1. Only madrigals can sublimate. Alice is a madrigal. Bob can sublimate. Which of the following must be true?

A. Alice can sublimate
B. **Bob is a madrigal**
C. Both
D. Neither

2. All bats can fly; All bats are mammals: Therefore, some mammals can fly. What is wrong with the logic?

A. **nothing; the logic is correct**
B. we should conclude "all mammals can fly"
C. there are some flying mammals that are not bats
D. statement (a) should be "all flying animals are bats"
E. statement (b) should be "all mammals are bats"

3. Examining individuals from two populations of beetles, we find that we can easily identify which population an individual comes from by examining the shape and size of their antennas. Therefore, we conclude that the two populations represent different species. This is an application of the

A. biological species concept
B. phylogenetic species concept
C. ecological species concept
D. **morphological species concept**

4. Researchers have found fossils of horse-like skeletons in Colorado. Deeper deposits contain skeletons of smaller bodied animals, and shallower deposits contain skeletons of larger-bodied animals. How does this observation support the theory of evolution?

A. It provides evidence that environments change through time.
B. **It provides evidence that species change through time.**
C. It provides evidence that the earth is very old
D. It provides evidence that all species are related to each other
E. This observation does not support the theory of evolution

5. After a long period of climate stability, the average temperature of the environment suddenly decreases (assume that there is little spatial variability in temperature). We expect _____ selection to give way to _____ selection

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

6. Half of a population of swallows dies in a storm. Does this represent natural selection?

A. Only if the population mutates afterwards
B. Only if the survivors were phenotypically different (e.g., bigger) on average
C. **Only if the survivors were genotypically different (e.g., different alleles) on average**
D. Only if the population increases back to its original size
E. Yes

7. Cotton-topped tamarins are small primates with tufts of long white hair on their heads. While studying these creatures, you notice that males with longer hair get more opportunities to mate and father more offspring. To test the hypothesis that having longer hair increases fitness in these males, you should _____.

A. test whether other traits in these males also increase fitness
B. look for evidence of hair in ancestors of tamarins
C. determine if hair length is heritable
D. **shave some males to make their tufts shorter and compare their mating success to controls**
E. determine whether there is sexual dimorphism between males and females

8. Why is it important to *randomize* experimental units to different treatments?

A. To allow us to see the difference between treatments and the control
B. **To avoid accidentally introducing differences between groups**
C. To be more biologically realistic
D. To achieve a larger sample size

9. Which is *not* a potential advantage of observational studies over experiments?

A. May be more practical
B. **Allows more different factors to be controlled for**
C. May be more ethical
D. May take less time

10. Human embryos show gill pouches similar to those that develop into fish gills in fish. This is an example of

A. genetic convergence
B. genetic homology
C. developmental convergence
D. **developmental homology**

11. 95% of a population of Staphylococcus bacteria is killed by an antibiotic treatment. Scientists determine that survivors were in a particular phase of their growth cycle, but found no genetic difference between survivors and others. In this case, we expect that natural selection for resistance is:

A. acting, because the logical conditions are met
B. not acting because there is no variation in reproductive success
C. **not acting although there is variation in reproductive success, because this is not linked to heritable traits**
D. not acting because the population is not reproducing sexually

12. Why did early evolutionary scientists favor natural selection over inheritance of acquired characteristics?

A. Because it is more logical
B. Because it better explains the fossil record
C. Because it better explains patterns of relatedness
D. **Because it was better supported by experiments**

13. After we moved to Canada, my daughter grew up tolerating cold temperature better than her US peers. This change in my daughter _____ an example of evolution, and her ability to do it _____ a result of adaptation through natural selection

A. is; is
B. is; is not
C. **is not; is**
D. is not; is not

14. The vertebrate eye has a blind spot, where broadly similar cephalopod eyes do not. This provides evidence that:

A. The vertebrate blind spot was selected by natural selection
B. The blind spot is due to random drift
C. The blind spot is due to gene flow
D. Evolution is goal-directed
E. **Evolution works gradually**

15. Heritable variation in traits *originates* from

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

16. Peas with one allele for short pods and one allele for long pods produce pods of medium length. These pods are less efficient for seed dispersal than either short or long pods. This is an example of:

A. directional selection
B. balancing selection
C. **disruptive selection**
D. stabilizing selection

17. Peas with one allele for short pods and one allele for long pods produce pods of medium length. These pods are less efficient for seed dispersal than either short or long pods. This is an example of:

A. genetic dominance
B. allelic dominance
C. **incomplete dominance**
D. homozygous dominance
E. heterozygous dominance

18. A statistical analysis shows that a population is in Hardy-Weinberg equilibrium. This implies:

A. The population is not evolving
B. The population is mating randomly
C. Gene flow is not occuring
D. All of the above
E. **Nothing! That's not even how statistics works**

It's hard to believe any population is "not evolving", and even harder to believe you could show that something is "in equilibrium" with a statistical test. We did give credit for D (as well as E), though, because apparently our teaching materials are still not consistent on this point.

19. Assortative mating occurs when individuals are more likely to mate with individuals similar to themselves. We expect assortative mating to lead to more _____ than expected by Hardy-Weinberg, if the traits underlying assortative mating are _____.

A. **homozygotes; heritable**
B. homozygotes; under stabilizing selection
C. heterozygotes; heritable
D. heterozygotes; under stabilizing selection

20. Malaria parasites have a wide variety of "coat" genes to determine the proteins on the outside of their cells. Parasites don't do well if their coat type is common, because they are more likely to run into a host who can recognize and attack them. This is an example of _____ selection due to _____.

A. **balancing selection; frequency dependence**
B. disruptive selection; frequency dependence
C. balancing selection; heterozygote advantage
D. disruptive selection; heterozygote advantage

21. The main reason genetic drift reduces genetic variation is that:

A. It weakens natural selection
B. It blocks gene flow
C. It reduces mutation rates
D. **Alleles can be lost at random**

22. Sex _____ a source of new alleles and _____ a source of new allele combinations

A. is; is
B. **is not; is**
C. is; is not
D. is not; is not

23. Populations where males share more equally in raising offspring are likely to show _____ variation in male reproductive success and _____ sexual dimorphism compared to populations where females provide almost all of the resources for offspring

A. more; more
B. less; more
C. more; less
D. **less; less**

24. Maggot flies raised on apple trees prefer to mate on apple trees, and flies raised on hawthorn trees prefer to mate on hawthorn trees. This behaviour is an example of:

A. disruptive selection
B. balancing selection
C. **pre-zygotic isolation**
D. post-zygotic isolation

25. Maggot flies raised on apple trees prefer to mate on apple trees, and flies raised on hawthorn trees prefer to mate on hawthorn trees. If this preference is an adaptation due to natural selection, it likely happened when the flies were experiencing:

A. **disruptive selection**
B. balancing selection
C. genetic drift
D. genetic dominance

26. The evolution of shrimp species near what is now Panama has been strongly influenced by geological changes that separated and un-separated the Pacific from Atlantic oceans at that point. This is an example of species divergence being driven primarily by

A. dispersal
B. **vicariance**
C. genetic incompatibility
D. genetic drift

27. A highly unusual weather event stranded some North American crows on a group of islands in the middle of the Pacific Ocean a few hundred years ago. They have no ability to fly outside of the island group and do not mate in nature with their original population. They have not evolved much in the generations since the event. Under which species concept might you argue that they represent a separate species?

A. **Biological**
B. Ecological
C. Morphological
D. Phylogenetic

28. In small populations, human blood-group alleles are often very close to Hardy-Weinberg equilibrium. In larger populations, they usually show _____ homozygotes than expected from HW, likely because of:

A. **more; non-random mating**
B. less; non-random mating
C. more; fitness differences
D. less; fitness differences

29. Most mutations are _____. _____ mutations are extremely important in shaping the course of evolution.

A. deleterious; deleterious
B. **deleterious; beneficial**
C. beneficial; deleterious
D. beneficial; beneficial

30. Many species of insect are observed to circle around electric lights at night. Many starve to death or injure themselves. Which of the following is a likely explanation for this?

A. The death of these insects is good for the species
B. They are acclimating to the lights
C. **This behaviour was adaptive when it evolved, but circumstances have changed**
D. They are undergoing evolution by inheritance of acquired characteristics

31. (2 marks) How does genetic drift contribute to speciation? Is it likely to contribute most strongly to sympatric, dispersal-driven, or vicariance-driven speciation?

It contributes to speciation by randomly increasing differences between populations, which can reduce hybrid fitness (and thus cause selection for reduced mating). Genetic drift contributes most strongly to dispersal-driven speciation, since that's the case where one population is very likely to be small, and drift is stronger in small populations.

One mark for increasing differences. One mark for dispersal-driven.

32. A population of grey squirrels has a 40% frequency of allele B (associated with darker fur) and a 60% frequency of allele b at the same locus. (6 marks in total)

a) What are the possible genotypes, and what frequency do you expect for each? (3 marks)

BB has an expected frequency of 16% (40% $\times$ 40%), Bb has an expected frequency of 48%, bb has an expected frequency of 36%

1 mark for the genotypes, 2 for the expected frequencies.

b) If the allele B is dominant, what proportion of the population would you expect to have dark fur associated with this locus? (1 mark)

Both BB and Bb types would have dark fur, so 16% + 48% = 64%

c) You find the population has more heterozygotes than expected. Briefly give one possible reason why this could happen. (1 mark)

Heterozygote advantage (which is a form of balancing selection) or if squirrels prefer to mate with different-colored squirrels (dissasortative mating)

d) If there are more heterozygotes than expected, can you predict whether there would be more or less dark-furred squirrels than expected? (1 mark)

Heterozygotes have dark fur in this model, so more. To see this has to be true, we could think about the light-furred squirrels, which have to be homozygous, and there have to be less of both kinds of homozygote.

33. Does natural selection tend to favor pre- or post-zygotic isolation? Why? How? Give an example of a trait that evolved in this way. (3 marks)

Pre-zygotic selection is favored because wasted zygotes are expensive. Natural selection favors pre-zygotic isolation by selecting for mechanisms by which populations that have post-zygotic isolation or low-fitness hybrids avoid mating. Examples include different mating sites of soapberry bugs or different timing of flowering in trees.

1 for waste; 1 for avoid mating; 1 for an example

34. You want to find out whether exercise is good for rats, so you put 10 mice in a cage with lots of room to exercise (and observe that they really do exercise) and 10 in a cage with no room to exercise. Identify two problems with this experiment and suggest ways to fix them (4 marks).

If you have only one treatment cage and one control cage you don't actually have replicates: a replicate is a unit that doesn't share anything with its treatment group except the treatment, so we need more cages (either put mice in separate cages or get more mice to fill more cages).

There might be some other reason why crowding is good or bad for mice. Small vs. large cages is not a good way to test our hypothesis. We need some other way to encourage or discourage exercise. Maybe provide exercise equipment or make one of the cages harder to move around in, but make the cages the same size.

Rats are not mice. If you want to learn something about rats, you should use rats in the experiment (that's Dushoff's error, but if you caught it, good for you).

One mark per reason, one mark per example.