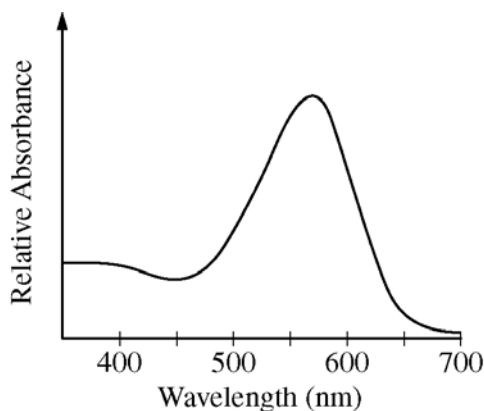
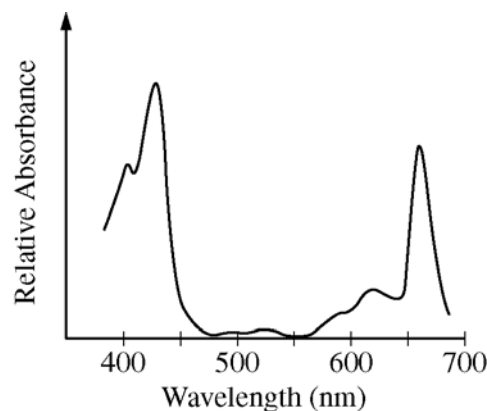


2013 AP[®] BIOLOGY FREE-RESPONSE QUESTIONS



Graph I



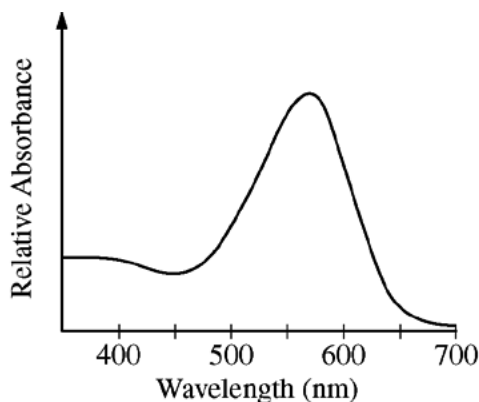
Graph II

| Color | Wavelength (nm) |
|--------|-----------------|
| Violet | 380–450 |
| Blue | 450–475 |
| Cyan | 475–495 |
| Green | 495–570 |
| Yellow | 570–590 |
| Orange | 590–620 |
| Red | 620–750 |

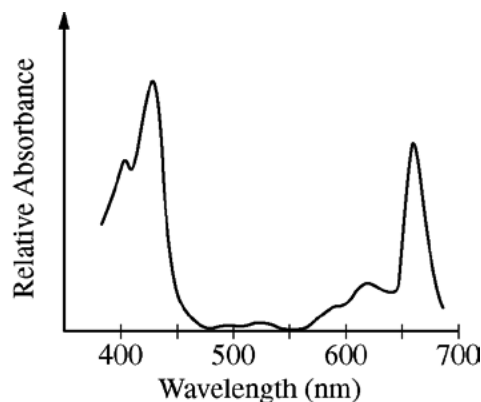
2. An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.
- Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer.
 - In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions.
 - Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum.

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Question 2



Graph I



Graph II

| Color | Wavelength (nm) |
|--------|-----------------|
| Violet | 380–450 |
| Blue | 450–475 |
| Cyan | 475–495 |
| Green | 495–570 |
| Yellow | 570–590 |
| Orange | 590–620 |
| Red | 620–750 |

An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.

- (a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer. (3 points maximum)

1 point per box

Identify BOTH pigments:

Graph 1 = bacteriorhodopsin AND graph 2 = chlorophyll *a*

Explain that an organism containing bacteriorhodopsin appears purple because the pigment absorbs light in the green range of the light spectrum and/or reflects violet or red and blue light. The reflected red and blue light appears purple.

Explain that an organism containing chlorophyll *a* appears green because the pigment absorbs light in the red and blue ranges of the light spectrum and/or reflects green light.

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Question 2 (continued)

- (b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions. (5 points maximum)

| Wavelength (Group) | Prediction (1 point each box) | Justification (1 point each box) |
|-----------------------------------|----------------------------------|---|
| 650 nm (1 st Group) | Intermediate rate | An intermediate level of absorption occurs at 650 nm (compared to 430 nm and 550 nm); <i>therefore</i> , an intermediate amount of energy is available to drive photosynthesis. |
| 550 nm (2 nd Group) | Lowest rate | The lowest level of absorption occurs at 550 nm; <i>therefore</i> , the least amount of energy is available to drive photosynthesis. |
| 430 nm (3 rd Group) | Highest rate | The highest level of absorption occurs at 430 nm; <i>therefore</i> , the greatest amount of energy is available to drive photosynthesis. |

NOTE: A student who combines two groups (e.g., “the 650 nm and 430 nm groups have higher rates of photosynthesis compared to the 550 nm group”) can earn a maximum of 4 points: up to 2 points for the prediction and up to 2 points for the justification.

- (c) Bacteriorhodopsin has been found in aquatic organisms whose ancestors existed before the ancestors of plants evolved in the same environment. **Propose** a possible evolutionary history of plants that could have resulted in a predominant photosynthetic system that uses only some of the colors of the visible light spectrum. (1 point per box; 2 points maximum)

Proposal that includes an environmental selective pressure:

- Green light was being absorbed by aquatic organisms using bacteriorhodopsin.
- Unabsorbed wavelengths of light were available resources that organisms could exploit.
- Absorbing visible light at all wavelengths may provide too much energy to the organism.
- Absorbing light from ultraviolet wavelengths (shorter wavelengths = higher energy) could cause damage to the organism.
- Absorbing light with longer wavelengths may not provide sufficient energy for the organism.

Appropriate reasoning to support the proposal:

- Natural selection favored organisms that rely on pigments that absorb available wavelengths of light.
- Endosymbiosis: chloroplasts evolved from cyanobacteria with pigments that used only certain wavelengths.
- Genetic drift eliminated pigments that absorbed certain wavelengths of light.
- Mutation(s) altered the pigment(s) used by organism.