

[01] Wein's Displacement Law defines the wavelength of maximal photon flux as a constant divided by temperature ($\lambda_{\text{max}} = 3.6 \cdot 10^6 \text{ (nm } ^\circ\text{K)} / T \text{ (} ^\circ\text{K)}$). If the temperature of an incandescent lamp is 3600 °K (its color temperature), what would be the approximate (*ca*) wavelength of maximal photon flux from the lamp?

- A. *ca* 10.0 nm B. *ca* 100 nm C. *ca* 1,000 nm D. *ca* 10,000 nm
 E. *ca* 100,000 nm F. *ca* 1,000,000 nm G. *ca* 10,000,000 nm H. None of the above.

Even without a calculator, you can obtain the correct answer by subtracting the powers of 10 ($6-3=3$) for 1,000 nm: C.

[02] Which of the following atmospheric gases absorb significant amounts of solar radiation (choose the best answer)?

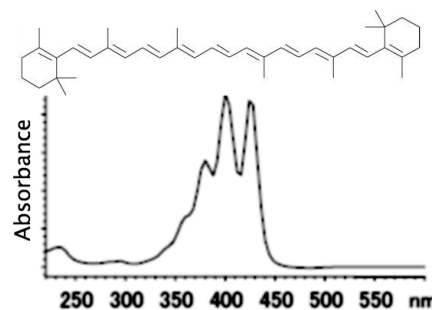
- A. N₂ (nitrogen) B. CO₂ (carbon dioxide) C. CO (carbon monoxide) D. Ne (neon)
 E. Ar (argon) F. A and B G. B and C H. B, C and E

Of the gases listed, the only one that absorbs significant amounts of solar radiation (infrared wavelengths) is CO₂: B.

[03] For a molecular structure and spectrum similar to the one shown, what would be its principle role in photosynthetic organisms (choose the best answer)?

- A. Protection from ultra-violet radiation
 B. Protection from infra-red radiation
 C. Electron transfer in aldehyde formation
 D. Excitation of orbital photons
 E. 'Splitting' of H₂O to produce H⁺, e⁻ and O₂
 F. It is a bilin and would function in light-harvesting to provide excitons to the reaction centers.
 G. It is a carotenoid and would function in light-harvesting to provide excitons to the reaction centers.
 H. None of the above

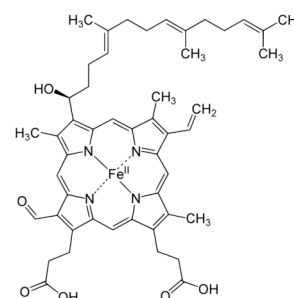
The absorbance in the blue means the color would be yellow to red (orange). It's a carotenoid, with a principle role as an accessory pigment in photosynthesis: G.



[04] For a molecular structure similar to the one shown, what would be its principle role in photosynthetic organisms (choose the best answer)?

- A. Absorption of red and blue light to provide excitons to the reaction centers.
 B. Electron transfer in photophosphorylation (chloroplasts) and oxidative phosphorylation (mitochondria) reactions
 C. Protection from ultra-violet radiation
 D. Absorption of red and yellow light to provide excitons to the reaction centers.
 E. 'Splitting' of H₂O to produce H⁺, e⁻ and O₂
 F. It's vitamin B12.
 G. It's hemocyanin, an oxygen carrier absent in photosynthetic organisms.
 H. None of the above

The iron (Fe) gives it away (hemocyanin is a Cu-complexed porphyrin in insects)... It's cytochrome c, functioning in electron transfer in both chloroplasts and mitochondria and thus ATP production (phosphorylation): B.



[05] What is an action spectrum of photosynthesis (Choose the best answer)?

- A. It is the absorbance spectrum of the light-harvesting chlorophylls, responsible for transferring the excited state e⁻ to the reaction center (resonance energy transfer)
 B. It is the wavelengths of fluorescence: the light emitted when an excited electron returns to the ground state
 C. It is the wavelengths of absorbance: when light is absorbed to cause the electron to 'jump' to the excited state
 D. It is the absorbance spectrum of the reaction center chlorophyll that undergoes photochemistry (Chl* → Chl⁺ + e⁻)
 E. It is the wavelengths of light causing ATP and NADPH production
 F. It is the combined spectra for absorbance and fluorescence (A and B)
 G. It is the combined spectra for excited state e⁻ transfer and photochemistry (C and D)
 H. It is the wavelengths of photons that are active in breaking molecular bonds.

ATP and NADPH production (directly linked to oxygen production and carbon dioxide fixation) are one metric for the action spectrum: E.

[06] In the reaction center photochemistry ($\text{Chl}^* \longleftrightarrow \text{Chl}^+ + \text{e}^-$) of PS II, which must occur first to allow the light reactions to continue (choose the best answer)?

- A. The electron (e^-) must be donated to a plastoquinone, so that it is no longer available to reduce the Chl^+ to Chl.
- B. The electron (e^-) must be accepted by the cytochrome b_6f complex, so that the Chl^* can be oxidized to Chl^+ .
- C. The electron (e^-) must be donated to plastocyanin, so that the Chl^+ can be reduced to Chl^* ($\text{Chl}^+ + \text{e}^- \longrightarrow \text{Chl}^*$)
- D. Water is partially split to provide an electron to Chl^+ so that the electron (e^-) can be donated to cytochrome b_6f .
- E. The excited orbital state of the Chl^* must revert to the non-excited (ground) state, releasing a photon which will reduce the Chl^+ to Chl ($\text{Chl}^+ + \text{e}^- \longrightarrow \text{Chl}^*$).

F. A and D

G. A and C

H. None of the above

Directly from the textbook, the electron must be donated to plastoquinone, only then can reduction of Chl^ by water splitting occur (the cytochrome complex is too far downstream, and is not the first step): A.*

[07] Following Raven's outline of cyclic and noncyclic electron flow in Photosystem I alone (cyclic) or both Photosystems I and II (noncyclic), which of the following components are associated with **only cyclic and not noncyclic electron transfer**?

- A. Pheophytin
- B. Plastoquinone
- C. Ferredoxin
- D. Cytochrome b_6/f complex
- E. Plastocyanin
- F. A, B and C
- G. C, D and E
- H. None of the above

No component is unique to only cyclic electron transfer: H.

[08] Which of the following molecule(s) is/are the immediate product(s) of carboxylation in the C4 pathway of photosynthesis?

A. phosphoenolpyruvate

B. pyruvate

C. oxaloacetate

D. erythrose

E. glycerol-3-phosphate

F. A and C

G. C and D

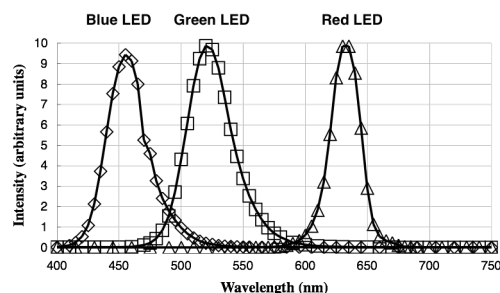
H. D and E

It's the four carbon oxaloacetate (the three carbon phosphoenolpyruvate is the substrate): C.

[09] Which of the following wavelength(s) (color[s]) of light would you expect to be most effective in the light reactions of photosynthesis?

- A. Blue light (ca 455 nm).
- B. Green light (ca 520 nm).
- C. Red light (ca 630 nm).
- D. Blue and green light.
- E. Blue and red light.
- F. Green and red light
- G. Yellow light (ca 570 nm)
- H. Indigo (440 nm)

Chlorophyll is the major photosynthetic pigment, and absorbs both blue and red, both wavelengths are used in photosynthesis (per the action spectrum): E.



[10] What is the difference between chlorophylls a and b?

- A. There is no difference
- B. Chlorophyll a has a phytol tail, chlorophyll b does not have a phytol tail.
- C. Chlorophyll b has a phytol tail, chlorophyll a does not have a phytol tail.
- D. Chlorophyll a has a methyl group (CH_3) that is replaced by an aldehyde group (CHO) in chlorophyll b.
- E. C and D
- F. All of the above except A
- G. B and D
- H. None of the above

Students tell me the answer is a methyl in chl a and an aldehyde in chl b: D.

[11] Which of the following is/are the major feature(s) that distinguishes prokaryotes from eukaryotes?

- A. Prokaryotes always lack internal membrane structures.
- B. Prokaryotes have unique circular DNA chromosomes that aggregate in the nucleoid.
- C. Eukaryotes have unique linear DNA chromosomes that aggregate in the nucleoid.
- D. Eukaryotic flagella (undulipodium) utilize a unique rotor/stator motor that causes the undulipodium to rotate, forming a helical structure that causes motility of the cell.
- E. Prokaryotes lack an enclosing membrane, instead they have a muco-polysaccharide or peptidoglycan exoskeleton that protects the cytoplasm.
- F. A and B
- G. A and C
- H. B and E

Of the answers provided, only circular chromosomes in the nucleoid distinguish prokaryotes from the eukaryotes: B.

[12] Which of the following distinguishes Gram-negative from Gram-positive bacteria in the Gram differential staining technique?

- A. Treatment with solvents such as alcohol or acetone selectively breakdown the thinner wall of Gram-positive bacteria, allowing the mordant-fixed dye to leave the bacterial cell.
- B. Treatment with solvents such as alcohol or acetone selectively breakdown the thinner wall of Gram-negative bacteria, allowing the mordant-fixed dye to leave the bacterial cell.
- C. The mordants (NaI or I_2) can only enter Gram-negative bacteria, fixing the crystal violet dye so that it is trapped inside the cell
- D. Crystal violet stains the thicker peptidoglycan wall of only Gram-negative bacteria
- E. The counterstain safranin reacts with crystal violet to selectively stain Gram-negative bacteria
- F. The crystal violet selectively stains Gram-positive bacteria, creating a purple color.
- G. The solvents (alcohol or acetone) selectively dissolve mordant-fixed crystal violet in Gram-negative bacteria.
- H. None of the above

As discussed in lecture, the ability of solvents to dissolve only Gram-negative walls is the key: B.

[13] Which of the following characteristic(s) can be used to classify eubacteria (choose the best answer)?

- A. Oxygen (gas) production when supplied with a preferred carbohydrate
- B. Gram-staining
- C. Ribosomal RNA sequences unique to a particular bacterial group or species
- D. morphology; cocci (round), bacilli (rod), and spirilli (spiral or helical) are typical morphologies
- E. A, B and C
- F. B, C and D
- G. A, C and D
- H. All of the above

Oxygen is not produced, but all the others are correct: F.

[14] Which of the following **cannot** be used to classify and identify the major groups of autotrophic protists?

- A. Use of glycogen for food storage
- B. Silicaceous (glass) walls
- C. Proteinaceous walls
- D. Carotenoid composition
- E. Phycobilins
- F. Use of oil for food storage
- G. Chlorophylls a, b and c
- H. All of the above can be used

Glycogen is only found in heterotrophic divisions: A.

[15] Which of the following multicellular protist groups contain phycobilin?

- A. Chlorophyta
- B. Rhodophyta
- C. Phaeophyta

Students tell me the answer is Rhodophyta: B.

Match the following unicellular, autotrophic divisions of the Protists with the one most distinguishing characteristic for each division. Choose the best answer. Do not use each answer more than once.

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|----------------------|-----------------------------------|---------------------------|
| [16] Euglenophyta | A. proteinaceous pellicle (walls) | B. phycobilins |
| [17] Chrysophyta | C. fucoxanthin | D. laminarin food storage |
| [18] Dinoflagellates | E. Floridean starch | F. oil food storage |
| | G. carotenoids | H. peridinin |

Euglenophyta have proteinaceous pellicles (A); Chrysophyta use the accessory pigment fucoxanthin (C); Dinoflagellates use the accessory pigment peridinin (H).

Match the three major multicellular, autotrophic divisions of the Protists with the one most distinguishing characteristic for each division. Choose the best answer. Do not use each answer more than once.

- | | | |
|------------------|-----------------------|-------------------------|
| [19] Rhodophyta | A. Only chlorophyll b | B. peridinin |
| [20] Phaeophyta | C. Paramylon | D. Starch food reserves |
| [21] Chlorophyta | E. Glycogen | F. Chrysolaminarin |
| | G. Flagella absent | H. None of the above |

Rhodophyta has no flagella (G); None of the listed characteristics distinguish Phaeophyta (H); Chlorophyta contain starch as a storage food (D).

[22] What is a heterokont?

- A. An organism that has both tinselated and whiplash undulipodium (flagella).
- B. An organism in which reproduction (sex) involves two types of gametes
- C. A large, transparent, thick-walled cell found in the filaments of certain blue-green algae that fixes nitrogen.
- D. An organism that retains condensed chromosomes (heterochromatin) throughout its life cycle.
- E. Cells resulting from the fusion of a prokaryote and eukaryote that have both a flagella and an undulipodium.
- F. As opposed to a homokont, a heterokont organism has dimorphic alternation of generations.
- G. An alternative name for a heterotroph, that must feed on organic materials originating from some other organism.
- H. None of the above

The tinselated and naked whiplash flagella describe the heterokonts: A.

[23] Under the Chemical Weapons Convention (CWC) (to which Canada is a signatory), saxitoxin is now listed as a Category 1 toxin. Which one of the following groups is known to produce this toxin (amongst others)?

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|--------------------|------------------|----------------------|----------------------|
| A. Xanthophyceae | B. Euglenoids | C. Bacillariophyceae | D. Cryptophyta |
| E. Dinoflagellates | F. Chrysophyceae | G. Haptophyta | H. none of the above |

No longer available for purchase, saxitoxin is found in the dinoflagellates: E.

[24] What is a pyrenoid?

- A. An organelle that contains peridinin.
- B. A protein-rich structure that contains a limited quantity of DNA (a nucleomorph)
- C. The pigment that is located in the eyespot of many eukaryotic protists.
- D. A threadlike structure that extends from the body of the protist cell.
- E. A small membrane-bound cavity under the cell surface.
- F. A protein-rich structure that contains the enzymes required for synthesizing siliceous cell walls.
- G. A region of the chloroplast that contains RuBisCO, in which starch is formed.
- H. None of the above

Directly from your textbook, pyrenoids are where RuBisCO is found, along with the Calvin cycle required for starch synthesis: G.

[25] Which of the following groups are stramenopiles (heterokonts)?

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|------------------|------------------|----------------------|---------------------|
| A. Xanthophyceae | B. Chrysophyceae | C. Bacillariophyceae | D. Phaeophyceae |
| E. A, B and C | F. A, C and D | G. B, C and D | H. all of the above |

*All are heterokonts: **H**.*

Match the following major heterotrophic divisions of the Protists with the one most distinguishing characteristic for each division. Choose the best answer.

[26] Oomycota

- A. cellulosic cell walls
- D. only terrestrial
- G. chitinous walls

[27] Myxomycota

- B. no undulipodia
- E. zoospores
- H. none of the above

[28] Dictyosteliomycota

- C. heterokont
- F. glycogen food storage

Oomycota is a heterokont (C); None of the listed characteristics distinguishes Myxomycota (H); Dictyosteliomycota is ameboid (B).