1. The biological species concept does not apply at all to

A. **strictly asexual populations**
B. extinct populations
C. populations with many different "morphotypes" that all look different from each other
D. populations that can survive in a wide variety of habitats and conditions

2. Two populations of bugs live on two different species of trees in the same forest. The adult bugs breed together sometimes, but the hybrid offspring are rarely able to survive to adulthood, because they are not well adapted to either species of tree. This is an example of ________ isolation that will likely lead to ________.

A. pre-zygotic; fusion
B. post-zygotic; fusion
C. pre-zygotic; natural selection for post-zygotic isolation
D. **post-zygotic; natural selection for pre-zygotic isolation**

3. Disruptive selection at the trait level is *most* likely to cause what kind of selection at the allele level?

A. **Balancing selection**
B. Stabilizing selection
C. Negative selection on rare alleles
D. Directional selection

4. Stabilizing selection at the trait level is often associated with

A. Positive selection on rare alleles
B. **Negative selection on rare alleles**
C. Frequency-dependent selection
D. Genetic drift

5. Yeasts grown in unstable environments develop the ability to quickly shut down their metabolism and survive in a resting state for long periods of time. The ability is itself an ________. The fact that the yeast can develop the ability is probably due to ________.

A. adaptation; adaptation
B. adaptation; acclimation
C. **acclimation; adaptation**
D. acclimation; acclimation

6. *E. coli* bacteria grown for many generations in the lab with limited food sources developed the ability to use glucose as a food source. Their ancestors did not have this ability, and neither did control strains grown under similar conditions with ample food. These experiments provide evidence that:

A. Evolution can occur in the laboratory
B. Natural selection can occur in the laboratory
C. Bacteria can evolve the ability to use glucose for food
D. **All of the above**

7. When we say an allele is "fixed" in a population, it means:

A. It is the most fit allele for that locus under current conditions
B. A defect in that allele has been repaired
C. **It is the only allele present at that locus in the population**
D. The allele is not subject to mutation

8. *Xenopus tropicalis* and *Xenopus laevis* are two closely related species of frog. *X. laevis* has two times the number of chromosomes as *X. tropicalis. X. laevis* most likely arose through:

A. allopatric speciation
B. **polyploidy**
C. reinforcement
D. coevolution

9. A population of maize plants has a recessive allele at a locus with simple dominance that heritably causes them to grow extra tall. The population genotype frequencies are near the Hardy-Weinberg expectation. A windstorm kills all of the extra tall plants, but not others. If we measure the population after the windstorm, we expect to find:

A. genotype frequencies are near the new Hardy-Weinberg expectation (based on the new allele frequencies)
B. **more heterozygotes than the expectation**
C. more homozygotes than the expectation
D. more tall alleles than the expectation
E. more short alleles than the expectation

10. Inbreeding depression is a concern in species conservation, because in small populations, individuals are more likely to find mates who are __________, leading to an increased number of deleterious __________ genotypes.

A. **close relatives; homozygous**
B. chosen from a small pool of unrelated individuals; homozygous
C. close relatives; heterozygous
D. chosen from a small pool of unrelated individuals; heterozygous

11. All else being equal, we might expect a large population to evolve more slowly than a small population because of differences in

A. gene flow
B. **genetic drift**
C. stabilizing selection
D. balancing selection

12. If a population is currently subject to inbreeding, we would generally expect to see more __________than __________.

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

13. Which of the following is the *strongest* correct statement we can make about life arising from non-life?

A. Life cannot arise from non-life
B. **Life must have arisen from non-life at least once**
C. Life must have arisen from non-life at least five times, because there are five kingdoms of life
D. Life must have arisen from non-life many times, because there is a huge diversity of different families of organisms

14. A biologist is trying to classify ancient, extinct, shellfish into species based on the shapes of their shells, with no genetic information. They are most likely to use which applicable species concept?

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

15. Two populations of pine trees live in the same area, but open their flowers at different times, so that they rarely mate with each other. If a scientist argues that this fact makes them different species, which species concept are they applying?

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

16. All 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

17. All cows can fly. Dushoff can fly. Therefore, Dushoff is a cow. What is wrong with this logic (assuming we accept the assumptions)?

  A. nothing; the logic is correct
  B. **The first assumption would need to say "Only cows can fly"**
  C. The order of the assumptions would need to be reversed
  D. The two assumptions contradict each other

Use the following information for the next two questions. Researchers raised 10 lines of bacteria starting from genetically identical individuals. After 100 generations, bacteria in 7 of these lines developed the ability to use one of the starches on the laboratory dishes as a new food sources. Subsequent experiments showed that these bacteria could out-compete ancestral strains, and the bacteria from the other three lines, under the laboratory conditions.

18. What is the most likely explanation for the observed change in the 7 lines?

  A. Random mutation
  B. Genetic drift
  C. Natural selection
  D. **Random mutation combined with natural selection**
  E. Genetic drift combined with natural selection

19. What is the most likely explanation for why the other 3 lines did not show the same change?

  A. The laboratory conditions were different for these lines
  B. These lines were subject to sexual selection
  C. **These lines had a different set of random mutations**
  D. These lines were subject to more gene flow

20. Whales have fairly complicated hip structures that seem to have little use. This is most likely because

A. Whales are evolving to become more amphibious (better able to use both land and water environments)
B. These structures arose through random mutation
C. These structures arose through genetic drift
D. **These structures are homologous to more useful structures in other mammals**

21. Which of the following definition *best* reflects an advantage in evolutionary fitness?

A. Organisms that tend to live longer
B. Organisms that are better at competing for resources
C. Organisms that tend to have more success at finding mates
D. **Organisms that tend to produce more viable offspring**

Use the following information for the next three questions. A population of plants has one allele (R) for red flowers and one (W) for white flowers. The two alleles have simple dominance, with white being the dominant allele. There are 35 RR plants, 40 RW plants, and 25 WW plants.

22. What is the allele frequency of W?

A. 0.25
B. 0.4
C. **0.45**
D. 0.55
E. 0.65

23. What is the genotype frequency of heterozygotes?

A. 0.25
B. **0.4**
C. 0.45
D. 0.55
E. 0.65

24. What is the expected phenotype frequency of plants with white flowers?

A. 0.25
B. 0.4
C. 0.45
D. 0.55
E. **0.65**

Use the following information for the next two questions. Biologists find a sub-population of plants that have a mutation that means that they can live only on acidic soils. The main population can't live on acidic soils at all. The patches of soil are bigger than the plants but close enough together that plants from different patches can still mate.

25. If these populations are to continue to diverge, they must overcome the obstacle of

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

26. If there are patches of acidic soil and patches of regular soil mixed together, the combined population is likely under

A. **stabilizing selection**
B. directional selection
C. **disruptive selection**
D. negative selection
E. positive selection

The desired answer was disruptive selection; the population is under selection to adapt to both kinds of soil, which pull in different directions. We are allowing stabilizing selection because the question prompt seems confusing: what did I mean by "mixed together"?

Use this information for the next three questions. At a certain allele, humans with the genotype NN are vulnerable to tuberculosis, those with the genotype CN have normal lung function and not vulnerable to tuberculosis, and those with genotype CC don't have normal lung function.

27. This is an example of

A. polyploidy
B. inbreeding
C. simple dominance
D. **complex dominance**

28. In an environment with high rates of tuberculosis, the genotype CN has the highest fitness. This is an example of

A. directional selection
B. **balancing selection**
C. disruptive selection
D. negative selection on allele N
E. positive selection on allele N

29. In an environment with low rates of tuberculosis, the genotype NN has the highest fitness. This is an example of

A. directional selection
B. balancing selection
C. disruptive selection
D. negative selection on allele N
E. **positive selection on allele N**

30. A species of frog was separated into two populations in the Andean mountains several thousand years ago by a cold spell that prevented them from living on hills separating two valleys. Offspring from the two populations are now observed to survive, grow and reproduce well on the hills and in the valleys. These two populations are most likely undergoing

A. **Fusion**
B. Divergence through reinforcement
C. Speciation through hybridization
D. Competitive exclusion
E. Allopolyploidy

31. Researchers in the 1700s did an experiment designed to understand the origin of microbes. They placed nutrient broth in two jars. One was sealed completely, and one was covered with cheese cloth that was meant to allow air to move in and out. They found that microbes grew in the cloth-covered jar, but not the sealed jar.

a) (2 point) What is a major problem with the experiment as described? What *two* principles can be applied to improve the experiment? Give a brief explanation of how you would do this.

The researchers are reported to have only used two jars. It's very hard to know if there was some random difference between them. We need to apply the principles of replication and randomization. We could do this by planning to have several jars of each type, and by first choosing everything we can about the jars (which physical jar to use, where to put it, what order to fill them in), and then choosing randomly which jars get cheesecloth and which get lids.

One-half mark for each principle, one-half mark for reflecting each in a brief explanation. Control is not a good answer, since the researchers did the main control that we want.

b) (2 points) Assume the researchers redid the experiment and found a similar result to the first experiment. What can you conclude? What remains uncertain (from the perspective of 18th century researchers who would have tried this experiment)?

We can conclude that microbes cannot grow in broth without air flow. This is presumably because something in the air is needed: it might be microbes, oxygen, or something else. It remains uncertain whether microbes can generate spontaneously; we don't know whether tiny microbes were able to travel through the cheese cloth or not. We also don't know whether there were existing microbes in the broth.

One mark for needing something in the air, one mark for not being sure whether microbes need to come from outside.

32. A population of maize plants has a locus with two alleles: E is associated with early flowering (and thus early breeding) and L is associated with late flowering. You observe 70 plants that flower early, 40 that flower late, and 50 that flower in between.

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. The genotype frequencies are EE: 70/160 = 44%; EL: 50/160 = 31%; LL = 40/160=25%

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?

There are 2*70+50 = 190 E alleles and 2*40+50 = 130 L alleles. The frequencies are 190/320=59% and 130/320=41%.

c) (1 point) Based only on the information above, and *before* doing the calculations, how might you expect this locus to differ from the Hardy-Weinberg expectation and why?

We should expect plants with the L allele to breed later and be more likely to match with other plants having the L allele. This could lead to *more homozygotes* than the HW expectation.

d) (1 point) What is the calculated Hardy-Weinberg expectation based on these allele frequencies?

If you do it without premature rounding, you would get EE = p*p = 35%; EL = 2*p*q = 48%; LL = q*q = 17%

1/2 a point for a correct version of the formula.

e) (1 point) How does the expectation compare to your observations? Be clear which numbers you are comparing to reach this conclusion.

We can compare any one frequency to any other. So for example the observed frequency of EE is 44% and the HW expectation is 35%. So we see more homozygotes than "expected" under HW, which is in fact what we kind of expected.

It's also fine to compare on the individual scale. If you multiply by the population size without premature rounding, the expectations are 56, 77, and 26 (don't add properly due to rounding!). So we still have more homozygotes than expected.