Bioloy 403 Problem Set #1 Answers.

1. Where did HIV come from? How do we know?

Phylogenetic analysis indicates that HIV-1 (Type 1) arose from a similar virus (SIV) in chimpanzees. Different strains of HIV-1 are more closely related to different strains of SIV in chimps, indicating that SIV has been transferred to humans more than once. It is believed that hunting of chimpanzees for food is the probable source of exposure.

HIV-2 (Type 2) is more closely related to an SIV found in a different primate than chimps, indicating yet another transfer of an SIV leading to a different HIV type. This type of HIV is not as virulent as Type 1, and this may explain its more restricted geographical distribution.

2. See Figure 1.17. Why does HIV continuously evolve during the "latent" phase of infection, which can last for years. In what sense does HIV stop evolving when CD4 counts drop? In what important way does it continue to evolve under natural selection?

HIV continually evolves to escape detection by the host immune system, which attempts to eliminate the virus and cells infected by it. The immune system learns to recognize HIV by particular peptide sequences (antigens) unique to the virus. This drives the virus to alter these peptide anitgens in order to escape detection.

When CD4 counts drop, the immune system is no longer producing the cells which are responsible for identifying and eliminating the virus and infected cells. Thus the selective pressure on HIV to change peptide antigens stops.

HIV nevertheless continues to evolve under natural selection within the host; for example, those genotypes which reproduce the fastest in the absence of continuous immune surveillance would be favored within the host.

3. List three reasons why HIV is deadly to the host. Why has HIV not evolved reduced virulence?

    1. The immune system is unable to eliminate the infection, but continues to produce T-cells which target the virus. The stem cells producing these T-cells can undergo a limited number of divisions, so the immune system effectively wears itself out over time.
    2. Natural selection within the host favors HIV genotypes with rapid reproduction. HIV infects cells of the immune system, which are destroyed either as a consequence of infection or because they become targeted by the immune system. So more rapid reproduction also means more damage to the host immune system.
    3. Natural selection for rapid reproduction favors a switch to different type of immune cells which become relatively common late during infection. Unfortunately, these cells are critical to immune function, and their loss triggers a collapse in immune function.
    4. The chance of HIV transmission is increased by maximizing the the number of viral particles in body fluids, which is achieved by a rapid rate of reproduction, with ultimately fatal consequences. Thus, less virulent forms of the virus are less likely to be transmitted.

    In principle, one could imagine that HIV might evolve reduced virulence if this resulted in more frequent transmission of the virus to new hosts. However, there is no indication that this has occurred over the time course of the epidemic. One explanation is that a trait of HIV strongly selected for within the host (rapid reproduction) also enhances its transmission from host to host (because rapid reproduction results in high titer of the virus). In this scenario, there is no reason to expect evolution of reduced virulence.

4. List two reasons why an HIV vaccine is not an immediate prospect, based on understanding of the evolutionary biology of the HIV virus.

   1. HIV has originated several times independently from different SIV ancestors, giving rise to different types (I and II) and subtypes. Vaccines targeted to one subtype have failed to provide protection against other HIV subtypes.
   2. The virus has continued to evolve since its introduction(s) into humans. This too means that a vaccine designed with regard to a particular version of the virus can fail to provide protection even to a different version of the same subtype, for example.

Wednesday:
Evolution of a non-experimental science

1. Define macro- and microevolution. What is the conceptual connection between the two?

   Microevolution is change in allele frequency from one generation to the next.

   Macroevolution is Darwin's descent with modification, alternatively large changes in form over time.

   A Neo-Darwinian tenet is that macroevolution is just lots of microevolution.

2. What fundamental fact about the flow of biological information is contradicted by the hypothesis of the inheritance of acquired characters?

   Information encoded in genes flows one way:

   DNA -> RNA -> protein

   Inheritance of acquired characters requires the exact reverse.

3. Why did rediscovery of Mendelian genetics ultimately lead to widespread recognition of the fundamental importance of evolution by natural selection? Why did early Mendelians nevertheless resist the idea?

   Rediscovery of Mendelian genetics solved the problem of inheritance. Successful incorporation of genetics into the theory of natural selection resolved many outstanding conceptual issues, including the problem of blending inheritance, and what a mutation is.

Early Mendelians were initially impressed by the power of mutations to change an organism's form; thus resemblance between parent and offspring seemed irrelevant to the most important changes in the organism. Rsemblance between parent and offspring is necessary for natural selection to operate.

Friday:
Phylogeny and homology

Why are fossils a bonus? That is, why is evidence for evolution overwhelming even if we had none?

DNA sequences provide a vast number of evolutionarily homologous traits which independently corroborate inferences about phylogeny (evolutionary relationships between organisms) from morphological characters and the fossil record.

Ch. 2 #6,7

6. Evolutionary homology is similarity due to common descent. Possession of an eye socket in a blind cave fish is the result of being descended from a sighted ancestor, so the similarity, the eye socket, is homologous. As are the wings of two different bird species; they are similarities inherited from a common ancestor. The spurs of a boa are also homologous to the hind legs of a kangaroo, because they are similarities inherited from a common ancestor. Of course, the boa's spurs look nothing like the hind legs of kangaroo, so they are not homologous in Owen's meaning of similar. The wings of birds are homologous according to both meanings.

7. a. analogous
   b. analogoous
   c. analogoous
   d. homologous
   e. homologous
   f. analogous