Test Bank, Chapter 1

1. Which of the following is NOT an example of evolution?

(a) Beak size in a population of birds becomes larger from one generation to the next because larger beaked birds had higher reproductive success and passed the trait to their offspring
(b) Over long periods of time whales gradually lost their hindlimbs
(c) When traveling to high altitude, human physiology changes to accommodate lower oxygen levels
(d) All of the above are examples of evolution

2. The fluke of a whale and the fluke of a shark:

(a) are homologous traits
(b) arose through convergent evolution
(c) are the result of natural selection
(d) b and c are correct
(e) all are correct

3. Mammary glands in whales and humans:

(a) are a synapomorphy for these species and other mammals
(b) are homologous traits
(c) were likely present in the most recent common ancestor of humans and whales
(d) all are correct
(e) none are correct

4. Based on current fossil evidence:

(a) whales were likely fully aquatic before they evolved peg-like teeth or baleen
(b) evolution of baleen forced whales to become fully aquatic
(c) the teeth of extinct whales such as *Dorudon* were similar to those of extinct land mammals
(d) a and c are correct
(e) b and c are correct

5. One important feature that links extinct organisms such as *Pakicetus* and *Indohyus* to cetaceans is:

(a) the shape of a bone in the middle ear
(b) the presence of forelimb flippers
(c) the lack of hindlegs
(d) peg-like teeth

6. The placement of whales within the artiodactyls is supported by:

(a) morphology of limb bones (e.g. the astragalus) in extinct whales
(b) DNA evidence
(c) the fact that some artiodactyls (e.g. hippos) spend a significant amount of time in the water
(d) a and b are correct
(e) all of the above

7. From examining the fossil record, scientists have postulated that long-term historic changes in cetacean diversity depended on:

(a) changes in the abundance of diatoms, one of their main food sources
(b) changes in the abundance of diatoms, which serve as food for animals that were preyed upon by cetaceans
(c) changes in sea temperature
(d) rising pollution levels in the ocean
(e) changes in the abundance of organisms that prey on cetaceans

8. Which of the following would explain why viruses such as influenza evolve so rapidly:

(a) they have a high mutation rate
(b) they have a high replication rate
(c) they can undergo viral reassortment
(d) none of the above
(e) all of the above

9. Which of the following statements is accurate regarding the evolution of drug resistance in a virus:

(a) the drug causes mutations in the virus that make it resistant
(b) even before the drug is administered, some virions might be resistant
(c) an individual virion that is exposed to the drug will adapt by becoming resistant; future applications of the drug will be ineffective against this virion
(d) all of the above

10. The molecular clock used to date the emergence of the 2009 H1N1 strain would be inaccurate if:

(a) mutations arose at different rates in different lineages
(b) the most recent common ancestor of the viral strains existed long ago
(c) the most recent common ancestor of the viral strains existed recently
(d) none of the above

11. New mutations:

(a) are random with respect to their effects on fitness
(b) are necessary for natural selection to cause evolutionary change
(c) are rare in a population
(d) a and b are correct
(e) all are correct

12. Evolution occurs when:

(a) individuals in a population change in response to the environment
(b) the average value of trait in a population changes from one generation to the next
(c) a and b are both correct
(d) Neither a or b is correct

Short answer/essay.

1. Please describe evidence three pieces of evidence found in *extant* cetaceans that supports the idea that their ancestors had hindlimbs.

1. **During embryonic development hindlimb buds form, but are then stop growing.**
2. **Some extant whales have a vestigial pelvis, which only makes sense if their ancestors had hindlimbs.**
3. **DNA evidence shows that cetaceans are nested within the artiodactyls. The common ancestor of artiodactyls would have had hindlimbs.**

2. Describe how scientists used carbon isotopes to determine whether extinct whales likely inhabited freshwater or saltwater.

Although most oxygen atoms have eight neutrons, some oxygen isotopes have more (e.g. 10). Seawater has more oxygen atoms with 10 neutrons (heavy) than freshwater, and animals that live in the sea incorporate more heavy oxygen into their bones than animals that live on land. Thus, by measuring the ratio of light to heavy oxygen in the bones of fossil whales, and comparing this to ratios found in extant organisms inhabiting freshwater or seawater environments, scientists were able to determine whether extinct whales likely lived in the sea or the land.

3. Describe two examples from extant cetacean anatomy or development that reflect their ancestral past.

1. **Vestigial pelvis in some species.**
2. **Hindlimb buds form during embryonic development.**
3. **Baleen whales have genes for building teeth that have been disabled by mutation.**

4. The influenza virus has only 10 genes, which is far fewer than other non-viral organisms. Why do you think viruses are able to survive and replicate with so few genes compared to other organisms?

Viruses are parasitic, relying on much of the replication machinery of their host to reproduce. Given this, their genetic code is much smaller and contains fewer genes than other organisms.

5. When scientists infected vaccinated and non-vaccinated mice with influenza, they found that after nine sequences of viral passage the hemagglutinin protein was altered in one of the groups. Which group was it, and what is the evolutionary explanation for the differences between the groups?

The protein was altered in the vaccinated mice. Mice that were vaccinated against influenza produced antibodies that recognized the hemagglutinin protein and enabled a swift immune response against infection. Under these circumstances, a virion that had a mutation altering the structure of the hemagglutinin protein might be able to evade detection by the immune system. Such virions would have a higher replication rate than those without the mutation. After several passages, the mutation would be at high frequency in the viral population. In non-vaccinated mice, selection pressure on the hemagglutinin protein was absent or reduced because newly infected mice did not have antibodies against the protein. Although there were likely virions in the viral population that had mutations in the hemagglutinin gene, these mutants would not have had a reproductive advantage, and hence would not have increased in frequency in the population.

6. Given what you learned about how influenza changes over time, how could you explain the emergence of drug resistance in bacterial pathogens. For example, certain strains of tuberculosis are resistant to many of the major classes of antibiotics traditionally used to fight this pathogen.

There is variation in the bacterial population, with some strains carrying mutations that make them resistant or partially resistant to antibiotics (while other strains do not). In the presence of antibiotics susceptible strains will die before they reproduce while resistant strains will survive. If

surviving resistant strains pass on the resistant mutation to their progeny, the proportion of the population that is resistant will increase over time.

7. The 2009 H1N1 pandemic strain included genes from influenza that normally infects pigs, birds, and humans. How is this possible? Why are mixed strains particularly likely to cause high mortality?

When a host is infected by more than one strain of influenza, the different viral strains can swap genes through the process of viral reassortment. Reassortant strains can be devastating because surface proteins are very different so the immune system does not recognize the virus. What is particularly concerning is that reassortment will combine foreign surface proteins from strains that affect other species with the infectious potential of human strains.

8. What is a scientific theory and how does this differ from how we often use the term in a non-scientific context?

In a non-scientific context we often use the word theory to describe a hunch or guess. However, in science the term theory has a very different meaning. A scientific theory is an overarching explanation for a collection of facts and observations about some major aspect of the natural world. Theories have been tested repeatedly and are supported by many independent lines of evidence.

9. Evolution is often described as a completely random process. Is this true? Why or why not?

Evolution involves elements that are random and elements that are non-random. Mutation is random because the likelihood of a particular mutation occurring in a particular individual is based on chance. Moreover, mutations that would be beneficial in a particular environment are no more likely to occur simply because they would be beneficial. The process of natural selection is completely non-random as mutations are either lost or preserved based on how they affect the reproductive success of their bearers. (Note: genetic drift is also random, though at this point in the book the students may not have a strong grasp of this).

10. You discover a new 50 million year old fossil that you believe might be an ancient cetacean. The creature looks nothing like a modern cetacean—it has four legs and clearly spent considerable time on land. Describe one feature that would indicate that this creature was, in fact, an early cetacean.

You could look at the shape of the involucrum, which forms a thick lip made of dense bone in cetaceans but not other mammals (i.e. it is a synapomorphy).

11. Describe one piece of evidence that indicates that early four-legged whales such as *Indohyus* and *Pakicetus* are more closely related to modern day whales than they are to the closest living four-legged relative of modern whales, the hippopotamus.

Both *Indohyus* and *Pakicetus* have an involucrum with a thickened internal lip, a unique feature of whales.

12. Sirenians (manatees and dugongs) are aquatic mammals that, like whales, lack hind limbs. Is lack of hindlimbs a homologous trait for sirenians and cetaceans?

No, this would be an example of homoplasy (term not discussed in text) resulting from convergent evolution. For this to be a homologous trait the common ancestor of sirenians and cetaceans would have also had to lack hindlimbs. We know that cetaceans are nested within the artiodactyls—since most artiodactyls have four legs, we can conclude that the common ancestor of all artiodactyls probably also had four legs. Thus, cetaceans would have had to have lost their legs independently from sirenians, to which they are more distantly related. This is likely a case of convergent evolution producing a similar adaptation to an aquatic lifestyle.

13. Before DNA evidence scientists had a difficult time discerning where cetaceans fit into the mammalian family tree. Based on morphological features used to classify artiodactyls, why would it have been difficult to link cetaceans to artiodactyls based on morphological evidence alone? How do more recent discoveries in the fossil record link cetaceans to artiodactyls?

One of the main synapomorphies for the artiodactyls is the pulley-shape of the astragalus, a bone in the ankle. Modern cetaceans do not have hindlimbs, so there was simply no easy way to link them to the artiodactyls. The finding that early fossil whales such as *Indohyus* and *Pakicetus* have the pulley-shaped astagalus along with derived cetacean features such as the shape of the involocrum, confirms the relationship between these groups.

14. Drawing on your knowledge of evolution, describe reasons why treatment and/or vaccination against viruses can be particularly difficult.

1. **Viruses have an extremely high replication rate. Every time a virion replicates there is the possibility for new mutation. Some of these mutations may change the virus such that it becomes resistant to**

treatment, or can elude the host immune system. Having a high replication rate increases the probability of mutations that are beneficial to the virus.

2. **Viruses often have a very high mutation rate. A higher mutation rate increases the probability that some new mutations will be beneficial to the virus.**
3. **Viral reassortment: different viral strains can exchange genetic material. This has similar effects as mutation. It can be particularly problematic for vaccines/treatment because of the possibility of combining novel surface proteins with properties that allow human to human transmission.**