1. Even though big-beaked finches are able to crack more kinds of seeds and survive in harsher conditions, researchers have observed evidence of multi-directional selection, where finch beaks sometimes evolve to be bigger and sometimes to be smaller. This is probably due to:

A. gene flow
B. genetic drift
C. heterozygote advantage
D. stabilizing selection
E. **tradeoffs**

2. Some cards are laid on a table. They are taken from a set of cards with solid green or blue backs, and pictures of ~~mountains~~ meadows or lakes on the front. You can see either the front or the back of each card. To *efficiently* test the hypothesis that all of the green-backed cards on the table have lakes on the front, you would turn over all of the green-backed cards you see, and

A. no other cards
B. all of the lakes you see
C. **all of the meadows you see**
D. all of the lakes and meadows you see

3. Prof. Dushoff's daughter is mean but not tall. According to simple logic rules, this would falsify which of the following statements?

A. **Mean people are tall**
B. Tall people are mean
C. Both A and B
D. Neither A nor B

4. The biological species concept does not apply *at all* to:

A. **asexual populations**
B. extinct organisms
C. geographically isolated organisms
D. plants

5. The phylogenetic species concept defines species by starting at the level of _____ and taking the _____ monophyletic groups based on that level to be a species.

A. individuals; largest
B. individuals; smallest
C. populations; largest
D. **populations; smallest**

6. Which of the following statements about inbreeding is true?

A. In many populations, it is observed that inbred individuals have higher fitness due to their parents having a smaller gene pool.

B. **Inbred individuals are more likely to be homozygous for rare genetic defects.**

C. Inbred individuals are more likely to be heterozygous for immune-system genes.

D. As populations get bigger, inbreeding becomes more common.

*Use the following information for the next two questions.* A randomized, controlled experiment compared raw milk under two different treatments. The milk was poured into bottles, which were placed in cold water or boiling water for several minutes before being stored in a refrigerator for four weeks. The experiment found that the boiled and un-boiled milk generally had different types of bacteria, and that people usually described the un-boiled milk as "sour" and "tasty", and the boiled milk as "bitter" and "nasty".

7. To follow good experimental practice, the researchers should have

A. Used two refrigerators: one for boiled milk and one for un-boiled milk

B. Used many refrigerators: one for each bottle of milk

C. Add some bottles not placed in water at all as a control

D. **First decided which bottles will go where, and then randomly chosen which bottles would get boiled or unboiled milk**

8. Which of the following explanations is directly inconsistent with the results of this experiment (not with other knowledge).

A. The cold water gives the sour bacteria a head start, which allows them to outcompete the nasty bacteria when they couldn't otherwise.

B. The boiled water gives the nasty bacteria a head start, which allows them to outcompete the sour bacteria when they couldn't otherwise.

C. Heating in boiled water kills the sour bacteria, but not the nasty bacteria

D. Heating in boiled water kills all the bacteria, and nasty bacteria come in from the environment.

E. **None of the above is inconsistent; they could all explain the observed result**

9. Which of the following is a likely explanation for the high number of unique species found on islands?

A. Extinction rates are lower on islands

B. **The isolation of islands provide opportunities for allopatric speciation**

C. Sympatric speciation is easier on islands because populations are smaller

D. Vicariance events are more common on islands

10. Most adaptive evolution is directly caused by _____ and indirectly made possible by _____.

A. genetic drift; gene flow
B. natural selection; gene flow
C. genetic drift; mutation
D. **natural selection; mutation**

11. Two related populations of lizards show distinct colour patterns due to environmental differences on either side of a mountain range. Researchers observe that when different colour variants meet they rarely mate, and when they do, the offspring are viable but have very low fitness. These facts are likely explained by _____ speciation followed by _____.

A. allopatric; exclusion
B. **allopatric; reinforcement**
C. sympatric; exclusion
D. sympatric; reinforcement

12. Two populations of warblers are reunited by a change in climate. Although hybrids on average have lower fitness, the two populations are observed to fuse together. This is likely because _____ is stronger than _____ in this case.

A. Gene flow; genetic drift
B. Genetic drift; gene flow
C. **Gene flow; natural selection**
D. Natural selection; gene flow

13. All of the following are examples that scientists believe show evidence for evolution by natural selection. Which of them does *not* represent an example of *directly observed* evolution?

A. **Cephalopods (like octopi) evolving eyes similar to mammal eyes but without a blind spot**
B. E. coli becoming more efficient at using different food sources
C. Finches changing beak size in response to changed environmental condition
D. Tuberculosis bacilli becoming resistant to drugs

14. The pattern of homologies in nature provides evidence for evolution because

A. Homologies can be developmental, genetic or structural
B. **The way homologies group together explains many observations**
C. We couldn't have homologies without evolution
D. We see more homologies than analogies

15. In a population of gazelles, researchers observe that some run faster than others, and that there is a correlation between how fast parents run and how fast their offspring run. To show that there is natural selection for this population to run faster, the researchers still have to _____.

A. Find the genetic basis for these differences
B. **Show that fast-running gazelles on average produce more offspring than other gazelles**
C. Show that running fast is heritable in this population
D. Show that fast-running gazelles are more attractive to other gazelles in this population
E. None of the above, their described observations are sufficient.

16. Hedgehogs and tenrecs are distantly related, but have many similarities, relating to how they gather food and protect themselves, that they don't share with closer relatives. This is most likely due to:

A. developmental homology
B. structural homology
C. genetic homology
D. **adaptation by natural selection**

*Use the following information for the next two questions.* A species of frog was separated into two small populations in the Adirondack mountains several thousand years ago by a cold spell that prevented them from living on hills separating two valleys. The two populations are now observed to mate in the intervening hill areas, but the offspring are rarely healthy and have low fitness.

17. Which of the following is *not* a likely explanation for the low fitness of hybrid offspring?

A. Disruptive selection
B. Genetic drift
C. **Gene flow**
D. Incompatible adaptive mutations

18. We expect these populations to be under some amount of selection for

A. Exclusion
B. Fusion
C. Polyploidy
D. **Reinforcement**

19. MN blood groups in humans show very little evidence of natural selection, but different populations have very different allele frequencies of M and N. These differences are likely driven by:

A. gene flow
B. **genetic drift**
C. non-random mating
D. random mating

20. Lions are extremely strong and fast, but there is no evidence that they have gotten stronger or faster in the last 200,000 years. This is likely an example of a transition from _____ selection to _____ selection.

A. **directional; stabilizing**
B. stabilizing; directional
C. disruptive; positive
D. positive; disruptive

21. Many shellfish use their tails to swim, but some have tiny tails that are curled under their shells, and have no known use. These tails likely result from:

A. allopatric speciation
B. sympatric speciation
C. analogy with functional tails
D. **homology with functional tails**
E. gene flow

22. Natural selection tends to favor _____ isolation because it results in _____.

A. **pre-zygotic; less wasted resources**
B. post-zygotic; less wasted resources
C. pre-zygotic; more effective adaptation
D. post-zygotic; more effective adaptation

23. Which of the following could represent a vicariance event for deer?

A. The closing of the isthmus of Panama, separating the Pacific ocean and the Caribbean Sea
B. A drought kills all but the best-nourished deer
C. A group of deer are carried by a flood and swim to safety on an offshore island
D. **A river changes course, splitting a deer population into two groups**

24. Scientists believe that adaptive evolution is driven by natural selection and not inheritance of acquired characteristics primarily because of

A. Patterns of relatedness between species
B. The fact that organisms can both gain and lose complexity over time
C. The logic of Darwin's theory
D. **The results of experiments and direct observations**

25. Random changes in coat patterns of coatis (small jungle mammals) can be caused by strong natural selection events driven by infectious disease. The connection between the two is most likely due to _____ driven by _____.

A. balancing selection; founder effects
B. balancing selection; genetic bottlenecks
C. genetic drift; founder effects
D. **genetic drift; genetic bottlenecks**

26. Peppered moths with the genotype DD or DL are dark in color, and essentially the same as each other. The D allele is an example of a _____ allele in a system with _____ dominance.

A. dominant; complex
B. **dominant; simple**
C. recessive; complex
D. recessive; simple

27. Over a period of about 100 years, beach mice in central California switched from being white to grey. The color change was primarily driven by a single locus with two alleles. The grey allele was most likely

A. dominant
B. recessive
C. favored by genetic drift
D. showing heterozygote advantage
E. **under positive selection**

28. A population of soapberry bugs grows up and breeds on two different plant species. If the bugs mostly breed with bugs from the same plant species, and plant preference is heritable, we would expect to see more _____ than _____ when looking at alleles related to plant preference.

A. heterozygotes; homozygotes
B. homozygotes; heterozygotes
C. heterozygotes; than expected under Hardy-Weinberg
D. **homozygotes; than expected under Hardy-Weinberg**

29. A different population of soapberry bugs shows genotype frequencies similar to Hardy-Weinberg expectation at these alleles. We can conclude that this population

A. Is mating at random
B. Is not experiencing natural selection at these alleles
C. Is not experiencing mutations at these alleles
D. **None of the above are safe conclusions**

30. A polyploidy event, followed by one of the populations evolving to exploit a different niche, would be an example of genetic _____ followed by genetic _____.

A. drift; isolation
B. isolation; drift
C. divergence; isolation
D. **isolation; divergence**

31. A wild population of dwarf whortleberry plants has a locus with two alleles: D is associated with darker leaves and L is associated with lighter leaves. You observe 30 plants dark plants, 40 light plants, and 90 intermediate plants.

a) (2 points) Assume that these observations are driven only by the locus under study. What is your estimate of the *genotype* frequencies in this population?

There are 160 plants. We assume that the dark plants are DD, light plants are LL and intermediate plants are DL, so the frequency of DD is 30/160=19%; LL is 40/160=25% and DL is 90/160=56%.

*1 point for the idea of adding and dividing, 1 point for perfect math.*

b) (1 point) What is your estimate of the *allele* frequencies?

The alleles are D and L. There are 2*30+90=150 D alleles and 320 total alleles, so the frequency of D is 150/320= 47% and the frequency of L is 1-150/320 = 53%.

c) (1 point) Somebody else finishes these calculations, and shows that there were more heterozygotes observed than expected in this population. What is a possible reason for this phenomenon?

Better heterozygote survival is the most likely explanation. It's also possible that there is some sort of process that makes individuals more likely to mate with individuals with a different phenotype, like maybe they are pollinated by bees that like to alternate flower color.

32. Striking features associated with sexual dimorphism are more common in males than in females.

a) (1 point) What general fact about male and female reproductive care drives this pattern?

Females usually invest more per offspring than males do.

b) (2 points) Why does it make sense that this fact could drive such a pattern?

If females invest more per offspring, males are likely to have greater variation in reproductive success (since males have a greater reproductive potential, but both sexes have the same average reproductive success). Therefore it makes more sense for females to be choosy and for males to compete for female attention in this case.

*One point for variation, one point for competition.*

c) (1 point) Make a prediction based on the logic in this question that you could test by observing patterns of sexual dimorphism.

We would predict that there would be a correlation between proportion of investment by females and sexual dimorphism in striking traits. This could be investigated by observation.

33. (2 points) You are running an experiment on the relationship between exercise and weight in mice. Your budget is limited to 20 mice. You go to pet store A, buy 10 mice, and put them all in separate cages without running wheels. You go to pet store B, buy 10 more mice, and put them all in separate cages with running wheels. Except for the presence or absence of wheels, all the cages are the same. You provide the mice unlimited access to food and measure their weight at the beginning and end of your experiment. What is the most important thing you could do to improve this experiment, and why?

It is important to *randomize* the mice. There are all kinds of potential differences between pet store A and pet store B that you do *not* want to need to worry about. Ideally, you would put all of the mice in cages first, and then randomly decide which 10 cages get wheels. But even if that is not possible, you would want to randomize both wheel locations and mouse assignments.

*One point for randomizing, one point for the idea that you don't want to have to worry about uncontrolled factors.*