

# Take Home Exam 1 Answers.

## QUESTION 1

1. Give a one sentence description of the field known as Bioinformatics.

Bioinformatics is the science at the intersection of Computer Sciences (informatics) and Genomics and the analysis of other biological data sets related to the acquisition of large amounts of data.

## QUESTION 2

ATP, GTP, NAD, NADP, FMN, and FAD are example of what type of cofactor?

- A. **Nucleotide or modified nucleotide**
- B. Lipid or modified Lipid
- C. Amino acid or modified amino acid
- D. oligosacharides

## QUESTION 3

Are viruses alive? Please include 2-4 points of evidence to back up your answer (simply a yes or no will not suffice).

**Examples** (other evidence we mentioned in class, discussion, or readings, is acceptable):

Yes, they are part of a living system, and the machinery that produces new viruses in an infected cell - aka the virus factory - is as metabolically active as a bacterium. The virus capsid is the propagation unit.

No, while viruses have genetic material and can evolve, the lack other important aspects of life. Yes they are part of a living system, but that does not mean that they are a life themselves.

## QUESTION 4

For most scientists, the field of bioinformatics does NOT include which of the following activities?

- A. Analyzing genome data using computers
- B. **Figuring out a protein structure from X-ray crystallography**
- C. Detecting homologs using primary sequence similarity
- D. Detecting homology using similarity in the secondary or tertiary structure of proteins

## QUESTION 5

Can a protein be 44% homologous to another protein?

- A. **Mostly no, with the exception of multi-domain proteins that have only one homologous in addition to one or more non-homologous domains.**
- B. Yes, if they share 44% sequence identity.
- C. No, without exception.

## QUESTION 6

Give a very brief description of the conditions under which evolution by natural selection occurs.

Requires excess of offspring, competition for resources, and variation among offspring.

## QUESTION 7

How many peptides (short proteins) of 70 amino acids in length are possible, given that there are 20 possible amino acids? For your answer only consider the principles of combinatorics and ignore possible incompatibilities between amino acids. How does this number compare to the estimated number of protons in the universe? (Note: these are two questions, requiring two answers)

**# of Peptides** →  $20^{70}$  →  $1.18 \times 10^{91}$

**# of Protons** → **between  $10^{78}$  and  $10^{81}$**

## QUESTION 8

How many types of subunits (note: this asks for the different types of subunits, encoded by separate genes, not the number of subunits) form the hexamer (the head) of nucleotide binding subunits in the F1 ATPase?

2

## QUESTION 9

How does Lysozyme destroy the stability of the bacterial cell wall?

- 1) Lysozyme prevents crosslinks made out of short peptides to be formed between the NAG-N-acetylmuramic acid polymers.
- 2) Lysozyme cleaves the crosslinks made out of short peptides that connect the NAG-N-acetylmuramic acid polymers.
- 3) **Lysozyme cleaves the beta 1-4 glycosidic bond between NAG and N-acetylmuramic acid.**
- 4) Lysozyme prevents the final transpeptidation step in the synthesis of the peptidoglycan.

## QUESTION 10

In the lysozyme structure 1HEW, the enzyme is crystallized together with an NAG trimer. This trimer

- 1) is a substrate of lysozyme
- 2) is an inhibitor of lysozyme
- 3) is the naturally occurring substrate of lysozyme
- 4) binds to the substrate binding site of lysozyme
- 5) binds to a subunit of lysozyme that regulated the catalytic activity
- 6) **2 and 4 are correct**
- 7) 1 and 4 are correct
- 8) 1 and 5 are correct

## QUESTION 11

Proteins that evolved from the same ancestral protein

- A. ALWAYS have significant similarity in their primary sequence.
- B. Cannot have different functions
- C. Can diverge so that they have only limited homology.
- D. Do not necessarily retain detectable similarity in the primary sequence.**
- E. Will ALWAYS have detectable levels of primary sequence similarity

## QUESTION 12

Which of the following occur after the primary transcript has been created, and before the the mRNA is translated?

- A. In eukaryotes, the 5' end of the RNA is capped with a modified guanosine**
- B. The 5' untranslated region is removed.
- C. Introns are removed through splicing the exons together**
- D. In eukaryotes for most RNAs a poly A tail is added at the 3' end**

## QUESTION 13

The cofactors listed in question 2 provide support for which hypothesis regarding the early evolution of life?

- A. DNA World
- B. Compartmentalized Cells First
- C. RNA World**
- D. Protein World
- E. Metabolism First

## QUESTION 14

True/False In the catalytic cycle of the ATPase, all of the catalytic subunits work in different phases of the catalytic cycle at any one point in time.

- A. True**
- B. False

## QUESTION 15

It is NOT possible to create a computer program to mimic evolution by means of artificial selection, because computers programs are NOT capable of finding new solutions that a human has never thought of before.

- A. True
- B. False**

## QUESTION 16

The head group of the ancestral ATPase (before the catalytic and non-catalytic subunits had evolved through a gene duplication) could have been a homohexamer with six identical subunits.

- A. True
- B. False

## QUESTION 17

True/False The different ATP binding subunit types that form the hexamer of the F1- ATP synthase are homologous to each other.

- A. True
- B. False

## QUESTION 18

What is homology?

- A. The creation of artificial life by any means.
- B. A difference found because of diverging evolutionary paths since the last common ancestor.
- C. Similarity due to shared ancestry, i.e. both got it from a common ancestor.**
- D. When two proteins share a function, such as nucleotide binding, they also share sequence similarities, because of the limited size of protein space.
- E. Shared sequence similarity based on convergent evolution, i.e. the ancestor did not have it.

## QUESTION 19

What is the Gaia hypothesis?

- A. Earth's plants control the planet's temperature by selection for flower color
- B. All life on Earth descended from ONE common ancestor
- C. The unit of life is the entire Earth and the entire biosphere is alive, because no single species can exist in complete isolation. The ecosystems on the Earth are protected by negative feedback loops that help maintain homeostasis.**
- D. Mars cooled faster than the Earth and therefore was a more habitable place for life earlier. Life arose first on Mars and traveled to Earth on meteorites
- E. Large glaciers and ice ages result from a runaway cold-house, where the Earth gets colder because glaciers reflect more light from the surface
- F. Zircon crystals in 3.8 billion year old rocks were produced by ancient life over 4 billion years ago. The zircon crystals are formed by running water and the bias in carbon isotope ratios indicates the presents of life.

## QUESTION 20

What might be the reason for proteins that show significant similarity in their primary sequence (when no simple repeats or low complexity regions are present) to be homologous.

- A. Sequence space is so big that stumbling onto a significantly similar sequence by chance is very unlikely**
- B. This is a trick question, because NOT all currently known proteins that share significant similarity are homologous
- C. There is a direct link between sequence similarity and percent homology
- D. Homologous sequences share a function and there is only a small region of protein space that can accomplish any one function
- E. All of the above

## QUESTION 21

Which elements make up the secondary structure of proteins?

- A. Hydrophobic domains, nucleotide binding motifs, and protein channels.
- B. Beta barrels, alpha corkscrews, and delta turns.
- C. Beta sheets, alpha helices, and loops.**
- D. Van der Waals interactions, hydrogen bonds, and disulfide bridges.
- E. Multiple protein chains interacting to form one macromolecule.

## QUESTION 22

Which of the following is a definition of life that has been adopted by many in the Astrobiology community?

- A. A contained metabolic system capable of evolution with heredity.**
- B. Cells. Life could only exist in a form compartmentalized by a lipid bilayer.
- C. Self-sustained metabolic system that does not require input from any other living system.
- D. An interacting web with intricate feedback loops to ensure homeostasis.
- E. Anything that can reproduce itself perfectly with no errors.
- F. All of the above are equally good answers.

## QUESTION 23

Which of the following is NOT part of the explanation for how complex functional molecules were assembled, despite the vastness of protein space?

- A. **Gaia directs protein evolution, through negative feedback loops, to the correct region of protein space.**
- B. There are multiple unrelated solutions for the same functionality, exemplified by the fact that there are non-homologous enzymes inhabiting completely different regions of protein space with the same function.
- C. An exact function does not need to be hit upon, because natural selection can take a protein with limited function and make it better.
- D. Similar structures have similar function, so there are entire regions of protein space occupied by homologs that all function equally well, or nearly so.
- E. Protein space is made slightly smaller by removing all of the possibilities that cannot be synthesized or they will clog up the ribosome

## QUESTION 24

Which of the following is NOT considered strong evidence for homology?

- A. The arrangement of secondary structure elements in space is the same or very similar.
- B. Significant primary sequence similarity
- C. Significant primary sequence identity
- D. **Identical function**
- E. None of the above

## QUESTION 25

If the murein sacculus of a bacterial cell is weakened, the cells may die because...

- 1) without a turgor pressure the cells can no longer import sugars and other substrates
- 2) **the cells blow up, because the osmotically driven water influx is no longer balanced by the turgor pressure.**
- 3) the osmotically driven influx of water changes the intracellular ion concentration leading to an inhibition of protein biosynthesis

## QUESTION 26

Transcription denotes the process

- 1) **by which mRNA is synthesized on a DNA template**
- 2) the inverse DNA strand is transcribed from a DNA strand
- 3) a protein sequenced is transcribed from an mRNA at the ribosome.
- 4) the processing of a pre-mRNA to the final mRNA that can be translated into a protein at the ribosome.