**[01]** Which of the following atmospheric gas(es) absorb significant amounts of solar radiation at wavelengths shorter than the visible wavelengths (*ca* 400–700 nm)?

A. $H_2O$ (water vapour) B. $CO_2$ (carbon dioxide) C. Ar (argon) D. $N_2$ (nitrogen)
E. $O_2$ (oxygen) F. A and B G. B and C H. None of the above

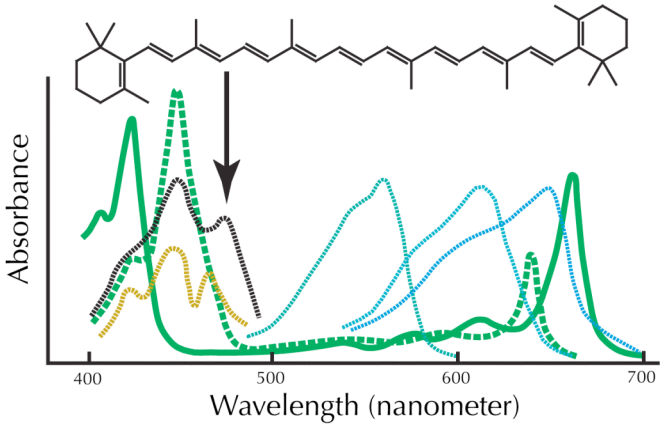
*Ozone isn't listed, and none of the others are significant UV-absorbers, so H is the answer (none of the above).*

**[02]** Wein's Displacement Law defines the wavelength of maximal photon flux as a constant divided by temperature in Kelvin (K) ($\lambda_{max} = 3.6 \bullet 10^6$ (nm K) / T (K)). How hot would the sun have to be to emit a maximal photon flux in the UV (ultraviolet) range (about 360 nm)?

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

*10,000 K is the closest answer (E).*

**[03]** For the molecular structure and spectrum (shown with an arrow), what would be its principle role in photosynthetic organisms (choose the best answer)?




A. Electron transfer in the electron transport chain (especially the cytochrome $b_6f$ complex)
B. Protection from ultra-violet radiation
C. Electron acceptor (quinone) from P680 of the Photosystem II reaction center.
D. It is a chlorophyll and would function in light-harvesting to provide excitons to the reaction centers.
E. 'Splitting' of $H_2O$ to produce $H^+$, $e^-$ and $O_2$
F. It is a bilin (linear tetrapyrolle) 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

*It's beta-carotene (it lacks the 4 N-containing pyrolles). It's used to 'harvest light' in the light reactions of photosynthesis:* ***G****.*

There are two major electron orbital transitions allowed in chlorophyll (a cyclic tetrapyrolle containing a divalent magnesium ion complexed with the N-atoms of the cyclic tetrapyrolle). What wavelength range do these transition energies correspond to (choose the best answer)?

**[04]** Most energetic transition: **[05]** Least energetic transition:

A: infrared (>740 nm) B: red (625-675 nm) C: orange (565-615 nm) D: yellow (545-595 nm)
E: green (485-535 nm) F: blue (450-500 nm) G: violet (375-425 nm) H: UV (250-300 nm)

*Blue is the most energetic absorbance band of chlorophyll (F); red is the least energetic (B).*

**[06]** What is an action spectrum of photosynthesis?

A. It is the absorbance spectrum of the chlorophyll that undergoes photochemistry (Chl* —> $Chl^+ + e^-$)
B. It is the absorbance spectrum of the light-harvesting chlorophylls, responsible for transferring excitons to the reaction centers
C. It is the wavelengths of light causing oxygen production (or $CO_2$ fixation).
D. It is the wavelengths of light emitted when an excited electron returns to the ground state.
E. It is the wavelengths at which light is absorbed to cause the electron to 'jump' to the excited state.
G. It is the combined spectra for exciton transfer and photochemistry (A and B)
F. It is the combined spectra for absorbance and fluorescence (D and E)
H. None of the above

*Either oxygen production or carbon dioxide fixation (or both) can be used to determine the action spectrum of photosynthesis (C).*

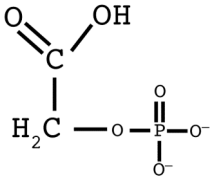
**[07]** During the light reactions, which chloroplast compartment becomes acidified (Choose the best answer)?

A. The stroma, because of proton consumption in water splitting (and other processes)
B. The stroma, because of proton transport by plastoquinone (and other processes)
C. The stroma, because of proton production during NADP reduction (and other processes)
D. The lumen, because of proton consumption in water splitting (and other processes)
E. The lumen, because of proton transport by plastoquinone (and other processes)
F. The lumen, because of proton production during NADP reduction (and other processes)
G. B and C
H. E and F

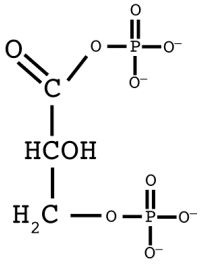
*It is the lumen that acidifies (the inside of the thylakoidal membranes (grana)), due to proton transport by plastoquinone from the stroma into the lumen. Water splitting produces protons, NADP reduction consumes protons. The answer is **E**.*

Match the following structures with the most appropriate biochemical pathway (choose the best answer; you may choose each answer more than once).

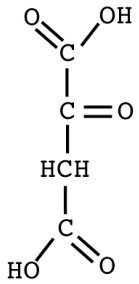
**[08]** 2-phosphoglycolate



**[09]** 1,3-bisphosphoglycerate



**[10]** oxaloacetate



A. non-cyclic photophosphorylation
B. Gluconeogenesis
C. cyclic photophosphorylation
D. C2 pathway (photorespiration)
E. C3 pathway (Calvin Cycle)
F. C4 pathway (Hatch-Slack)
G. A and E
H. C and E

*'Counting the carbons' –as explained in lecture– provides a useful hint: **D, E and F**.*

**[11]** Which one of the following 7 carbon compounds is produced from 3-phosphoglycerate using ATP and NADPH?

A. glyceraldehyde-3 phosphate
B. oxaloacatate
C. glycolate
D. sedoheptulose 1,7-bisphosphate
E. malate
F. erythrose
G. xylulose
H. None of the above

*The seven (7) carbon sedoheptulose (D), which we learned how to pronounce in class.*

**[12]** What is the name of the carboxylating enzyme that uses bicarbonate ($HCO_3^-$) as a substrate?

A. RuBisCO
B. Coca Cola
C. Pepsi
D. phosphoenolpyruvate carboxylase
E. oxaloacetate decarboxylase
F. sedoheptulose bisphosphatase
G. None of the above

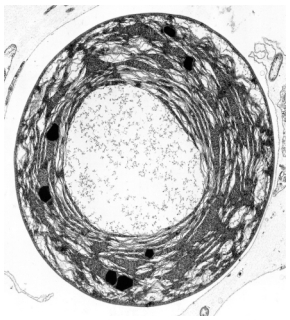
*Students tell me the answer is **D**.*

**[13]** In recent bioengineering of photosynthesis, what is the source of the enzyme used to bypass photorespiration?

A. phosphoenolpyruvate carboxylase from *Saacharomyces cerevisiae*
B. synthetic RuBisCO
C. human PEPCase
D. tartronic semialdehyde reductase from *Escherichia coli*.
E. tartronic semialdehyde reductase from *Salmonella* sp.
F. C and D
G. C and E
H. None of the above

*Students tell me the answer is **D**.*

**[14]** Which of the following characteristics are true of the organism shown in the figure (right)?



A. It is a eukaryotic cell, a photosynthetic protist.
B. It is a photosynthetic bacteria that has chlorophyll a and phycobilins.
C. It is a photosynthetic bacteria that has chlorophylls a and b, and carotenoids.
D. It is a methanogenic ($CH_4$ producing) halophilic archaea.
E. It is rounded thylakoid within a eukaryotic cell.
F. It is an anoxygenic photosynthesizing purple bacterium
G. It is the nitrogen-fixing bacteria *Anabaena*.
H. None of the above

*It is Prochloron (Figure 13-16 in your textbook), a bacteria with traits reminiscent of higher plants (chl a and b, and carotenoids):* ***C****.*

**[15]** Which of the following distinguishes Gram-negative from Gram-positive bacteria?

A. Only Gram-negative bacterial walls are dissolved by solvents (e.g., acetone or ethanol)
B. Only Gram-positive bacterial walls are dissolved by solvents (e.g., acetone or ethanol)
C. Crystal violet stains only Gram-negative bacteria D. Safranin stains only Gram-positive bacteria
E. A and C F. B and C G. B and D H. None of the above

*The sensitivity of walls to solvents is the key property of the Gram procedure. If safranin or crystal violet were to stain only one of the two types of bacteria, it would be used instead of the Gram stain. The answer is A.*

**[16]** Some protist groups exhibit triple-membrane-bound chloroplasts (reported in Euglenoids, for example), while others have chloroplasts that are bounded by four membranes (Cryptophyta). Which of the following endosymbiotic (or other) events would result in <u>three</u> membranes (Choose the best answer)?

A. A procaryote ingesting a photosynthesizing prokaryote
B. A eucaryote ingesting a photosynthesizing prokaryote
C. A procaryote ingesting a photosynthesizing eukaryote
D. A eucaryote ingesting a photosynthesizing eukaryote
E. An autogenous mechanism in either a prokaryote or a eukaryote
F. A or B and E
G. C or D and E
H. C and D

*To get three membranes, either a third membrane has to be created de novo, or one of four membranes has to disappear. C and D would result in four membranes, but disappearance of a membrane is not listed in the possible answers. So, a 'typical' endosymbiotic event (A or B that creates a double membrane), followed by an autogenous mechanism is the best answer (****F****).*

**[17]** Which one of the following shape-shifting groups uses starch for food storage?

A. Chrysophyta B. Euglenophyta C. Chrysophyceae D. Haptophyta
E. Bacillariophyta F. Xanthophyceae G. Phaeophyceae H. None of the above

*None use starch. The answer is H.*

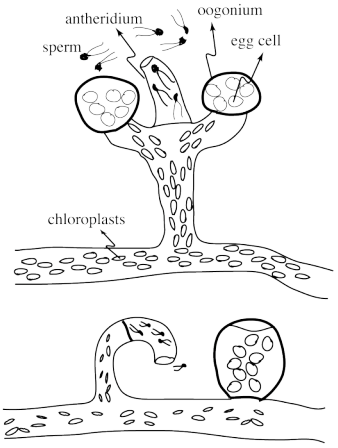
Match the three unicellular, autotrophic divisions of the Protists with the one most distinguishing characteristic for each division. Choose the best answer.

**[18]** Dinophyta
**[19]** Xanthophyceae
**[20]** Euglenophyta

A. Chlorophyll b and phycobilins
B. oil food reserve
C. Cell wall composed of cellulose or calcified scales
D. Fucoxanthin
E. Chlorophylls a and c
F. Chrysolaminarin
G. peridinin
H. Chlorophylls a and b

*Dinophyta have peridinin (G). Xanthophyceae has oil food stores (B). Euglenophyta has chlorophylls a and b (H).*

**[21]** Which of the following is/are correct for the diagram (from your lab manual)?




A. It is part of a *Volvox* life cycle
B. It is a member of the Xanthophyceae group
C. It is part of an *Ectocarpus* life cycle
D. It is a member of the Phaeophyta group
E. It is part of a *Polysiphonia* life cycle
F. A and B
G. C and D
H. D and E

*The Xanthophycean Vaucheria:* ***B***.

Match the three major multicellular, autotrophic divisions of the Protists with the one most distinguishing characteristic for each division. Choose the best answer.

**[22]** Rhodophyta

A. paramylon
B. glycogen
C. cellulose walls
D. phycobilins
E. chlorophylls a and b
F. carotenoids
G. chlorophylls a and c
H. chrysolaminarin

**[23]** Phaeophyta

**[24]** Chlorophyta

*Red algal phycobilins are notable amongst the multicellular algal groups (D). Phaeophyta is unique in having chlorophylls a and c (G) (all the groups have carotenoids, it is not distinguishing), while Chlorophyta has chlorophylls a and b (E).*

**[25]** The Chlorophytes are typically divided into three major groups, the Ulvophyceae, and Chlorophyceae and the Charophyceae. Which of the following trait(s) distinguishes the Ulvophyceae from the other two major groups?

A. zygotic meiosis
B. mostly freshwater
C. photorespiratory enzymes
D. centrioles
E. A and B
F. B and C
G. C and D
H. None of the above

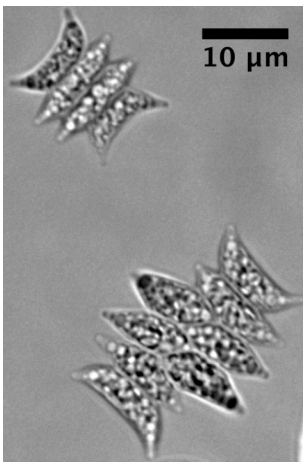
*None of the traits distinguish Ulvophyceae, H is the answer.*

**[26]** Terrestrial oomycetes (water molds) can be important plant pathogens on species besides potato, and historically important for more than the potato famines. For example, *Plasmopara viticola* (commonly called Downy Mildew) is a pathogen of grapes, and one of the first examples of chemical control of a plant pathogen. Which of the following can be used to control Downy Mildew?

A. Bordeaux wine
B. Saxitoxin
C. Biocontrol with Bacillus species
D. Beaujolais mixture
E. Hydrogen sulfide
F. Copper chloride
G. Copper sulfate and lime
H. None of the above.

*Bordeaux mixture is not on the list, but copper sulfate and lime is (G).*

**[27]** Using the key below, identify the algal species (right) (Choose the best answer)




A. *Scenedesmus* B. *Pandorina* C. *Gonium*
D. *Tetraspora* E. *Pediastrum* F. *Microspora*
G. *Hydrodictyon* H. Desmids

*The spines and four or eight cells give it away: Scendesmus (A).*

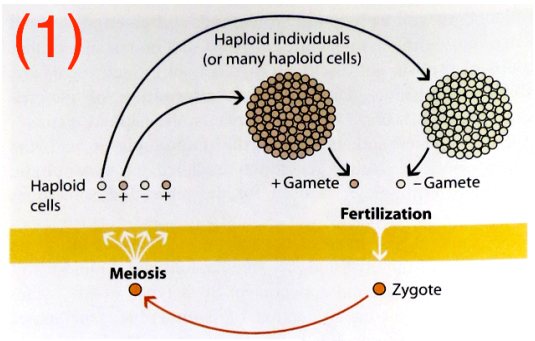
KEY TO SOME COMMON GREEN ALGAE AND EUGLENOIDS

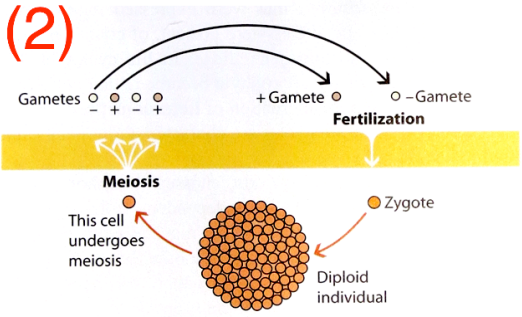
| | | |
|---|---|---|
| 1. | Plants unicellular or colonial | 2 |
| 1'. | Plants filamentous | 14 |
| 2(1). | Motile by flagella | 3 |
| 2'. | Nonmotile | 8 |
| 3(2). | Unicellular | 4 |
| 3'. | Colonial | 5 |
| 4(3). | Cells long and tapering when swimming, round when resting; one flagellum and a red eyespot | *Euglena* |
| 4'. | Cells oval; 2 flagella; chloroplast cup shaped | *Chlamydomonas* |
| 5(3'). | Colony a flat plate, 4-8-16 cells | *Gonium* |
| 5'. | Colony spherical | 6 |
| 6(5'). | Cells close together, usually 16 | *Pandorina* |
| 6'. | Cells remote from each other | 7 |
| 7(6'). | 32 (usually) to 128 cells | *Eudorina* |
| 7'. | Hundreds of cells | *Volvox* |
| 8(2'). | Unicellular | 9 |
| 8'. | Colonial | 10 |
| 9(8). | Cells in two symmetrical halves connected by a narrow isthmus | *Desmids* |
| 9'. | Cells spherical to oval, someimtes in irregular masses; on wood or moist soil | *Protococcus* |
| 10(8') | Colonies with four cells (sometimes eight) in a row; spines often on end cells | *Scenedesmus* |
| 10'. | Colonies with more than four cells | 11 |
| 11(10'). | Colonies mucilaginous; cells in groups of four within mucilage | *Tetraspora* |
| 11'. | Colonies not mucilaginous | 12 |
| 12(11'). | Cells forming a net often visble to the unaided eye | *Hydrodictyon* |
| 12'. | Cells forming a flat plate | 13 |
| 13(12'). | Plate irregular; some cells with long, sheathed bristles | *Coleochaete* |
| 13'. | Plate regular; marginal cells with lobes, horns, or short spines | *Pediastrum* |
| 14(1'). | Filaments unbranched | 15 |
| 14'. | Filaments branched | 21 |
| 15(14). | All cells short | 16 |
| 15'. | Some cells long | 7 |
| 16(15). | Cells with thick walls; chloroplast diffuse | *Micospora* |
| 16'. | Cells with thin walls; chloroplast in a ring around interior of cell | *Ulothrix* |
| 17(15'). | Chloroplasts star-shaped, usually two per cell | *Zygnema* |
| 17'. | Chloroplasts not star shaped | 18 |
| 18(17'). | Chloroplasts spiral | *Spirogyra* |
| 18'. | Chloroplasts not spiral | 19 |
| 19(18'). | Cell wall thin; chloroplast a flat plate which is broad in surface view and appears as a thin line in sideview | *Mougeotia* |
| 19'. | Cell wall thick | 20 |
| 20(19'). | Chloroplast more or less uniform; some cells with apical caps; swollen oognia | *Dogonium* |
| 20'. | Chloroplast dense and granular; cells large, with a very few short rhizoidal branches | *Rhizoclonium* |
| 21(14'). | Branches short, with a bulb-like base tapering into a long spine.. | *Bulbochaete* |
| 21'. | Branches relatively long | 22 |
| 22(21'). | Cells with thick walls | *Cladophora* |
| 22'. | Cells with thin walls | 23 |
| 23(22'). | Plant body showing marked differentiation between a single row of large cells forming the main axis and numerous tufts of short lateral branches with small cells | *Draparnaldia* |
| 23'. | Plant body not so differentiated | *Stigeoclonium* |

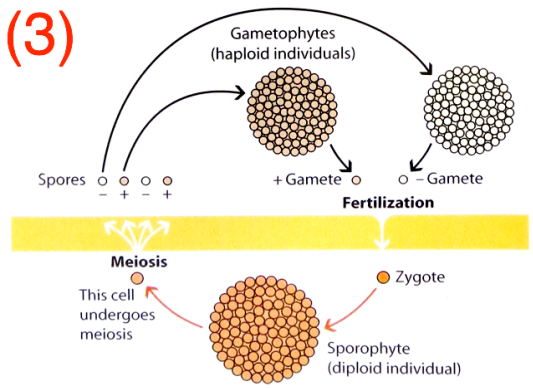
**[28]** Which of the following trait(s) distinguishes the Acrasiomycota (cellular slime mold) from the Myxomycota (acellular slime mold)?

A. glycogen B. heterokont C. chitin walls D. cellulose walls
E. A and B F. B and C G. C and D H. None of the above

*None are distinguishing (H) (both have cellulose walls at some life stage).*




**[29]** Which one of the meiotic life cycles shown to the left would you expect to be most common in the Myxomycota (plasmodial slime mold) (Choose the best answer)?

A. 1 (zygotic) B. 2 (gametic) C. 3 (sporic)
D. 1 (sporic) E. 2 (zygotic) F. 3 (gametic)
G. 1 (gametic) H. 2 (sporic)

It's gametic (2), with a diploid multi-cellular form (B).