

EE-526 Introduction to Bioengineering

Example Exam

Lecture 2 Cell Biology

Q. Which of the following is involved in chromosome segregation during cell division? **(1 pt)**

- a. Microtubules
- b. Microfilaments
- c. Intermediate filaments

A: a

Q. Which part of the eukaryotic cell is involved in ribosomal RNA synthesis? **(1 pt)**

- a. Nucleolus
- b. Endoplasmic reticulum
- c. Golgi apparatus
- d. Mitochondria
- e. Chloroplast

A: a

Q. Which part of the eukaryotic cell is involved in lipid synthesis and detoxification processes? **(1 pt)**

- a. Rough endoplasmic reticulum
- b. Smooth endoplasmic reticulum
- c. Golgi apparatus
- d. Mitochondria
- e. Chloroplast

A: b

Q. Which parts of the eukaryotic cell are involved in energy processing? Select all the appropriate answers. **(3 pts)**

- a. Golgi apparatus
- b. Chloroplast
- c. Lysosomes
- d. Ribosomes
- e. Mitochondria

A: b, e

Q. What kind of molecules can pass through the cell membrane? Select all the appropriate answers. **(3 pts)**

- a. Polar molecules
- b. Non-polar molecules
- c. Large molecules
- d. Small molecules

A: b,d (e.g. oxygen, CO₂, lipids)

Q. Which transport uses ATP? (1 pt)

- a. Simple diffusion
- b. Primary active transport
- c. Facilitated Diffusion
- d. Secondary active transport

A: b

Lecture 3 DNA and RNA

Q. What are the structural differences between RNA and DNA? (4 pts)

A: RNA is a single-stranded structure while DNA is a double helix. They also share common nucleobases (e.g. adenine, cytosine, guanine), whereas one of them is different (RNA has uracil and DNA has thymine).

Q. How many genes does a human have? (1 pt)

- a. About 200
- b. About 2,000
- c. About 20,000
- d. About 200,000
- e. About 2,000,000

A: c

Q. What is the synthesis direction of DNA polymerases? (1 pt)

- a. 5' to 3'
- b. 3' to 5'

A: a

Lecture 4 Proteins

Q. A _____ (peptide/disulfide/acetylene/ethylene) bond links two consecutive amino acids in a protein chain. (1 pt)

A: peptide

Q. AlphaFold is a deep learning method that is revolutionising protein engineering by: (1 pt)

- a. Predicting protein structure
- b. Suggesting proteins for transcribing selected DNA
- c. Designing DNA for robust protein synthesis
- d. Designing fluorescent markers for proteins

A: a

Lecture 5 Biochemistry

Q. What are the key ingredients required to start translation during protein synthesis? (1 pt)

- a. DNA, mRNA, tRNA
- b. mRNA, Ribosome, Amino acids
- c. mRNA, Ribosome, Initiator
- d. mRNA, DNA polymerase, Ribosome

A: c

Lecture 6-7 Thermodynamics

$$K_d = \frac{[A][B]}{[AB]} = \frac{k_{off}}{k_{on}} = K_a^{-1}$$

$$Y_B = \frac{[A]}{K_d + [A]} \approx \frac{[A]_{total}}{K_d + [A]_{total}} \text{ if } [B]_{total} \ll K_d \text{ or } [A]_{total} \gg [B]_{total}$$

$$\frac{1}{K_d} - \frac{Y_B}{K_d} = \frac{Y_B}{[A]}$$

$$[AB] = [AB]_0 * e^{-k_{off}t}$$

$$t_{1/2} = \frac{\ln(2)}{k_{off}}$$

$$[AB] = \frac{[A][B]_0}{[A] + K_d} (1 - e^{-(k_{on}[A] + k_{off})t})$$

All formulas will be provided.

Questions will be similar in difficulty to the problem set on this topic.

Lecture 8 Techniques and Methods I

Q. What is the ideal temperature for medium-term storage (~1-3 years) of a glycerol stock of bacteria? (1 pt)

- a. 4°C
- b. 20°C

- c. -20°C
- d. -80°C

A: -20°C

Lecture 9 Techniques and Methods II

Q. Which enzyme is essential for the PCR process? (1 pt)

- a. Protease
- b. RNA Polymerase
- c. DNA Polymerase
- d. Ligase

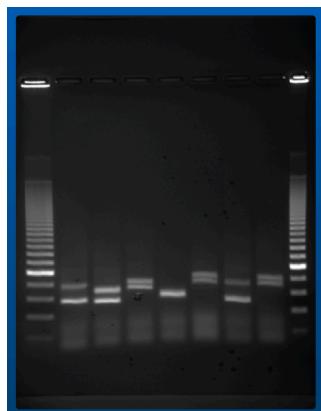
A: c

Q. Why is PCR an important tool in molecular biology? (1 pt)

- a. It sequences the entire genome.
- b. It helps in the direct observation of proteins.
- c. It aids in the conversion of RNA to DNA.
- d. It allows for the rapid amplification of specific DNA sequences.

A: d

Q. The picture below shows the result of the agarose gel of 7 PCR reactions in which you tested different primer pairs to find the most optimal pair. Which PCR reaction achieved the best result? (2 pts)



A: 4th reaction from the left. Because this is the only reaction that produced a single product band.

Q. How can initial target DNA template concentration be determined in digital PCR? (2 pts)

1. _____

A: essentially by simply counting the number of positive PCR reactions.

Lecture 10-12 Advanced Topics

Q. Which of the following microfluidic techniques offers the highest throughput? (1 pt)

- a. Valve-based microfluidics
- b. Droplet microfluidics
- c. Digital microfluidics
- d. Paper-based microfluidics

A: b

Q. What is achieved by including both an analog and a digital detection mechanism on a single microfluidic device? (1 pt)

- a. Increased throughput
- b. Increased dynamic range
- c. Higher limit of detection
- d. Improved device robustness

A: b

Q. Name at least 3 application areas for organ-on-a-chip and organoid technologies. (3 pts)

1. _____
2. _____
3. _____

A: Biological mechanism studies, drug discovery, toxicity studies, radiobiology, regenerative medicine, models for disease / cancer