1. The Spring Salamander (*Gyrinophilus porphyriticus*) is found along streams and in small wetlands in West Virginia. They move about, and hide under rocks, logs and litter and exist in intermediate population sizes. How would you go about quantifying their numbers along a particular stretch of stream?
   (A) Direct Counts
   (B) Aerial Surveys
   (C) Quadrat Method
   (D) Mark-Recapture Method
   (E) Censusing

2. Deer surveys in some areas are done by flying above the forest in airplanes when in leaf-off condition, and detecting their presence as blobs using an infra-red wavelengths. When this census method is chosen, wildlife biologists are using:
   (A) Direct Counts
   (B) Quadrat Method
   (C) Mark-Recapture Method
   (D) Indirect Counts
   (E) Motion Detectors

3. An urban ecologist is studying roach population dynamics. She uses live traps to catch 132 roaches, marking each one with a small dab of paint, then releasing them. A week later, she returns to the population, and traps 110 roaches, 16 of which are tagged. What is her estimate of the roach population size?
   (A) 13
   (B) 19
   (C) 907
   (D) 456
   (E) 232,320

4. A flock of starlings lands on the Life Sciences Building lawn. An observant Bio. 221 student notes that they appear to be regularly spaced. He snaps a photograph of the flock
from above, prints out the photo, then repeatedly throws a ‘quadrat’ comprised of a paper clip bent into a square. He counts the starlings in each quadrat, finally calculating the mean and variance of the number of birds per quadrat. Ignoring the fact that he wasn’t directly overhead while taking the photograph (which would alter the apparent density from one edge to the other), he calculates a variance:mean ratio of 1.462, a number which is found to be significantly greater than 1. What can he say about the dispersion of individuals within the flock?

(A) The individuals are randomly distributed
(B) The individuals are clumped
(C) The individuals are spaced
(D) The individuals are hyperclumped
(E) The individuals exhibit no dispersion pattern whatsoever

5. A species of floating pondweed has single fronds that grow by enlarging then dividing. This species expands and divides once every 2 days. If the pond is covered on day 59 of the growing season, on what day was the pond 1/16\textsuperscript{th} covered?

(A) Day 55
(B) Day 54
(C) Day 51
(D) Day 3.7
(E) The pond was never 1/16\textsuperscript{th} covered.

6. A pond becomes polluted with herbicide runoff from an adjacent farm field. The floating pondweed, which had completely covered the pond, now begins to die off; one out of every two fronds dies every two days, and none are enlarging and splitting. Counting Day 59 as the starting point when the pond was completely covered, on what day will the pond be 1/8\textsuperscript{th} covered?

(A) Day 7.375
(B) Day 53
(C) Day 56
(D) Day 63
(E) Day 65

7. Starting with $10,000, and assuming continuously compounded interest, how much longer would it take to grow that balance to $1,000,000 if you earned 9\% interest instead of 10\%?

(A) 1 more year
(B) 2 more years
(C) 5 more years
(D) 46 more years
(E) 51 more years

8. If the CIA web site is correct that the population of Afghanistan is growing 4.77\% each year, and we assume Afghanistan is in a stable age distribution (probably incorrectly!), what is \( r \) for Afghanistan?

(A) 0.0466
(B) 0.0477
(C) 1.0466
(D) 1.0477
(E) It is impossible to estimate r because we would have to use the Euler equation.

**************************linked questions*******************************
The following six questions use the life table data below derived from a cohort study of black-capped chickadees, a small songbird native to North America:

<table>
<thead>
<tr>
<th>Age (x)</th>
<th>l_x</th>
<th>m_x</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>.4</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>.16</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>.04</td>
<td>3</td>
</tr>
</tbody>
</table>

9. What type of survivorship curve is illustrated by the chickadee data?
(A) Deevey Type I
(B) **Deevey Type II**
(C) Deevey Type III
(D) Deevey Type IV
(E) Deevey Type V

10. First, determine the expected lifetime offspring production of a newborn chickadee.
(A) 0
(B) 0.50
(C) **0.64**
(D) 2.50
(E) 5.50

11. What is the generation time of chickadees in this population?
(A) 0.64 y
(B) 1 y
(C) **1.875 y**
(D) 2.206 y
(E) 3 y

12. What is the probability that a chickadee will survive from age 2 to age 3?
(A) 1
(B) 0.16
(C) 0.04
(D) 0.5
(E) **0.4**

13. If the present chickadee population has \( N_0=10 \), \( N_1=20 \), \( N_2=5 \), and \( N_3=8 \), what would you project the total chickadee population size will be one year from now?
14. Is the population in a stable age distribution?
(A) Yes
(B) No. I know this because the number of individuals in each class changed between now and one year from now.
(C) No. I know this because the proportion of individuals in each class changed between now and one year from now.
(D) No. I know this because the eigenvalue of the matrix is not 1.
(E) No. I know this because a cheery bird such as the chickadee cannot possibly be SAD.

15. Which of the following is not true regarding the propensity fitness idea?
(A) It can be applied to different entities depending on the purpose of the study
(B) It quantifies the rate of propagation of an individual’s genes into the future
(C) It melds the population-level notion of $\lambda$ with the idea that fitness is an individual trait
(D) It is the population growth rate of the individual
(E) It helps evolutionary biologists in studies of natural selection

16. Density-dependent effects on population growth can take many forms. If we examine attempts by the human population of western Europe to colonize North America, we see that early attempts made with small groups of people failed (the Vikings, Roanoke Colony, etc.). This could be due to insufficient numbers of people to perform all the functions of a working society, in a situation not unlike introducing too few pack animals (such as wolves) into an area one is trying to colonize. This form of density-dependence is known as:
(A) Resource depletion
(B) Negative density-dependence
(C) Sigmoidal density-dependence
(D) Asymptotic density-dependence
(E) The Allee effect

17. What is the maximum ‘r’ for this population?
(A) 0.005
(B) 0.004
(C) 3.6
18. What is the carrying capacity of the aquarium for snails?
(A) 680
(B) 1133
(C) 720
(D) 760
(E) K cannot be determined with the information given

19. A young naturalist named Willie is sitting at home one morning, downing a bowl of cereal, when – WHAM! – a wood thrush slams into the dining room window, breaking its wing. Little Willie rescues the stunned bird and places it in a cage. He quickly realizes he will have to feed this bird to keep it alive, so he hops on the internet and reads about what wood thrushes eat. He quickly finds that wood thrushes love to eat…snails! If Willie sets up an aquarium of snails following the density-dependent equations above, how many snails could he maximally harvest in a sustainable fashion from the tank each year to feed the bird? (Assume he keeps them at the optimum N for harvest.)
(A) 340
(B) 578
(C) 680
(D) 920
(E) 1068

20. Willie inoculates his aquarium, with 10 snails purchased from the Exotic Jungle pet store. Given the b and d functions above, how long will it take for the population to reach 200?
(A) 0.328 y
(B) 0.387 y
(C) 0.425 y
(D) 0.861 y
(E) 0.979 y

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ end of linked questions~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
21. A Bio. 321 research group sets up mini-communities of a small annual plant, *Brassica rapa*. Unfortunately, they plant seeds at an extremely high density, so although all seeds germinate, gradually each community gets fewer and fewer individuals surviving as the plants grow. They harvest 2 replicate communities every 2 weeks during their experiment and document this density-dependent process on the figure above. Unfortunately, they forgot to label their axes. Knowing what you know about density-dependent processes in plants, how should they have labeled their X and Y axes?

(A) N (x-axis), W (y-axis)
(B) N, ln(W)
(C) ln(N), W
(D) ln(N), ln(W)
(E) N, k

22. Which of the following equations best describes the population growth rate of the invasive species, when in competition with the native?

(A) EMBED Equation.3

(B) EMBED Equation.3

(C) EMBED Equation.3
23. What would the outcome of competition be after a long period of competition between these two species?
(A) The native would win, and the invasive would be excluded.
(B) The invasive would win and the native would be excluded.
(C) The two species would coexist.
(D) The outcome would depend on the initial starting N’s of each.
(E) The outcome cannot be predicted with the information given.

24. In the absence of the invasive, what would the long-term equilibrium population size be for the native species?
(A) 50
(B) 83
(C) 100
(D) 166
(E) 183

25. If a subset of genotypes within the native species of earthworm exploited a very different niche, and these individuals left more offspring because they competed less with the invasive, what would be expected to happen to the competition coefficients?
(A) $a_{12}$ and $a_{21}$ would both increase
(B) $a_{12}$ would increase, while $a_{21}$ would decrease
(C) $a_{12}$ would decrease, while $a_{21}$ would increase
(D) $a_{12}$ and $a_{21}$ would both decrease
(E) nothing would happen to $a_{12}$ and $a_{21}$; they are constants.

26. If natural selection occurred in the manner suggested in the problem above, how might the probable outcome of change?
(A) the native would be more likely to exclude the invasive
(B) the invasive would be more likely to exclude the native
(C) conditional competitive exclusion would be more likely
(D) it would be less likely the native would ever get established
(E) competitive coexistence would be more likely

Bald eagles primarily eat fish. The Madison River in Yellowstone National Park is home to a fantastic trout population where a large eagle population nests and feeds on the abundant fish. The park rangers have been following eagle populations over decades, and have noticed a distinct cycling of their numbers through time. In the following problem set, we will assume that the eagle-trout population dynamics follow the Volterra predator-prey equations.
27. Ten eagles are presently found along a 20-mile stretch of the Madison in Yellowstone. If a single eagle can capture \( \frac{1}{1000} \)th of the trout population each year, and it takes 500 captured trout to provide the energy to produce one baby eagle, what is the eagle birth rate if there are 1,000,000 trout along that stretch of river?

(A) 0.5  
(B) 1  
(C) 2  
(D) 3  
(E) 0

28. If the eagle death rate is 0.25, what is presently happening to the eagle population size?

(A) it is growing  
(B) it is declining  
(C) it is remaining constant  
(D) it is zero  
(E) it cannot be determined because we don’t have enough information

29. If \( r \) for the trout population is 0.05, at what eagle population size would the trout population be stable (neither growing nor declining)?

(A) 5  
(B) 10  
(C) 25  
(D) 50  
(E) 100

30. At what trout population size would eagle numbers be constant?

(A) 10,000  
(B) 65,000  
(C) 125,000  
(D) 250,000  
(E) 1,000,000

31. Place a single point on the zig figure below showing where the two populations are at present, relative to the zig’s, and draw a single arrow from that point showing the trajectory of the two-species predator-prey community. (worth 1 question if completely correct).