

QUESTION 1 (25 POINTS)

(a) (10 Points) List five cellular compartments or cell organelles. Briefly describe its ultrastructural features and name its major function in keywords.

1. Nucleus: double-membrane organelle. Important for RNA transcription DNA replication, and DNA storage. (2 pts)
2. Mitochondria: double-membrane organelle with inner membrane folded. Important for energy production. (2 pts)
3. Endoplasmic reticulum: single-membrane organelle. Important for synthesis of transmembrane and secreted proteins (protein folding, and protein N-linked glycosylation). (2 pts)
4. Golgi apparatus: single-membrane organelle. Important for protein modification (O-linked glycosylation, M6P) and sorting. (2 pts)
5. Lysosome: Single-membrane organelle. Important for degradation. (2 pts)

Or any other organelles such as plastid, vacuole, peroxisome, proteasome, ribosome...etc.

(b) (5 Points) How do we explain the origin of cell organelles such as mitochondria and plastids?

Endosymbiont hypothesis: Mitochondria and plastids originate through the symbiosis of aerobic prokaryotic cells and host (pre)-eukaryotic cells. (2 pts)

Initially, a prokaryotic cell is engulfed into a eukaryotic cell. The host cell provides the outer membrane to surround the prokaryotic cells. The prokaryotic cells were reduced to cell organelles such as mitochondria or plastids and lost their independence due to gene transfer in the host cell nucleus. (3 pts)

(c) (5 Points) List five facts supporting the theory/hypothesis you described in the part (b) and explain why (in keywords).

1. Have double membrane. Inner one from the prokaryotic cell, and outer one from the plasma membrane of host cell. (1 pt)
2. Have circular DNA. It's similar to prokaryotic DNA. (1 pt)
3. Lack histones. Prokaryotic cells don't have histones. (1 pt)
4. Have smaller ribosome. Similar to prokaryotic cells. (1 pt)
5. Start protein synthesis with formyl-methionine. Prokaryotic cells also use it to start the protein synthesis. (1 pt)

Others such as polycistronic versus monocistronic mRNA, mode of division involving Ftsz (for plastids only), mitochondria and plastids are phylogenetically related to prokaryotes...etc.

(d) (5 Points) Briefly explain the following terms (in keywords):

nucleomorph: a small, reduced eukaryotic nucleus found in certain plastids. (1 pt)

apicoplast: a reduced, non-photosynthetic plastid found in most Apicomplexa. Formed by secondary endosymbiosis. It has four membranes. (1 pt)

secondary endosymbiosis: An eukaryotic cell engulfs another eukaryotic cell. Eventually, one is reduced to become an organelle of the host cell. (1 pt)

stromatolites: layered fossil structure formed by microorganisms such as cyanobacteria. Provide the most ancient record of the life on Earth. (1 pt)

compartmentalization rule: a membrane separates a plasmatic and a non-plasmatic compartment. (1 pt)