Key to Lecture Midterm Exam – Spring 2021

1. **Define:**
   Define metabolism and then explain how metabolism relates to bioenergetics. Make certain your answer includes four technical terms (two specific categories of metabolism and two indicating energy transfers occurring).

   Metabolism refers to all the chemical reactions occurring within living organisms and includes **catabolic** (breakdown) reactions and **anabolic** (building or synthesis) reactions. Energy transfers are required (bioenergetics is involved) because building reactions require energy (are **endergonic**) and catabolic reactions release more energy than was required for their initiation (are **exergonic**).

   Define proton motive force and then explain how this force is associated with ATP synthesis during both oxidative and photophosphorylation.

   The **proton motive force is a concentration and electrical gradient** created when protons are transported out of the cytoplasm across a cellular membrane. The transport of these protons may involve bacteriorhodopsin, cytochromes, flavoproteins or other membrane-bound proteins and is an active process. Due to the electrochemical gradient, the protons "want" to flow passively back across the membrane and they can do this by passing through **ATP-synthase enzymes**. When they do this, every three protons passing through ATP-synthase will provide enough energy to bind 1 ADP and one inorganic phosphate molecule together forming one ATP.

   Define symbiosis and then explain two ways respiratory chemoheterotrophs are dependent upon oxygenic photoautotrophs for their survival on this planet, and vice versa.

   Symbiosis is a condition existing when two or more different types of organisms are living together in a close association. All respiratory chemoheterotrophs are dependent upon oxygenic photoautotrophs because they require oxygen as a final electron acceptor in their metabolic processes and the oxygenic photoautotrophs produce oxygen by splitting water molecules. Chemoheterotrophs require preformed carbon sources for their nutritional needs and photoautotrophs make these available by fixing carbon from the atmosphere. We either eat photoautotrophs directly or eat other animals that eat them. The oxygenic photoautotrophs depend on respiratory chemoheterotrophs for some of the carbon dioxide they use to make organic compounds (although carbon dioxide is also released by fermentative organisms so they don't rely entirely on us). Respiratory chemoheterotrophs also release metabolic water that might be used by oxygenic photoautotrophs.

2. Light/ adenosine triphosphate (ATP)/ phosphorylation

3. Ribozyme/ endoenzyme (enzymes active inside cells)

4. Temperature/ light

5. Energy of activation or activation energy

6. Competitive inhibition

7. Matching letter sequence is – C, F, E, B, A and D.

8. Reduction

9. Glycolysis/ Kinase/ isomerase

10. Constitutive

11. Fermentation/ pyruvic acid or pyruvate

12. Acetaldehyde/ heterofermentative

13. Cellular respiration/ pyruvate dehydrogenase

14. Krebs cycle/ acetyl coenzyme-A/ matrix of mitochondria

15. Carbon dioxide is formed when organic acids (pyruvate, isocitrate and α-ketogluterate) are decarboxylated just prior to and during the Krebs cycle. Each carboxyl group ($COOH^-$) removed from an organic acid passes two electrons and one hydrogen proton to NAD reducing it to NADH + H^+ and what remains of each carboxyl group is carbon dioxide (CO_2) a waste gas.

    Molecular oxygen serves as a final electron acceptor at the end of the electron transport chain (ETC) or system (ETS). Overall, its function is to allow for the oxidation of coenzymes (NADH + H^+ and $FADH_2$) so they can be used again (to assist glycolysis and Krebs cycle enzymes). When each 0_2 molecule picks up 4 electrons and 4 hydrogen protons, two molecules of water (H_2O) are formed. This is helpful for cells because molecular oxygen is potentially toxic and they eliminate the potential damage it could cause by forming water with it. The water is also useful for metabolic processes.

16. Reduced coenzymes – NADH + H^+ and $FADH_2$/ Niacin and riboflavin

17. Cytochromes/ Eukaryotic cells use the cristae of mitochondria for oxidative phosphorylation and the thylakoids of chloroplasts for photophosphorylation. Prokaryotic cells use their cell membranes for both processes, but that is not what this question was asking.

18. Bacteriorhodopsin

19. Plastoquinone/ The pigments of photosystem II pull electrons and hydrogen protons away from water molecules and molecular oxygen (O_2) is formed.

20. Matching letter sequence is – F, D, E, A, B, H, C and G.

21. Hydrogen sulfide

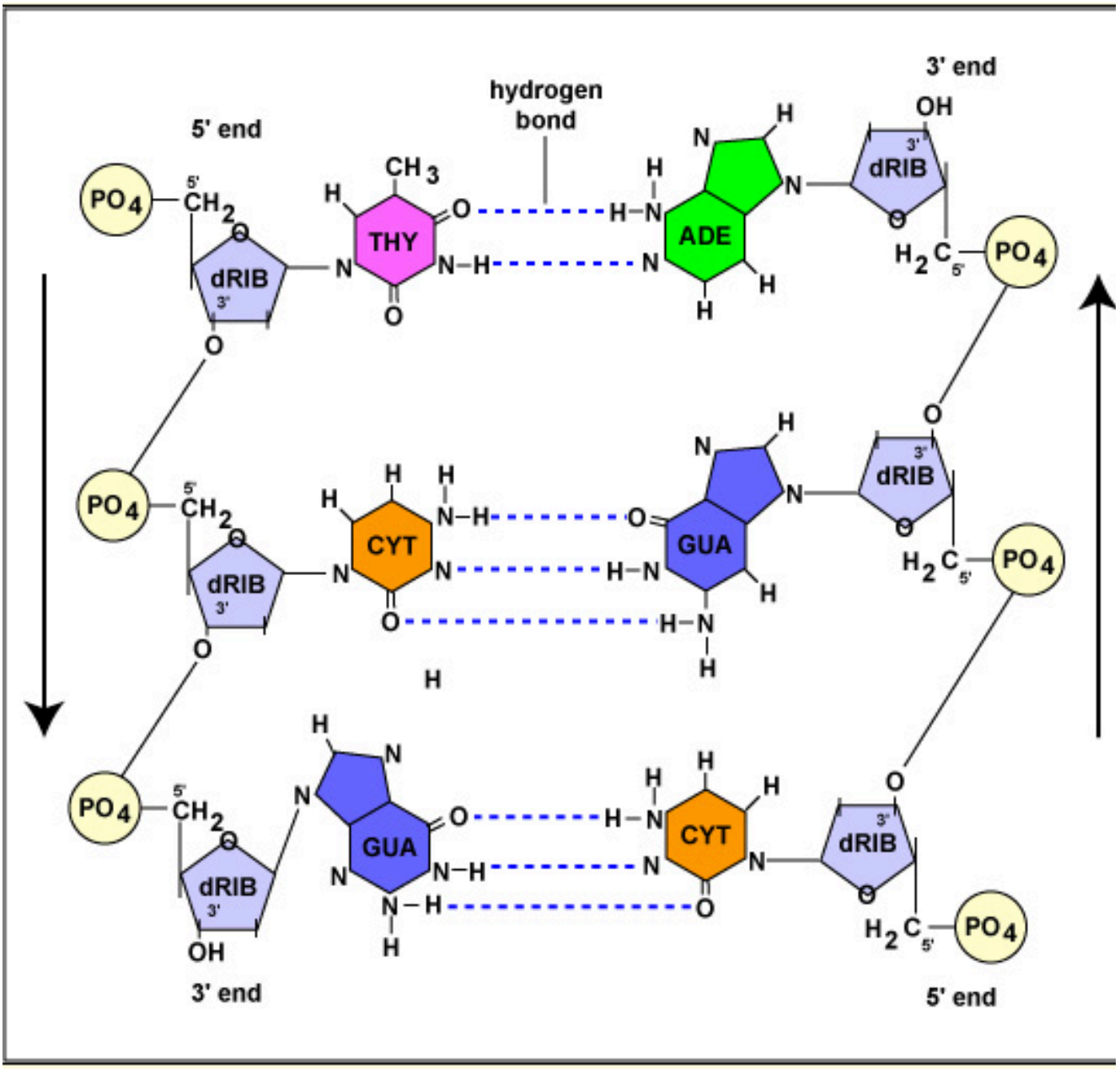
22. NADPH + H^+/ reduction

23. Calvin-Benson or Calvin-Benson-Basham/ Ribulose-Bisphosphate Carboxylase Oxygenase (RuBisCO)/ ATP and NADPH + H^+

24. Define:
Define the terms **complementary** and **antiparallel** as they apply to DNA molecules and then diagram and clearly label a small segment of DNA showing these features.

The two strands of the DNA double helix are complementary in that they form two parts of a whole molecule. The bases adenine and thymine are complementary to one another and form two hydrogen bonds between them while the bases cytosine and guanine are complementary and form three hydrogen bonds between them. If the base sequence of one strand is known, the sequence of the other strand is also known because the two are complementary.

The two strands of a DNA molecule are also antiparallel and this is because they are oriented in opposite directions 5' to 3'.



24. Define – continued:

    Define post-transcriptional modification and explain what occurs during this process.

    Post-transcriptional modification is a process all eukaryotic RNA molecules are subjected to after they are synthesized. In the case of mRNA, multiple regions called **introns** (intervening regions) are removed and the remaining **exons** (expressed regions) are spliced together by the snRNA molecules of spliceosomes. Following this a methylated guanine "cap" and a poly-adenine "tail" are added to protect the mRNA from catabolic enzymes. An unusual feature of this process is that the exons ultimately spliced together are not necessarily encoded by the same genes.

    Define light repair as it was explained in lecture. Include the factor required to activate the enzymes involved and what those enzymes do.

    Light repair as it occurs in prokaryotic cells is a mechanism involving enzymes activated by visible light. These enzymes move along DNA molecules and if they find T-T dimers they break them apart. Since T-T dimers are often formed when DNA is exposed to ultra violet light (one of the forms of electromagnetic radiation in sunlight) many different types of bacteria use light repair enzymes.

25. Uracil/ ribose

26. Replication/ helicase/ primase (although primase enzymes are technically DNA-dependent RNA-polymerase enzymes, primase is a better answer here)

27. Okazaki fragments/ ligase

28. Transcription/ sigma factor/ polycistronic

29. Nucleoside triphosphate molecules (dNTPs and rNTPs)

30. Transcription yields RNA = AUG CCG UUU ACC GCU GUG GAA UGG AAC UAG
    Translation yields a polypeptide = Meth, Pro, Phen, Thr, Ala, Val, Glu, Tryp, Asn – STOP
    NO/ There are 10 codons and only nine amino acids because the last codon (UAG) is a stop or terminator codon and does not encode any amino acid. The AUG at the beginning must encode the amino acid methionine or translation cannot occur (prokaryotic cells may or may not remove it later).

31. The genetic code is redundant because many different codons encode the same amino acids (often as many a six different codons per amino acid). This redundancy occurs because there are 64 possible codons (three terminator codons and 61 codons encoding amino acids). Only 20 amino acids are typically used for polypeptide synthesis, so there are far more codons than amino acids. This redundancy is beneficial in that it reduces the potential for damage caused by some point mutations, but that was not the question being asked.

32. Ribosomal/ codon and anti-codon

33. The gRNA molecules produced by bacteria guide CRISPR-associated proteins (Cas proteins) to viral DNA molecules that have invaded the cell. The Cas proteins then chop up the viral DNA before it can take over the cells function. The CRISPR-associated proteins that are involved here are a type of restriction endonuclease enzyme.

34. Spliceosomes/ The miRNA molecules are involved in the regulation of gene expression in eukaryotic cells. There are lots of these little RNA molecules formed within cells and they act to "silence" mRNA through a variety of means.

35. Translation/ transfer-RNA/ aminoacyl-tRNA-synthetase

36. Allosteric

37. Repressor

38. Operon/ operator/ Active repressor proteins can bind DNA at the operator site and when they do, transcription of the structural genes is blocked at that point (transcription is repressed).

39. Permease/ allolactose/ Allolactose binds to the active repressor and inactivates it. This causes the repressor to release the DNA (fall off the operator site) and allows transcription of the structural genes to begin (transcription is induced).

40. Catabolite repression/ cyclic-AMP

41. Matching letter sequence is – F, E, A, B, C and D.

42. Mutations

43. Alkylating agents/ base analogs

44. Nonsense/ silent

45. Frameshift/ Frameshift mutations are likely to change most if not all of the amino acids being encoded beyone the mutation point. The resulting polypeptide is very unlikely to be functional.

46. Translocation or transposition/ transposase

47. Inversion/ Proteins often contain regions that can be combined with sections of other proteins and still be functional. This is much like the prefix "trans" can be combined with multiple endings and still make sense (trans-lation, scirption, position, location, poson, posase, etc.).

    Post-translational modification can also involve combining sections of different proteins with one-another, so an inversion might have no or little damaging affect.