Evolution BIOL403 Spring 2009

1. (8 pts) The Origin of Species is justly famous for containing not one but two remarkable propositions about evolution of life on earth. What were they?

1. The history of life is a branching tree

2. The fit of of organisms to their environment (adaptation) is explained by natural selection

2a,b. (8 pts) Identify each pair of traits as either homologous or analogous, and say why.

A. The eye of an octopus and a whale

Analogous; the eye of an octopus and a whale are similar due to common functional requirement, not common ancestry

B. The arm bones of a whale and a shrew

Homologous; the arm bones of a whale and a shrew are similar due to common ancestry.

3. (4 pts) Acanthostega was probably not our direct ancestor. Why are evolutionary biologists nevertheless so interested in this organism?

Acanthostega is closely related to our tetrapod ancestor which colonized the land 380 MYA, and it shows adaptations for living and feeding in a terrestrial environment. Thus it illuminates the evolutionary changes that took place in the invasion of land by tetrapods.

4. (4 pts) The Universal Genetic Code has been called a frozen accident by evolutionary biologists. In what sense is it an accident, and what sense is it frozen?

The code is an accident in the sense that it is arbitrary; many other codes would have done as well.

It is frozen (unchanged over billions of years) because changing it would have catastrophic effects on fitness.

5. (4 pts) Why are ring species of particular interest to Neo-Darwinians?

Ring species provide evidence that many small changes (microevolution) leads to macroevolution (large changes, including speciation).

6. (4 pts) Type II HIV is much less widespread than Type I, and less virulent (the time course to development of AIDS is longer). Explain why these two observations are probably connected.

Type II HIV probably does not reproduce as fast as Type I. Rapid reproduction of the virus results in high titer of the virus in bodily fluids, which is associated with both higher virulence and a higher rate of transmission.

7. (12 pts) List three predictions of (macro)evolution as a branching tree. For each, give an illustrative example.

Life as a branching tree predicts:

1. Homologous similarity between extant species

Example; the tetrapod limb in land vertebrates

2. Older forms give rise to more recent ones (fossil record)

Example: fossils of amphibians appear earlier in the record than fossils of birds.

3. The existence of transitional forms

Examples: archaeopteryx, basilosaurus, acanthostega

8. (8 pts) Cite two real world supporting examples for the proposition that evolution by natural selection is not progressive (forward looking).

The non-progressive nature of evolution is evidenced by examples of non-optimal design and/or behavior and vestigial traits, including:

The recurrent laryngial nerve takes a very ciruitous route to the larynx in terrestrial vertebrates because it is wrapped around the aorta. The original routing was more direct because it arose in a (fish) ancestor with no neck. Lack of foresight is indicated by the failure of natural selection to anticipate necks.

The virus HIV dooms itself to extinction by evolving to infect white blood cell types (called CXCR4) that are common only late in infection. This change prevents transmission of the virus, because these cell types are not common in uninfected individuals. Because this change also hastens collapse of the immune system and death of the host, it also guarantees extinction of the virus population as well.

Whales have a pelvis because they are descended from a terrestrial tetrapod ancestor. The fact that whales evolved to return to the environment from which their tetrapod ancestors came suggests a lack of progress.

And many others.

9. (4 pts) What are (different) alleles?

Alternative sequences at a genetic locus

10. (16 pts) List four requirements for natural selection to operate. For each requirement, provide an evaluation of how/whether the requirement is met for the example of the evolution of beak depth in a population of Medium Ground Finches on Daphne Major.

1. **The trait must be variable in the population:**

   Before the drought, there was considerable variation in beak depth in the population

2. **The trait must be (at least partly) heritable:**

   Strong resemblance between parent and offspring indicated beak depth is highly heritable in the population.

3. **There must be differential survival and/or reproduction:**

   During the drought, most individuals died.

4. **Survival and or reproduction must be non-random with respect to the trait:**

   Survivors had significantly deeper beaks than did the population prior to the drought.

11. (4 pts) In mutation accumulation experiments using C. elegans, control lines showed little or no reduction reduction in fitness. Suggest how environmental conditions in these lines differed from those maintained in the experimental (mutation accumulating) lines.

The control lines were maintained by keeping animals crowded, on short rations, and keeping them that way (new generations were not started with one individual, as in the accumulation lines).

12. (8 pts) Some organisms appear to have scarcely changed their phenotype over many millions of years ("living fossils"), whereas others have changed rapidly since the end of the last glacial age (10,000 years ago). Suggest how natural selection can account for both observations.

Stabilizing selection in a largely unchanged environment can account for evolutionary stasis.

Directional or diversifying selection in a changing environment can account for rapid evolutionary change.

13. (12 pts) What are the two principal sources of new genetic variation arising within populations? Cite evidence indicating that both sources contribute to the response to selection in artificial selection experiments.

Mutation and recombination

In some artificial selection experiments, a response to selection (ie, evolution) stops after 20-30 generations, indicating exhaustion of existing genetic variation. In these cases, new combinations of existing alleles must be responsible for the observed response to selection.

In other selection experiments, a response to selection continues for 100 generations and more. It is thought that mutation must be contributing to variation and thus the response to selection in these cases.

14. Why do we count to ten when we're mad (and not 2 or 12, for example)?

(Any answer credited)

Because our tetrapod ancestor had ten fingers