AP Bio FRQ Fridays

2016 #2
Rate, Population Growth, & Regulation of Gene Expression

NOTES

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Bacteria can be cultured in media with a carefully controlled nutrient composition. The graph above shows the growth of a bacterial population in a medium with limiting amounts of two nutrients, I and II.

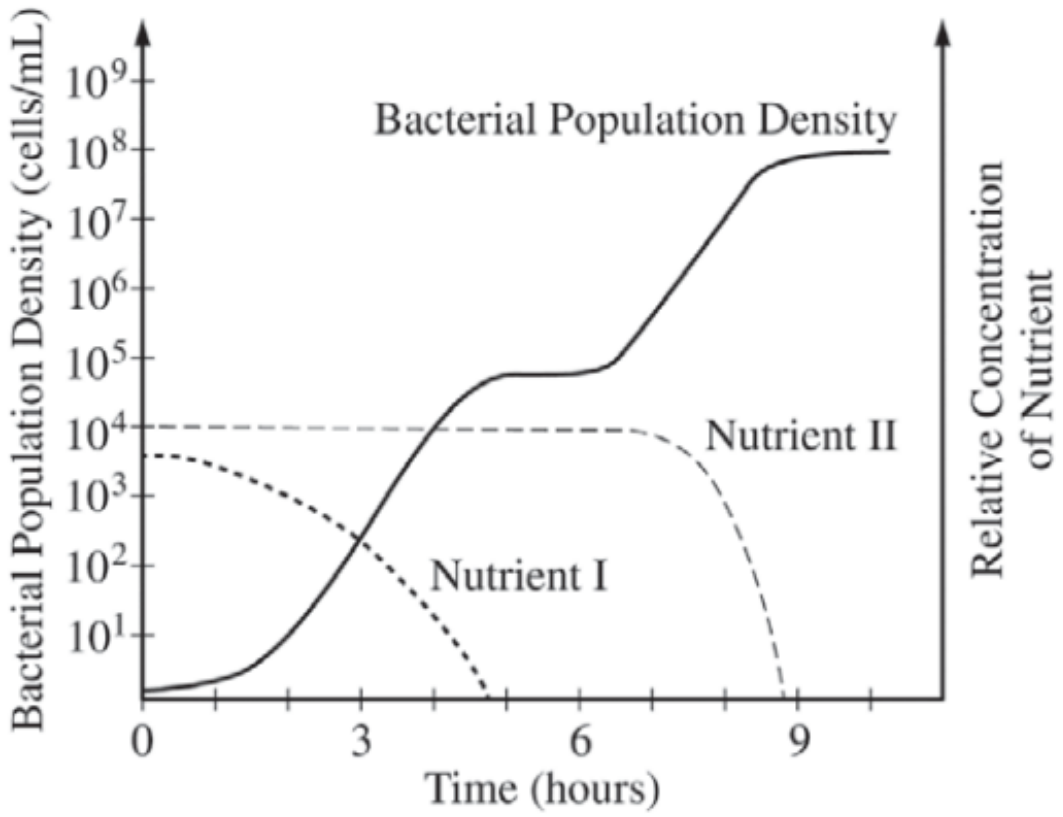

Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

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(a) **Estimate** the maximum population density in $\frac{\text{cells}}{\text{mL}}$ for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.

Estimate (1 point)

- 10^8

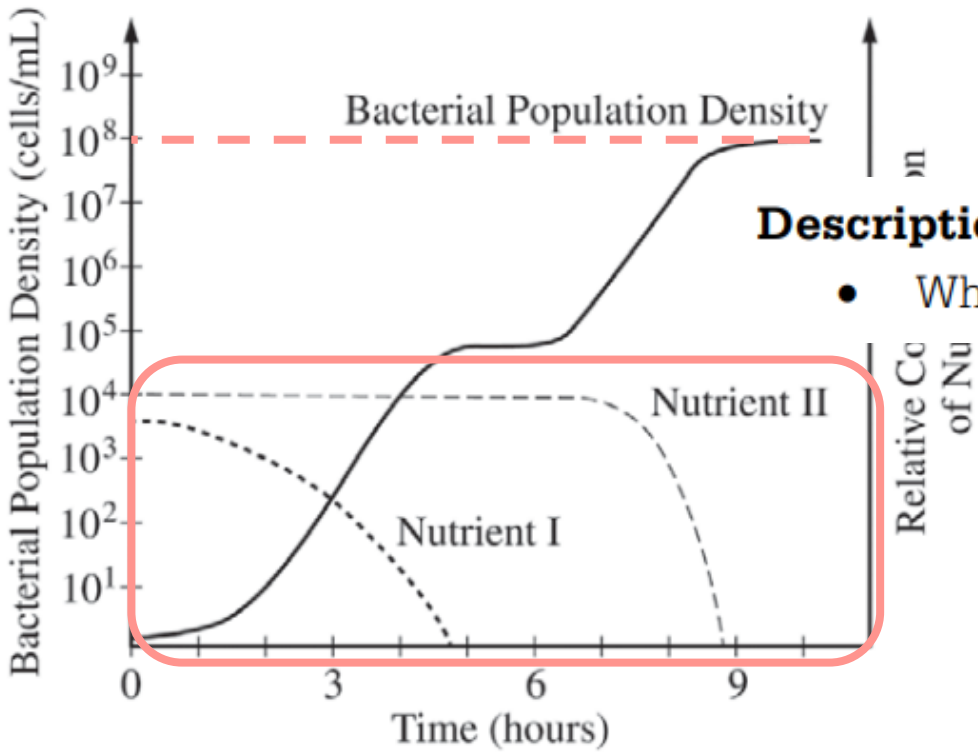

Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

Description (1 point)

- When both nutrients are depleted

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Estimate (1 point)

- 10^8

Description (1 point)

- When both nutrients are depleted

The maximum bacterial population density is 10^8 cells/mL in this culture. Further growth beyond this point is prevented by limited resources; both nutrient 1 and nutrient 2 are entirely depleted.

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(b) Using the data, **calculate** the growth rate in $\frac{\text{cells}}{\text{mL}\times\text{hour}}$ of the bacterial population between hours 2 and 4.

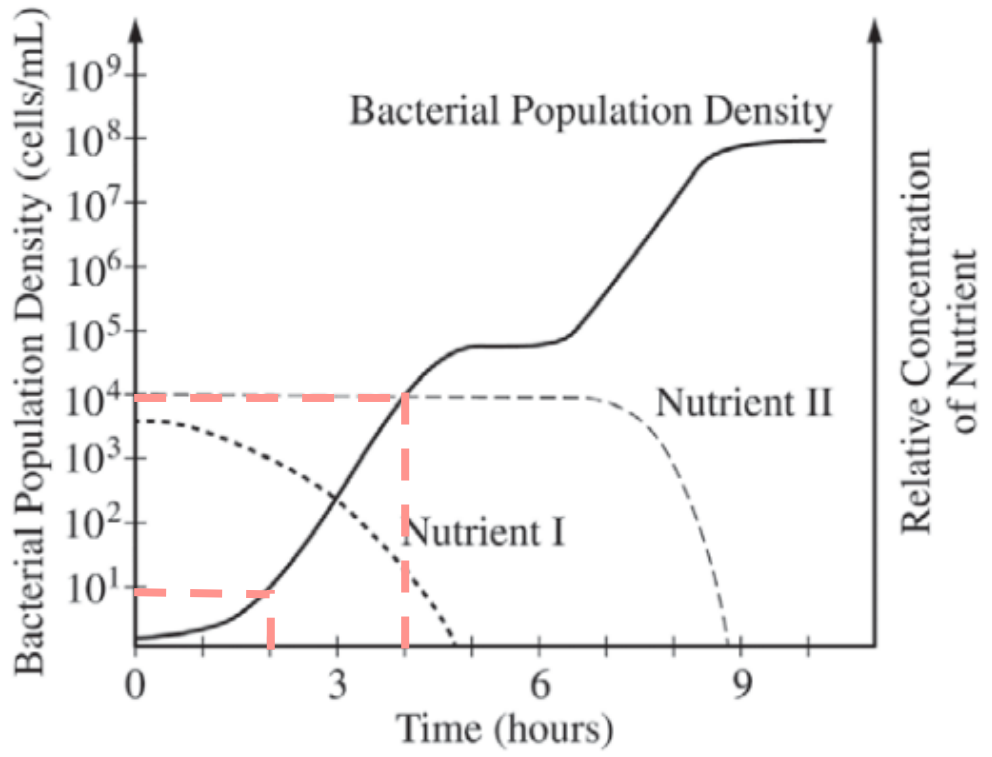

Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

$$rate = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$rate = \frac{10^4 - 10^1}{4 - 2} = \frac{10000 - 10}{4 - 2}$$

$$rate = \frac{9990}{2} = 4995$$

Calculation (1 point)

- 4,995

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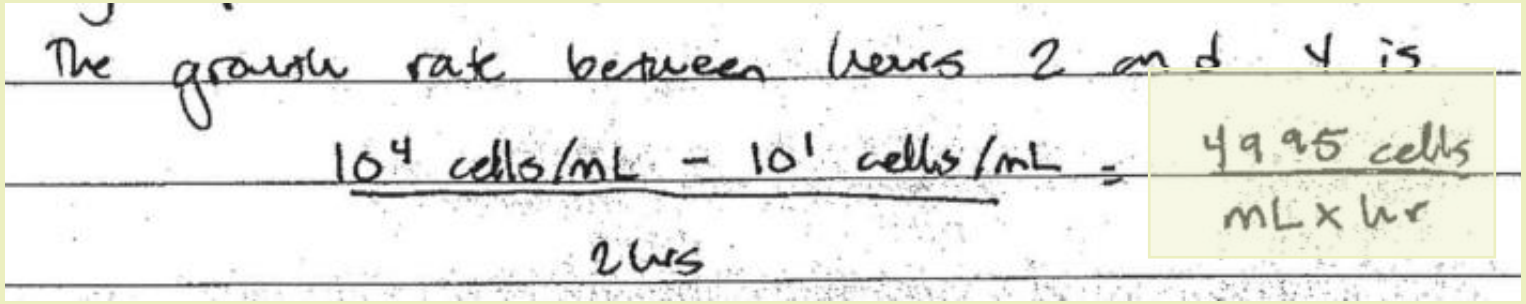
Calculation (1 point)

- 4,995



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(c) **Identify** the preferred nutrient source of the bacteria in the culture over the course of the experiment. Use the graph to **justify** your response. **Propose** ONE advantage of the nutrient preference for an individual bacterium.

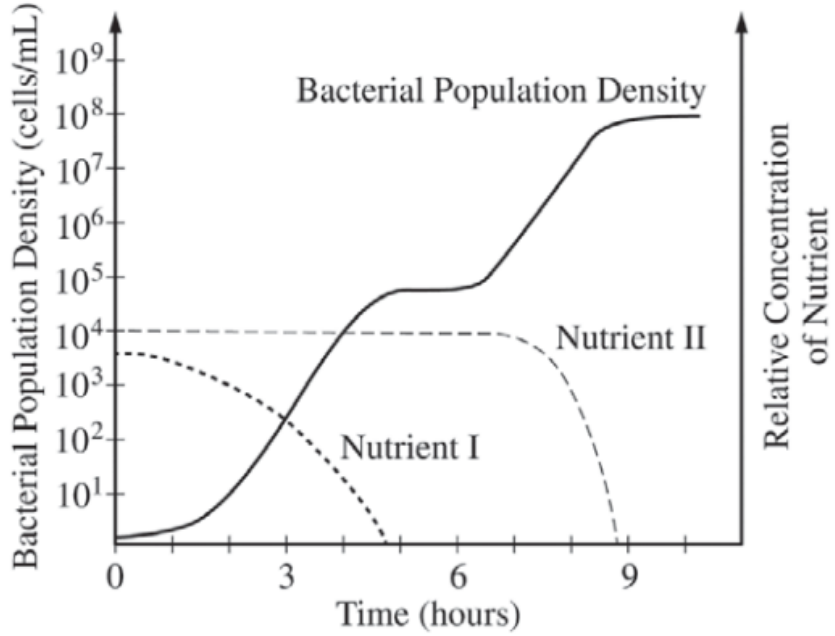

Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

Identification (1 point)

- Nutrient I is the preferred nutrient.

Justification (1 point)

- When both nutrients are present in the growth medium, only nutrient I is used.
- Nutrient II is only used after nutrient I is depleted.

Proposed advantage (1 point)

- Do not spend energy making enzymes/proteins that the cell doesn't need.
- Do not have to express all metabolic genes at once.
- The preferred nutrient provides more energy.

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The bacteria prefer nutrient I, as evidenced by the fact that they consume nutrient I first, as shown by nutrient I's depletion prior to nutrient II's depletion. The amount of nutrient II only begins to decline, & be consumed, once nutrient I is already gone. Nutrient I probably is a more efficient source of energy, or, in other words, requires the bacteria to expend less energy relative to the energy gained from the nutrient. This preference would be an advantage to an individual bacterium because it could then expend more energy on reproduction.

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(d) **Describe** how nutrient I most likely regulates the genes for metabolism of nutrient I and the genes for metabolism of nutrient II. **Provide** TWO reasons that the population does not grow between hours 5 and 6.

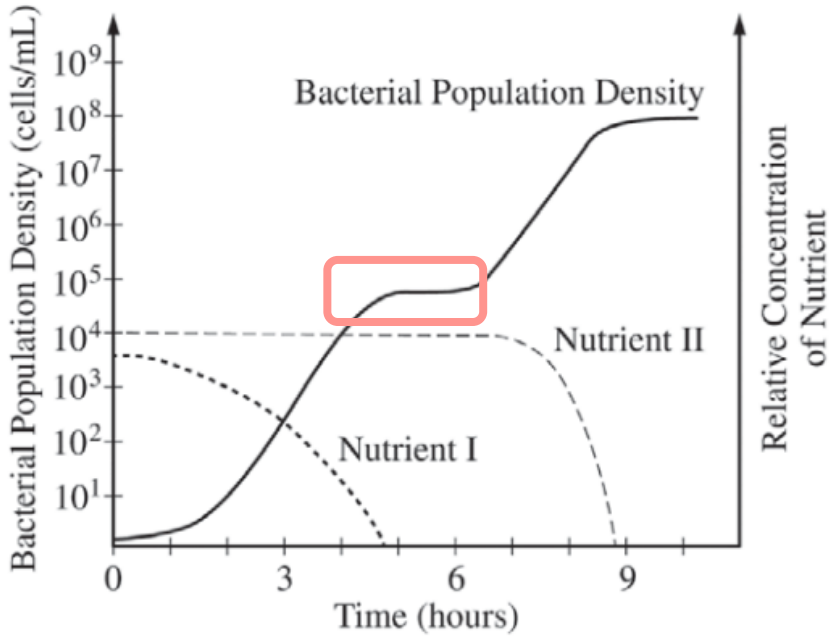

Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

Description (2 points)

- Nutrient I promotes expression of genes required for metabolism of nutrient I.
- Nutrient I represses expression of genes required for metabolism of nutrient II.

Reasoning (2 points)

- Nutrient I is depleted from the growth medium OR neither nutrient is being consumed.
- Takes time to produce proteins/enzymes required to metabolize nutrient II.

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When nutrient I is present in the environment, it turns on the genes that allow the bacteria to digest nutrient I. It probably does this by activating a phosphorylation cascade that produces a molecule that binds to the promoter and allow RNA polymerase to bind. This allows the genes to be transcribed, leading to the uptake and consumption of nutrient I. At the same time, nutrient I probably also prevents the genes for digesting nutrient II from being transcribed, giving the bacteria a preference for nutrient I. It probably does this through a phosphorylation cascade that produces an inhibitor that prevents RNA polymerase from binding to the genes for nutrient II. Only when nutrient I is absent will nutrient II be absorbed.

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absorbed.

The population does not grow between hours 5 and 6 because it is not consuming nutrients. It could not be consuming nutrient II because it takes time for the inhibitor caused by nutrient I to be released so that the genes for ~~digesting~~ consuming nutrient II can be transcribed. Alternately, the inhibitor could be released quickly, but the proteins to uptake nutrient II could take a long time to produce, and thus the population does not consume nutrients for that hour. Perhaps the bacteria have a mechanism for waiting after the depletion of nutrient I to see if more nutrient will become available before turning to nutrient II.