Understanding Life Science

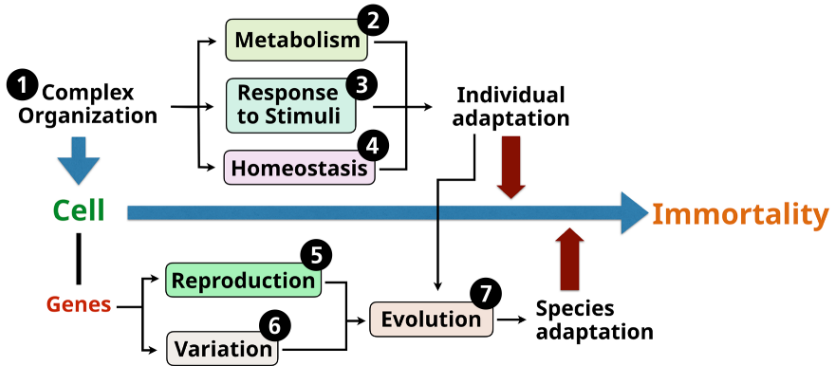
Midterm Exam

2020 Autumn

Name **Student ID #**

❊ Multiple Choice Questions (1 point each, except a couple of questions stated otherwise)

Questions 1~6: In reference with the figure shown here, determine if each of the following statements is True (**T**) or False (**F**).



1. Both catabolism and anabolism constitute ②, of which this figure concerns only anabolism because that is the one requiring the energy input from outside.

2. ⑥ is a direct consequence of ⑤, and together they make the process of ⑦ work.

3. Individuals that took care of ②, ③, ④, successfully have a better chance of leaving their genes into the next generation, thereby leading the direction of new speciation.

4. Without ②, carrying out ③ & ④ properly is impossible.

5. ⑥ cannot be generated without changes in gene sequence.

6. If a trait is determined by an epigenetic effect...
   a. it will be found to be identical among different races of human.
   b. it is not a heritable trait.
   c. it is not a true trait.
   d. It does not cause changes in the sequence of the gene responsible for the trait.
   e. it cannot be subjected to the process of natural selection.

7. The mitochondrial DNAs are haploid is because…
   a. they lack the homologous chromosome pairs.
   b. they lack genetic recombination.
   c. they have half the amount of DNA compared with those of chromosomal DNAs.
   d. they are inherited from mothers only.
   e. they are not replicated before the cell division.

8. The power of Cryo-EM, compared with conventional electron microscopy, is that…
   a. it allows live imaging of biologically important molecules.
   b. it allows visualization of virus particles such as Covid-19.
   c. it provides images with no artifacts.
   d. it enables to see 3-D structure of macromolecules in near-native state.
   e. it allows viewing molecules at much higher magnification in color.

9. Which of the following processes of a human would be affected LEAST by a functionally defective rough endoplasmic reticulum (RER)?
   a. Establishing correct blood type (ABO blood type)
   b. Acidification of the lysosome
   c. Transmitting nerve signals
   d. Entry of Covid-19 virus into the lung tissue cells
   e. Maintaining stable structure of nuclear envelope

10. A guy living next door, Sunghan, who is annoying and a real jerk, argues against the endosymbiosis theory I learned from my biology class. He claims that the mitochondrion was not originated from an independently living prokaryotic cell, but it was derived from a portion of the nucleus that happened to be separated from the main body. If he was right… (**explain your answer**) (3 points)
    a. mitochondria should not have their own DNA.
    b. ribosomes should not be present in the mitochondria.
    c. the outer and the inner membranes of mitochondria should be chemically identical.
    d. all the above (a, b, and c) should be correct.
    e. I will be damned.

11. According to the first law of thermodynamics…
    a. energy is released when ATP is hydrolyzed into ADP and a phosphate.
    b. you'd better have something to eat in order to take this exam well.
    c. entropy of the universe keeps increasing.
    d. cell cannot be generated spontaneously through the process of the chemical evolution.
    e. autotrophic organisms are theoretically impossible.

12. Which of the following is not a very good example of the cellular "compartmentalization"?
    a. Control of gene expression in the nucleus
    b. Glycosylation of proteins in the rough endoplasmic reticulum
    c. Breakdown of molecules by lysosome
    d. Transport of histone proteins into the nucleus
    e. Detoxification of xenobiotics in the smooth endoplasmic reticulum

13. It is possible to create some genetic diversity in a crop using genome editing technology, such as CRISPR-Cas9 system. Perhaps this can be accomplished by…
    a. introducing a new gene from a different species.
    b. identifying all the genes involved in the particular trait determination.
    c. generating mutations on certain target genes.
    d. increasing the resistance to specific disease.
    e. producing more seeds of the crop.

14. The importance of generating unequal chance of survival and mating in the population during the process of natural selection is…
    a. to create an unstable environment to speed up the process of evolution.
    b. to allow only selected individuals can leave their genes into the next generations.
    c. to increase the degree of competition in the population.
    d. to reduce the genetic diversity of the population.
    e. to ensure only the heritable traits can be selected during the process.

15. If the binding of an enzyme with its substrate was maintained by covalent bonds…
    a. the enzyme would be structurally very stable.
    b. the enzyme would be able to function more efficiently.
    c. the substrate molecule should be carbohydrates.
    d. the speed of reaction catalysis by this enzyme would be too slow.
    e. the enzyme would require much less energy for its catalytic function.

16. Even though dolphins are a mammal derived from an ancestral land mammal, their morphological feature, including aerodynamic body shape with fins, strikingly resembles that of fishes. Which one below is a reasonable account for this finding?
    a. This resemblance is a homologous structure.
    b. It is a result of their effort of adaptation to the similar type of environmental pressure.
    c. The feature is a useful clue in assessing the evolutionary relationship among different organisms.
    d. Their actual evolutionary relationship cannot be determined by using DNA sequence comparison in this case.
    e. The similarity in wings of birds and bats is another example of this type of resemblance.

17. Which of the following organelle's function was likely to be most directly related with the sudden extinction of gigantic flying insects around 250 million years ago?
    a. Rough endoplasmic reticulum
    b. Golgi
    c. Lysosome
    d. Mitochondria
    e. None of the above

18. The DNA sequence of human genome is 98.8% identical to that of chimpanzee. Therefore, …
    a. humans cannot interbreed with chimpanzees.
    b. for the remaining 1.2 % of DNAs, the differences are mainly the result of mutation.
    c. DNA sequence of the common ancestor for humans and chimpanzee will be also 98.8% identical to that of humans.
    d. the DNA of human is more stable than that of chimpanzee by about 1.2%.
    e. a DNA sequence comparison between human and chimpanzee made 1 million years ago would have also shown the same result.

19. The result of Neanderthals genome sequencing project revealed that the modern humans inherited several "bad genes" such as genes causing depression, allergy, diabetes, etc. from them. Which of the following explanations would be most reasonable interpretation to this finding?
    a. These genes underwent bad mutations after being transferred to us from them.
    b. Neanderthals are the direct ancestors of the modern human.
    c. Both Neanderthals and modern humans migrated out of Africa to Europe at similar time period.
    d. These troublesome genes might not have caused any problem to them under the environment they lived.
    e. As two independent species, Neanderthals and modern humans could not interbreed properly, thus resulting in the traces of such bad genes.

20. Certain drugs such as quinolones serve as an effective antibiotic by inhibiting bacterial DNA replication. This is possible because…
    a. the enzyme catalyzing DNA replication in bacteria is different structurally from that of eukaryotes.
    b. the drugs attack only the bacterial genes.
    c. the drugs cannot penetrate the eukaryote cells.
    d. prokaryotic ribosomes are structurally different from those of eukaryotes.
    e. the drugs inhibit the bacterial cell wall synthesis.

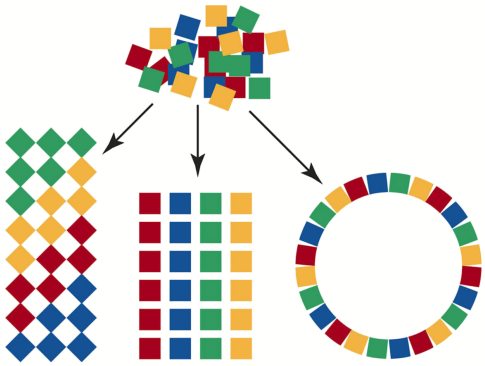
21. The chemical reactions shown below are all to be carried out in test tubes filled with water. Which one can be completed without adding any enzymes? **Explain your answer** (3 points)
    a. Synthesis of cell membrane from individual phospholipids
    b. Synthesis of proteins from amino acids
    c. Synthesis of glucose from CO_2 using the energy provided by breakdown of ATP into ADP
    d. Synthesis of RNA from nucleotides
    e. Replication of DNA double strands.

Essay Questions (5 points each)

1. Recently, the method of triggering autophagy by intermittent fasting has received much attention and popularity as a possible means of fighting against aging. If this was ever true, briefly propose your idea of explaining how this can work.

2. Explain the rationale behind the logic of using DNA sequence comparison for determining the evolutionary relationship among organisms.

3. Explain how this illustration can explain the emergent property, and briefly discuss the relationship between the emergent property and “systems biology”.



4. **Bonus question (5 point).**
   Propose your idea that can explain the mechanism for the monarch butterfly having increased longevity in every 4th generation.