**BIOL 103 Practice Questions for Test 1**

**For all math, SHOW YOUR WORK  
For all short answer, GIVE SPECIFIC EXAMPLES.**

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| 1. Captain Kirk leaves one Qwibble on the planet Qwohog, which has plenty of food and no predators.  If each Qwibble produces six offspring every eight hours (then the parent dies), how many Qwibbles will there be by the end of the week?  What is their doubling time?            N0 = 1             Q = 6   (not 7, because the parent dies)  Nn = N0 x Qn They reproduce every 8 hours, this means 3 times per day, at the end of the week they will have produced 3 times 7, so n = 21              N21 = **1 x 621** = 2.19 x 1016 Qwibbles present after one week  Doubling time:  N = 61/8 hours = 21/d hours  (1/8 hours) log 6 = (1/d) log 2  d = 8 x log 2 / log 6 = 3.09 hours   1. If a town of 10,000 people doubles every five years, how big will it be in 2026?  Suppose instead toxic waste contamination kills off 20% per year; how many will be left?   **N0 = 10,000 = 1 x 104           population doubles every 5 years   2014 to 2026 = 12 years**  **N12 years = N0 x 2t/d      N12 years =  (1 x 104) 212/5**  **N12 years =  52,780 people (about 52,800) in the year 2026  If instead of reproduction, toxic waste kills off 20% per year, then the remaining population each year will be: 1-0.2 = 0.8 times N the previous year  After 20 years, the population N will be: N12 = N0 x (0.8)12 = 10,000 x (0.8)12 = 687 people**   1. Why does natural selection favor individuals who overpopulate their habitat and cause precipitous population decline?  What is the real reason the lemmings "jump in the sea"? Do the lemmings have alternatives? Explain.  The lemmings reproduce to large numbers. With population density too high, some will starve.  But lemmings that disperse find more food. So natural selection favors lemmings in which high population density triggers the instinct for dispersal to find new habitats.   The lemmings migrate in all directions. Some migrate to cliffs over the fjords, where they may jump in. Some that jump in may drown--but the few that make it across the fjord may find new habitat with plentiful resources, and will produce large numbers of progeny. Most will inherit the tendency to disperse--despite the fact that many (even most) die. Similarly, in human warfare a few individuals gain lots of resources, despite the fact that many die.  At the same time, there is always genetic diversity. A few lemmings will not have the gene for dispersal, and may stay behind. They will produce some offspring, especially after the others have left. So, the genes for both behaviors remain. Thus you can't say there is only one "winning" strategy; both alternatives have advantages and disadvantages.   1. Jane Grey interviews a prospective student for the Westchester School for Mutants. The student is completely resistant to all forms of influenza, including swine flu, avian flu, and tribble flu. The condition is dominant and not X-linked.  If this Mutant had a son, what is the son's chance of resisting next year's sandworm flu?   Since the flu resistance is dominant, and seems to apply to all forms of flu: The son has 50% chance of inheriting the flu resistance gene.  This answer assumes that the student has only one mutant flu-resistance allele; the other allele is normal.  Suppose we find that the rare individuals who inherit two copies of the flu Mutant allele have defective immune systems and die by age 20. How does this modify our definition of "dominant" inheritance for this   This Mutant allele has multiple effects, and one of its effects (immune system defect) is actually recessive. This situation is analogous to the case of sickle cell trait, in which one copy confers malaria resistance, but two copies confer the recessive disease of sickle cell anemia. 2. Suppose the "kwisatz haderach" trait is determined by codominant alleles plus environmental influence. Can you explain Alia's unusual phenotype?   See the pedigree in the Powerpoint. Alia inherits two copies of the K trait (ability to see present and future, experience ancestral personalities, etc.) But the trait is supposed to develop over time, as the child grows. Instead, the drug (environmental effect) causes prenatal expression of the full trait. So from birth, Alia has all the adult knowledge and experience of her ancestors.   1. What is the role of population size, gene frequencies, and genetic drift in evolution of new species? Explain.   The smaller the population, the more rapid the change in gene frequencies; thus, the more rapidly the population can change its genetic character. For a new species to evolve, it must go through a period in which a small population is isolated, allowing genetic drift as well as propagation of new genes favored by natural selection. The new genes can then propagate throughout the population. As the population grows, the new genes become "fixed" as drift becomes less likely. When the population becomes so different as to prevent natural interbreeding with other descendents of the original population, there is a new species. 2. If natural selection means "survival of the fittest," than how can one "fittest" species evolve into more than one? How can more than one be "the fittest"? Explain.   Natural selection is always relative; a particular group produces more offspring than another group. But natural selection depends on the particular environmental conditions. If two groups split off and experience different environments (such as underground vs. living in a tree), then natural selection will drive the populations in different directions. Also, selection involves random genetic drift. If animals end up on different islands, their small populations will experience drift in different directions. For the test, you should be able to apply this question to Galapagos, for example, the evolution of diverse finches or tortoises.  Note: "Environment" also acts on INDIVIDUALS without changing their genes. On the "genes vs. environment" question, what I am getting at is how an INDIVIDUAL can experience environment; for example, a person's height can be shorter than one's genetic potential, if one receives poor nutrition. 3. Explain how each of the following traits is determined by genes and/or environment: Huntington’s disease; Diabetes; Cancer; Spoken language.   Huntington’s disease is determined by a dominant allele of a gene that makes an abnormal protein. It is expressed late in life, causing brain degeneration, but there is little environmental effect.  Diabetes Type 2 is influenced by genes that predispose (make the disease more likely). About 10% of the disease is caused by genes, and the rest of the effect by diet and lack of exercise. So even if you have bad genes, if you eat well and exercise you will not show the symptoms. However, there is a different kind of diabetes called Type 1 in which you lack two copies of the insulin gene. In this case, you have juvenile-onset diabetes and will always have the disease.  Language is made possible by genes expressing proteins for the voicebox. Only humans can speak; chimps, our nearest relatives, cannot. However, the language that we speak is entirely environmental. The language depends on what language we hear and learn to speak.   1. Explain the difference between genetic and cultural evolution.  Use an example to show how these may be confused.   Genetic evolution involves natural selection based on traits specified by DNA (such as the physical ability to speak).  Cultural evolution involves selection of traits that are NOT specified by DNA, such as the particular language spoken (French vs. English).  These phenomena can be confused because children “inherit” their spoken language from their parents; but this inheritance is cultural.  A child adopted into a different country will grow up speaking the language of his or her adoptive parents.   1. Suppose you ingest 500 Salmonella bacteria in contaminated turkey, and in three hours you feel sick; there are now 500,000 bacteria. What is their doubling time in your body, in minutes?          Nt  = N0 x 2t/d              N0 = 500         Nt  = 500,000             t = 3 hours      d = ??  500000 = (500)23/d 500000/500 = 1000 = 23/d log 1000 = (3/d)(log 2) 3 = (3/d)(0.30) d = 3(0.30)/3 d = 0.30 hours to double      how many minutes?  (0.30 hours)(60 min/hour) = 18 minutes to double   1. A Klingon anthropologist tries to explain the pointed ears of Vulcans by the hypothesis that Vulcan women prefer men with more pointed ears, so many generations lead to Vulcans with extremely pointed ears.   What form of natural selection does this illustrate? What problems do you see with the Klingon hypothesis? How might the hypothesis be modified?  The evolution of pointed ears is an example of runaway selection: After many years of natural selection favoring pointed ears, the Vulcans have extremely sharp pointed ears.  The problem here is how to explain the source of selection pressure.  The Klingon argues that Vulcan women irrationally prefer pointed ears.  But if that were the case, then any woman with a mutant allele (not preferring pointed ears) would drive selection in the opposite direction; especially if developing pointed ears is energetically expensive.  Furthermore, it could just as easily be that the men prefer women with pointed ears.  A possible modified hypothesis would be that pointed ears are linked to the trait of men providing resources for children.  In this case, women that select men with pointed ears would be likely to raise more children, and thus natural selection would occur.  This hypothesis would be hard to test, however, since Vulcans don’t let Klingons tell them who to marry.   1. Compare and contrast the sandworm and the camel in terms of desert adaptation. Include (1) water use, (2) heat avoidance, (3) digestive chemistry.   The camel stores water, for use over several months without drinking. The sandworm, however, avoids water. *Dune* does not make clear how the sandworm cell structure forms without water content (most living cells are 80% water).  Both camel and sandworm have evolved a relatively large body size to store nutrients. The sandworm of course is much larger. In order to avoid heat, the sandworm buries underground (as do rodents and snakes). By contrast, the camel holds its large body up off the hot surface of sand.  The camel’s digestion has evolved to spare water as much as possible, but it still must use water for digestion. Digestion of complex foods (plant carbohydrates) releasing CO2 yields energy for the camel to grow and move. The sandworm’s digestion is said to produce acids, aldehydes, and oxygen. But such chemistry requires water; the absence of water from the chemical conversions is not explained. The source of energy is also not explained.   1. Based on your graph of [**water saturation**](http://biology.kenyon.edu/slonc/bio3/Handouts3.pdf): Suppose air that is raining at 40 degrees F warms up to 80 degrees F. What is the percent water saturation? How does the air feel?   If it’s raining at 40 deg F, then the air is saturated, at about 0.75% water. As the temperature rises to 80 deg F, the amount of water is still 0.75% -- but at the higher temperature, this amount of water is no longer at saturation. So the relative humidity equals 0.75% divided by 2.4% (saturation at 80 deg F). That’s 31%, which feels dry, but comfortable during the day. For sleeping, 40-50% would feel better.   1. Suppose you have a dew collector on Dune that provides 12 liters per meter-squared per year.  If Fremen need to drink 1.5 liters per day: How many square meters of collector would Fremen need to provide water for a sietch community of 25 people?   A sietch community of 25 people needs (25)(1.5 l/day)(365 days/year) / (12 l/m2-year)  = 1140 square meters of collector. Check that all your units work out.  Why do you think a dew collector on Dune would be less effective than the dew collector in Jerusalem?  On Dune, the problem for a dew collector is, how much water does the air contain? If there is 25% water, as in the Sahara, then the dew collectors will work. But if there is near zero water, on a planet lacking an ocean, then there will be no water to form dew. |