Multiple choice. (1 point each) Choose the one best answer to each of the following questions.

1. ____ Biochemical synthesis of new cell material is called
   A. Metabolism
   B. Anabolism
   C. Catabolism
   D. Synthetabolism

2. ____ The suffix -troph is derived from a Greek word meaning
   A. to feed
   B. to assimilate
   C. to energize
   D. to break down

3. ____ Chemoorganotrophs use which of the following as an energy source?
   A. Organic compounds
   B. Inorganic compounds
   C. Both organic and inorganic compounds
   D. Light

4. ____ A fastidious organism is
   A. oxygen sensitive
   B. temperature sensitive
   C. nutritionally demanding
   D. atmospheric pressure sensitive

5. ____ If $\Delta G^0$ is positive
   A. the reaction is exergonic and requires the input of energy.
   B. the reaction is endergonic and requires the input of energy.
   C. the reaction is exergonic and energy will be released.
   D. the reaction is endergonic and energy will be released.

6. ____ Which statement is true?
   A. Coenzymes are generally bound tightly to their respective enzymes.
   B. Prosthetic groups are generally bound tightly to their respective enzymes.
   C. Coenzymes and prosthetic groups are both bound tightly to their respective enzymes.
   D. Coenzymes and prosthetic groups are technically not bound to any enzymes.

7. ____ In an electron carrier system, the net energy change is determined by the difference in reduction potentials between the
   A. primary electron donor and the terminal electron donor.
   B. primary electron acceptor and the terminal electron acceptor.
   C. primary electron acceptor and the terminal electron donor.
   D. primary electron donor and the terminal electron acceptor.

8. ____ The Embden-Meyerhof Pathway is another name for
   A. the citric acid cycle
   B. glycolysis
   C. electron transport
   D. NADH production
9. ____ In glycolysis
A. the crucial product is ATP; the fermentation products are waste products.
B. the crucial product is ethanol or lactate; ATP is a waste product.
C. the crucial product is CO₂; ATP is a waste product.
D. the crucial product is not relevant because glycolysis is not a major pathway.

10. ____ In chemiosmosis
A. OH⁻ accumulates on the outside of the membrane while H⁺ accumulates on the inside.
B. OH⁻ accumulates on the inside of the membrane while H⁺ accumulates on the outside.
C. both OH⁻ and H⁺ accumulate on the inside of the membrane.
D. both OH⁻ and H⁺ accumulate on the outside of the membrane.

11. ____ Which statement is not true? Uncouplers prevent ATP synthesis
A. by interfering with electron flow.
B. by creating leaky membranes.
C. without affecting electron transport.
D. by destroying the proton motive force.

12. ____ The chemical substance that enters the citric acid cycle for further metabolism is __
A. ethyl alcohol
B. acetyl-CoA
C. adenosine triphosphate
D. pyruvic acid

13. ____ Which of the following occurs in the absence of oxygen?
A. Fermentation
B. Anaerobic respiration
C. Anoxygenic photosynthesis
D. All of the above.

14. ____ Most chemolithotrophs are
A. phototrophs
B. autotrophs
C. heterotrophs
D. organotrophs

15. ____ For a carbon source, chemoorganotrophs generally use such compounds as
A. glucose
B. carbon dioxide
C. triglycerides
D. sunlight

16. ____ For each molecule of pyruvate that enters the citric acid cycle, how many molecules of CO₂ are generated?
A. 1
B. 2
C. 3
D. 6
17. ____ Whether an organism is classified as a photoheterotroph or a photoautotroph depends on its

A. energy source.
B. carbon source.
C. oxygen requirements.
D. All of the above.

18. ____ How many ATP result from the transfer of electrons from NADH to O\textsubscript{2} through the electron transport chain?

A. 1
B. 2
C. 3
D. 6

19. ____ To describe a type of photosynthesis as "oxygenic" implies that

A. oxygen is produced
B. oxygen is consumed
C. oxygen functions as a catalyst

20. ____ Which statement is true?

A. The cytochromes contain iron; chlorophyll contains magnesium.
B. The cytochromes contain magnesium; chlorophyll contains iron.
C. Both the cytochromes and chlorophyl contain iron but not magnesium.
D. Both the cytochromes and chlorophyl contain magnesium but not iron.

21. ____ Chlorophyl \textsubscript{a} is green because it

A. absorbs green light and reflects red and blue light.
B. absorbs red and green light and reflects blue light.
C. absorbs red and blue light and reflects green light.
D. absorbs green light and what it reflects is irrelevant.

22. ____ The carotenoids and the phycobilins

A. are involved in the capture of light energy.
B. function as accessory pigments.
C. are photoprotective.
D. All of the above.

23. ____ Non-unit membrane structures known as chlorosomes and functioning in photosynthesis are characteristic of

A. heliobacteria
B. green sulfur bacteria
C. purple phototrophic bacteria
D. myxotrophic bacteria

24. ____ When electrons are forced backwards, against the thermodynamic gradient, to reduce NAD\textsuperscript{+} to NADH, the process is called

A. reverse proton motive force.
B. reverse reduction
C. reverse electron flow
D. reverse energy flow

25. ____ Photosystem II in oxygenic phototrophs is able to accept electrons from water because

A. excitation of P680 by light results in a redox potential of -0.75V.
B. pheophytin, the next electron carrier has a redox potential of -0.5V.
C. noncyclic electron flow doesn't require electrons to come from cytochrome c.
D. P680 has an initial redox potential of +1.0V.
26. ____ Plastocyanin is
A. a membrane bound sac found in certain bacteria.
B. a photosynthetic pigment found in all phototrophic bacteria.
C. a copper-containing protein that donates electrons in photosystem II
D. a blue-green bacterium known for its unusual photoreactive complex.

27. ____ The Calvin cycle
A. is responsible for the fixation of CO$_2$.
B. utilizes only ATP.
C. requires phosphofructokinase and pyruvate decarboxylase
D. all of the above

28. ____ Which of the following phototrophs are most sensitive to sulfur and are also often capable of respiration or fermentation?
A. purple non-sulfur
B. purple sulfur
C. green sulfur
D. heliobacteria

29. ____ The electron carrier used by the green anoxygenic phototrophs to directly reduce NAD$^+$ is called
A. iron sulfur protein
B. bacteriochlorophyll
C. plastocyanin
D. ferrodoxin

30. ____ Phototrophic bacteria responsible for up to 50% of CO$_2$ fixation in aquatic environments belong to the
A. purple bacteria
B. green bacteria
C. heliobacteria
D. cyanobacteria

31. ____ Compounds produced by cyanobacteria that are responsible for the earthy odors in water supplies contaminated by these organisms are called
A. geobacteria
B. gleothece
C. geosmins
D. geodecans

32. ____ A specialized pigment that protects cyanobacteria from UV damage is called
A. scytonemin
B. cyanophycin
C. phytoerythrin
D. akinete

33. ____ The bc$_1$ complex serves as a coupling site in both photophosphorylation and electron transport phosphorylation. Protons are released to the exterior of the cell due to the action of a
A. proton pump.
B. Q-cycle.
C. terminal electron acceptor.
D. primary electron donor.
Matching. (1 pt. each) Match the phototrophic genera in the left column with the appropriate description in the right column.

| _____ Synecococcus, Gleoethece | A. Unicellular, used to study circadian rhythms. |
| _____ Rhodospirillum, Chromatium | B. Filamentous, some used as a popular food source. |
| _____ Fischerella, Stigonema | C. Anoxygenic green bacteria |
| _____ Pleurocapsa, Dermocarpa | D. Anoxygenic purple bacteria |
| _____ Anaebaena, Nostoc | E. Filamentous, produce specialized nitrogen fixing cells called heterocysts. |
| _____ Oscillatoria, Spirulina | F. Produce offspring called baeocytes by internal division |
| _____ Chlorobium | G. Branching filaments. |

Short answer. (1-2 pts each)

Phycobiliproteins occur as high-molecular-weight aggregates known as ______________________________. Cells with an increased number of these structures are grown at __________________________ (higher/lower) light intensities.

In synthesizing one molecule of glucose from carbon dioxide, the Calvin cycle must be run ________ times.

When external electron acceptors are not available in anoxic environments, carbon is catabolized by ____________________.

Explain the difference between a chemically defined (minimal) medium and an undefined (complex) medium.

*Rhospirillum rubrum* is capable of growing either photoheterotrophically or chemoorganotrophically. What do these terms mean?

You are an anoxygenic green bacterium that contains chlorophyll a. What are your two favorite colors and why?

Some bacteria are capable of fermenting glucose to 2 molecules of lactate (\(\text{H}^+\)) and 2 protons (\(\text{H}^+\)). What is the free energy yield? \(\Delta G^\circ_f\) values - glucose (-917kJ), lactate (-517kJ), \(\text{H}^+\) (-39kJ @ pH7). Theoretically, how many ATP would this produce?
Complete the following diagrams. (0.5 points each item)

Identify the steps at which NAD(P)H is generated by circling the appropriate reaction on the following diagram of the citric acid cycle.

Using the bar on the left side of the page, draw an electron tower indicating the relative positions of the following redox couples. Circle those compounds that would act as electron donors to the fumarate/succinate couple (+0.03). Be sure to label the bar appropriately.

\[
\begin{align*}
2H^+/H_2 & (-.42) \\
NAD^+/NADH & (-.32) \\
\text{Ubiquinone}_{\text{ox}}/\text{Ubiquinone}_{\text{red}} & (+0.11) \\
\text{NO}_3^-/\text{NO}_2^- & (+0.42) \\
1/2\text{O}_2/\text{H}_2\text{O} & (+0.82)
\end{align*}
\]
Short Essay Questions. Please answer 3 of the following 4 short essay questions (5 points each - 5 bonus points possible for answering all 4 questions)

Describe the process of aerobic electron transport phosphorylation beginning with NADH as the primary electron donor. Include all electron carriers and all coupling sites. Include a description of the relative redox potentials of the various electron carriers.

Describe either oxygenic or anoxygenic photophosphorylation from the primary electron donor to the terminal electron acceptor. Include a description of the relative redox potentials of the various electron carriers.
Compare and contrast fermentation and respiration. Describe how proton motive force is generated in each type of metabolism.

What is chemiosmosis? How were uncouplers and inhibitors used to support the chemiosmotic theory?