1. What is the primary cause of antibiotic resistance in the tuberculosis bacteria described in the case study?

Answer: A mutation in a specific gene enabled the tuberculosis bacteria to survive and multiply despite antibiotic treatment, leading to resistance.

2. How did doctors confirm the cure of tuberculosis in the case study patient after initial treatment?

Answer: A culture of the lung fluid and a chest X-ray were performed 10 months after treatment began, confirming the absence of active tuberculosis.

3. What is the significance of superbugs in healthcare?

Answer: Superbugs are bacteria resistant to multiple antibiotics, making common treatments ineffective and posing a major challenge in treating infections.

4. According to Lamarckism, how did giraffes develop longer necks?

Answer: Giraffes stretched their necks to reach higher leaves due to food scarcity, and this acquired trait was passed to offspring, leading to longer necks.

5. Why was Lamarckism disproved?

Answer: Acquired characteristics do not alter an organism's genetic structure and thus are not inherited, as confirmed by later genetic studies.

6. What is the core principle of Darwin's Theory of Natural Selection?

Answer: Organisms with favorable variations survive, reproduce, and pass these traits to offspring, leading to the evolution of new species over time.

7. How did the diversity in beak shapes of Galapagos finches contribute to their survival?

Answer: Finches with beak shapes suited to available food sources (e.g., seeds, insects, cactus) survived and reproduced, leading to diverse beak types.

8. What is meant by "survival of the fittest" in Darwin's theory?

Answer: Organisms with variations that best suit their environment survive and reproduce more effectively, passing favorable traits to future generations.

9. How does Neo-Darwinism address the limitations of Darwin's original theory?

Answer: Neo-Darwinism incorporates genetics, explaining variations through mutations, genetic recombination, and gene flow, which Darwin could not.

10. What is the Last Universal Common Ancestor (LUCA)?

Answer: LUCA is the hypothetical single-celled ancestor from which all life forms on Earth are believed to have descended billions of years ago.

11. How does molecular biology provide evidence for evolution?

Answer: Comparing DNA nucleotide and protein amino acid sequences shows similarities between organisms, indicating common ancestry (e.g., fewer differences in hemoglobin beta chain between humans and chimpanzees).

12. Based on Table 2.1, which organism is most closely related to humans evolutionarily, and why?

Answer: Chimpanzees, because they have zero differences in the amino acid sequence of the hemoglobin beta chain compared to humans.

13. How do fossils like Archaeopteryx support the theory of evolution?

Answer: Archaeopteryx, with features of both reptiles and birds, acts as a connecting link, showing transitional forms in evolutionary history.

14. What trend is observed in the cranial capacity of human ancestors from Sahelanthropus to Homo sapiens?

Answer: Cranial capacity increased from 350 cm^3 in Sahelanthropus tchadensis to 1350–1450 cm^3 in Homo sapiens, enabling advanced cognitive functions.

15. What role did brain development play in human evolution?

Answer: Increased brain size and complexity enabled tool-making, language, social interactions, and cultural advancements, aiding human survival and dominance.

16. What is the function of the myelin sheath in neurons?

Answer: The myelin sheath insulates axons, speeds up impulse transmission, provides nourishment, and protects axons from external injuries.

17. How does the neocortex contribute to human cognitive abilities?

Answer: The neocortex, with approximately 16 billion neurons and 7000 synapses per neuron, enables advanced thinking, decision-making, learning, and memory.

18. What are the main parts of a synapse, and what is its role in impulse transmission?

Answer: Parts: presynaptic membrane, synaptic knob, synaptic cleft, postsynaptic membrane. Role: Transmits impulses unidirectionally by releasing neurotransmitters that stimulate the next neuron.

19. Differentiate between the sympathetic and parasympathetic nervous systems.

Answer: The sympathetic system prepares the body for emergencies (e.g., increases heartbeat), while the parasympathetic system promotes relaxation and routine functions (e.g., increases saliva production).

20. What is a reflex arc, and why is it significant?

Answer: A reflex arc is the pathway of impulses in a reflex action, involving a receptor, sensory neuron, interneuron, motor neuron, and effector. It enables rapid, involuntary responses to protect the body.

Application-Level Questions

21. A new antibiotic is developed, but bacteria become resistant within a year. Explain how this could happen based on the case study.

Answer: A mutation in the bacterial genome could confer resistance to the new antibiotic, allowing resistant bacteria to survive and multiply, passing the trait to offspring, as seen in the tuberculosis case.

22. If a population of birds faces a drought reducing seed size, how might natural selection affect their beak size?

Answer: Birds with smaller beaks suited to smaller seeds would survive and reproduce, passing this trait to offspring, leading to a population with smaller beaks over generations.

23. Why might a doctor use evolutionary principles to design a treatment for a viral infection?

Answer: Understanding how viruses evolve (e.g., through mutations in RNA) helps predict resistance patterns, allowing doctors to combine drugs or develop new treatments to target evolving variants.

24. How could the absence of a myelin sheath affect an organism's survival in a predator-rich environment?

Answer: Without a myelin sheath, impulse transmission would be slower, delaying responses like fleeing from predators, reducing the organism's survival chances.

25. If a species of fish in a polluted river develops a mutation for toxin resistance, how might this lead to a new species?

Answer: The mutation allows resistant fish to survive and reproduce in the polluted environment. Over time, accumulated variations and isolation from non-resistant fish could prevent interbreeding, forming a new species.