DISCLAIMER: I teach this course slightly differently every year. You might not recognize a few things on this exam because we didn't cover them this semester—and that's OK.

*1. Fill in the blanks! Use one letter per blank. When you're done, the **first letters of each word**, read downwards, will give you the answer to this question:*

> *Charles Darwin's grandfather was interested in "spontaneous generation" (the possibility of life coming from non-living things). The story goes that he did chemical experiments on pieces of pasta, and actually got a noodle to move around under its own power. This is probably untrue—but the story inspired an English author to write a novel about a scientist who created a living being in his lab. What is the title of the novel? (15 pts. total)*

F
RAY
ALLELES
NEODARWINISM
KELVIN
EUSOCIALITY
NOMENCLATURE
SALTATION
THEOLOGY
EVOLUTION
INBREEDING
NO

FRANKENSTEIN

2. This ended up as one of the practice problems. . .

a) According to the 1910 census, the population of the United Stetes was 91,972,266. Goddard estimated that 1% of the population was feeble-minded. Assume that the population of the US was in Hardy-Weinberg equilibrium. Calculate the allele frequencies, and then calculate the percentages of the population that would be heterozygous and homozygous dominant.

Easy enough. If the US is in H-W, then the frequency of ff individuals is 0.01. Let the frequency of the normal and the feeble-minded allele be p and q, respectively. Then q is the square root of 0.01, or 0.1; and p = 0.9.

b) At one time or another, thirty states had laws mandating the compulsory surgical sterilization of the feebleminded. (As of 1996, Arkansas and nine other states still did have such a law on the books.) There were organizations in the early 20th century that lobbied for their enactment nationwide.

Imagine that, in some alternate-reality USA, a mandatory, nationwide law really was put into effect that forced the sterilization of all feebleminded individuals before they could reproduce. Assume that the authorities were so efficient that they were able to track down and sterilize 90% of the feebleminded—and that they never, ever sterilized anyone who wasn't feebleminded. What would be the frequencies of genotypes, and of alleles, after one generation?

Sterilization pretty much removes you permanently from the breeding population, just as surely as execution would. So let's set the fitnessess so that the fitness of the ff genotype is only one-tenth of the fitnesses of the other two:

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wFF = 1.0
wFf = 1.0
wff = 0.1
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Plug these into our favorite formula. . .

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p2*wFF + 2pq*wFf + q2*wff = w-bar
0.9*0.9*1 + 2*0.9*0.1*1 + 0.1*0.1*0.1 = w-bar
w-bar = 0.991
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Now divide all terms by w-bar to get the predicted response to selection:

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freq (FF) = 0.9*0.9*1/0.991 = 0.817
freq (Ff) = 2*0.9*0.1*1/0.991 = 0.182
freq (ff) = 0.1*0.1*0.1/0.991 = 0.0001
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Just for fun, we can quickly calculate the new p as 0.817 + (0.182/2) = 0.908. So one generation of selection has changed the frequency of the gene for normal intelligence by a factor of 0.8%. End result: Even if you could create a government program that was as efficiently run as this one -- which we may well be skeptical of -- it would have a tiny effect on allele frequencies.

3. *Based on what you have learned so far, discuss the following quote from a 1985 article in Creation magazine, published by Answers In Genesis Ministries. By "discuss", I don't mean "just repeat what the quote says in slightly different words", or "tell me whether you agree or not." Read the quote carefully and critically, and in your answer, compare and contrast what it says with what you know from this class or other sources of information. (20 pts.)*

> *Most evolutionary scientists work on the rule of thumb that understanding the present is the key to understanding the past. This belief is called uniformitarianism. But some of the difficulties in applying this belief become obvious when it is noted that over the last thirty-five years, the amount of mud released by the Mississippi River into the Gulf of Mexico has dropped by more than half. While the river still discharges more sediment into the ocean than any other United States river, its sedimentary load is ranked now about sixth in the world. . . . Other rivers in the U.S.A. also add to the problems of the evolutionary uniformitarianists who want to believe that the present is the key to the past. In the year following the Mt. St. Helens eruption, the Cowlitz River in south west Washington, received one hundred*

and forty million tons of sediment. It now transports only thirty millions tons per year. This would mean that catastrophies [sic] are of far greater significance in the history of the world than normal uniform behaviour.

Main thing I was looking for here was an understanding that there are different shades of meaning to Lyell's uniformitarianism. I talked about uniformity of law, of process, and of rate, and mentioned that rate uniformity often doesn't work. The article seems to be saying that because *rates* of a geologic process (sediment transport) are variable, the entire support for uniformitarianism goes out the window. But it ain't so; law and process uniformitarianism work fine even if we know that the rate of a process has varied in the past.

You may now select any two questions from the remaining six. Each is worth twenty points. Grammar, spelling, etc. all are important and will be graded.

***4.** Read the following quotation by a famous 19th-century American industrialist. What view does it take of natural selection and its applications? Why did such interpretations become popular at this time and place? (HINT: Think of the video "The Day the Universe Changed".)*

But, whether the law [of competition] be benign or not, we must say of it. . . : It is here; we cannot evade it; no substitutes for it have been found; and while the law may be sometimes hard for the individual, it is best for the race, because it insures the survival of the fittest in every department. We accept and welcome, therefore, as conditions to which we must accommodate ourselves, great inequality of environment, the concentration of business, industrial and commercial, in the hands of a few, and the law of competition between these, as being not only beneficial, but essential for the progress of the race.
—Andrew Carnegie. "Wealth." North American Review, 1889.

The video had that segment on how Darwinism inspired American capitalists, who were inspired by metaphors like "survival of the fittest" and "struggle for existence."

***5.** One interesting problem for evolutionary biology is how to explain menopause, the ending of a woman's childbearing years. One might predict that any mutation that shortened a woman's lifespan after menopause would not be selected against, since it couldn't affect the number of children born. By the same token, any mutation that lengthened the childbearing years, postponing or preventing menopause, might be selected for. Despite these theoretical arguments, women may live for several decades after ceasing to menstruate. Come up with two evolutionary hypotheses for why humans go through menopause, and briefly outline how they could be tested. (HINT: One hypothesis might have something to do with kin selection. . .)*

One good answer would be: If post-menopausal women can help their own children and other relatives to raise *their* children, they will favor the spread of their own genes indirectly (this is basically the definition of kin selection, right there).

6. *Carl Baugh, proprietor of the Creation Evidences Museum in Glen Rose, Texas, claims in his 1992 book Footprints and the Stones of Time that geologists "date the fossils by the rocks and the rocks by the fossils." He calls this "circular reasoning" (it assumes as true what it supposedly sets out to prove as true) that gives no logical support for anyone to think that the Earth is more than a few thousand years old. Discuss his statement in light of your understanding of what geologists actually do.*

I was just lookin' for a simple explanation of Steno's law and Smith's work—establishing relative geological age, and then correlation.

7. *Despite all the seeming evils of inbreeding, there actually are a number of plants and animals that usually or always engage in inbreeding—often the closest form of inbreeding possible, self-fertilization. Many insects and rotifers, some lizards, and many plants (including Mendel's favorite, garden peas) always self-fertilize. Under what circumstances—if any— would natural selection favor the evolution of frequent or obligatory inbreeding? What kinds of lifestyle and ecological niche would you expect an inbreeding species to have?*

Well, maybe. . . highly sparse, scattered populations (where chance of finding a mate is very low), and/or conditions in which very rapid population growth is adaptive (e.g.. a food source that is extremely abundant for a short period of time).

8. *Sickle-cell anemia, common in parts of Africa, is caused by a single gene with (for our purposes) two alleles, H and S. HH individuals have normal hemoglobin and red blood cells; SS individuals have sickle-shaped cells and many associated health problems. HS individuals have a mild form of the disease but are also resistant to malaria.*

a) *In an African population, the frequency of the S allele has been measured at 0.13, and the fitnesses of the three genotypes have been estimated as: $w_{HH} = 0.8$, $w_{HS} = 1.0$, and $w_{SS}=0.2$. Calculate the mean fitness in this population, and then predict what the allele frequencies should be in the next generation.*

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Let q = freq(S) = 0.13
    p = 1-q = freq (H) = 0.87

w-bar = p2*wHH + 2pq*wHS + q2*wSS
      = 0.87*0.87*0.8 + 2*0.87*0.13*1.0 + 0.13*0.13*0.2
      = 0.606 + 0.226 + 0.00338
      = 0.835

Predictions for the next generation:

freq(HH) = 0.87*0.87*0.8/0.835 = 0.725
freq(HS) = 2*0.87*0.13*1.0/0.835 = 0.271
freq(SS) = 0.13*0.13*0.2/0.835 = 0.00405

New p = 0.725 + (0.271/2) = 0.861
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b) *It has been observed that in populations like this, despite there being strong natural selection imposed by lethal diseases, allele frequencies tend not to change from one generation to the next. Come up with an explanation for why this is the case. (HINT: The answer is not "mutation, migration, drift, random mating. . ."—it's not one of the Hardy-Weinberg equilibrium factors you probably memorized. It's something we haven't covered explicitly, but you should be able to figure it out.)*

The idea here is that selection against sickle-cell anemia (SS) is counterbalanced by selection against the normal but malaria-susceptible phenotype (HH). Since the HS genotype has the highest fitness, the S allele will tend to stay in the population. This is called a *balanced polymorphism*.