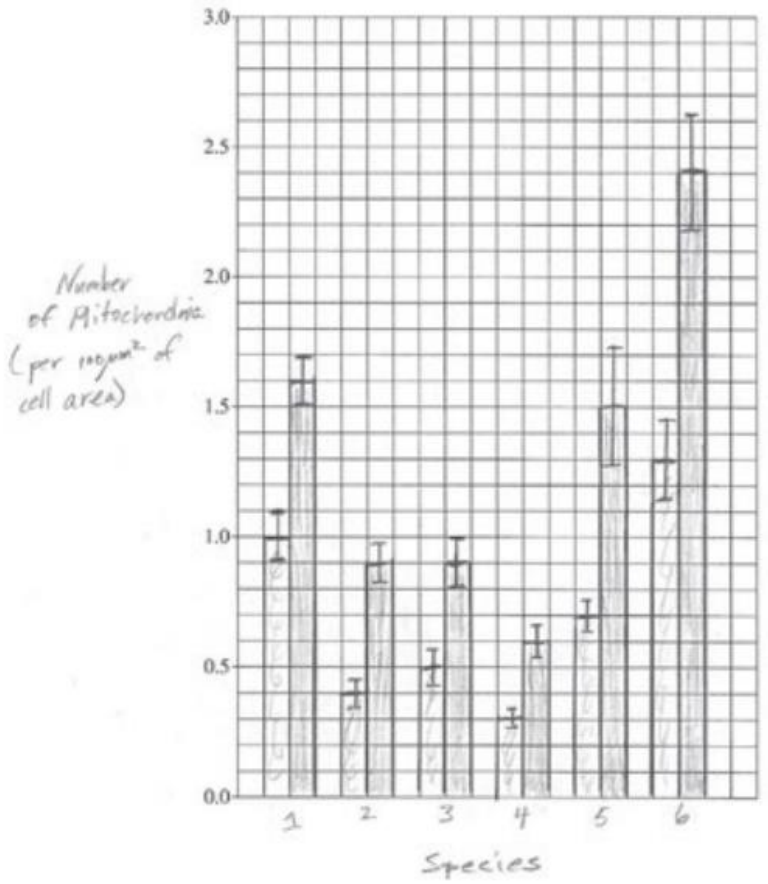
(c) Based on the data in Table 1, **describe** the relationship between the level of CO_2 and the average number of mitochondria per unit area of a cell.



Accept one of the following:

- The number of mitochondria is greater under conditions of elevated CO_2 (than under normal CO_2).
- It is a positive relationship/correlation.

c) Levels of CO_2 and average number of mitochondria per unit area of ~~the~~ a cell have positive correlation because ~~as~~ the plants with higher CO_2 levels have ~~more~~ greater number of mitochondria per unit

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(d) The leaves of a particular plant species are typically green, but scientists notice a plant in which the leaves have white stripes. They determine that the stripes result from a mutation in mitochondrial DNA that interferes with the development of chloroplasts. The scientists crossed plants using pollen from the plant with white-striped leaves and ovules from a plant with green leaves. **Predict** the phenotype(s) of the leaves of offspring produced from this cross. Provide reasoning to **justify** your prediction. **Explain** why plants with the same genotype are able to differ in the structure and/or number of certain organelles in response to changes in atmospheric levels of CO_2.

from a plant with green leaves. **Predict** the phenotype(s) of the leaves of offspring produced from this cross.

- The leaves will be (all) green/not have white stripes.

Provide reasoning to **justify** your prediction.

- (All offspring will have the same leaf phenotype as the ovule-producing plant because) mitochondria are maternally inherited/transferred by the ovule.

Explain why plants with the same genotype are able to differ in the structure and/or number of certain organelles in response to changes in atmospheric levels of CO_2.

- (Plants have different phenotypes because) changes in CO_2 levels/the environment affect the expression of certain genes.

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d) Phenotype of the leaves of the offspring would be green. That is because mutations in mitochondrial DNA can only be passed from the female parent. Plants with same genotype are able to differ in structure and/or number of organelles in response to levels of CO_2 because different factors play a role in phenotypes or and gene expression of organisms. Since CO_2 is an important factor, it could have an effect.