The Evidence for Evolution

A. What needs to be explained?
1. the fossil record — the order of groups, the similarities, the extinctions
2. variation under domestication
3. the perfectness of some adaptations
4. vestigial organs — the imperfectness of some organisms/parts of organisms
5. ring species
6. homologies at every level (homology = character shared by a set of species and present in their common ancestor)
7. observed organic change at a small level — in lab, pepper moth, etc.

B. Any evolutionary theory must also explain HOW:
1. a population can be transformed enough to produce individuals different from the ancestral population
2. a population can be transformed that does not interbreed with forms like its ancestors

C. The evidence:
1. variation under domestication — how Darwin started his book. The commonest examples to Americans are probably dogs. Starting from one or a few ancestors, we have a whole range of domestic dogs, from webbed-foot dogs (ex: Newfoundlands) to the smallest (ex: breeds of Chihuahuas) to the largest (ex: forms of St. Bernards). If only Chihuahuas and St. Bernards were alive, could they breed? Would they be separate species? What is a species anyway? (we will actually defer looking at this particular question for a while). What about increases in milk production of cows, length of hair of sheep, number of horns of rams (LA Fair), various forms of cabbage (broccoli, cabbage, cauliflower, Brussels sprouts), various melons (crenshaw, honeydew, cantaloupe, casaba, canary)?

   If human interference can create organisms easily as different as some species in nature, why can't nature do the same?
2. change observed in nature: peppered moth (*Panaxia dominula*). Black form took over as trees became polluted, white form returning now with pollution controls. Pesticide resistance in many organisms. Resistance to myxomatosis virus in rabbits in Australia. Lessened virulence of myxomatosis virus.

   Change, if not of one species to another, at least major changes within a species can occur, cannot also change occur enough to make different species if given longer time periods?
3. Lab experiments: artificial selection in the lab can modify the response to almost any trait in any organism amenable to such artificial selection. Virtually all traits vary, most quantitatively, some quantitatively.

4. Clines and ring species: many species vary morphologically along geographic gradients. Bears get larger the higher the latitude; the frequency of the Est-5 0.85 allele increases with decreasing latitude. Ring species are those species showing continuous morphological change, from interbreeding population to interbreeding population around some geographic feature, except at one point of the geographic feature where there are two separate species that do not interbreed. People may pigeonhole organisms into discrete types; nature is seldom so neat. Examples: salamanders in California, gulls in book (Chapter 3).

   In other words, the **SAME KINDS OF CHANGES THAT SEPARATE ADJACENT POPULATIONS CAN ALSO SEPARATE SPECIES**.
5. Experimental making of new species. Especially in plants, polyploidy (increase in number of chromosome sets) can be induced experimentally. The new plants are usually viable, but cannot cross with the parent species successfully. Many commercially available plants, especially flowers, are artificial polyploids. Many natural examples of polyploidy or other chromosome aberration speciation are known in plants, including the evening primrose (*Oenothera*) complex in California (which is a translocation, not a polyploid complex).

   One can artificially make new species by the same mechanisms that ~70-80% of natural flowering plant (Angiosperm) species have been made.
6. The principle of uniformitarianism: one can extrapolate small changes over short times to large changes over long times.
7. Homologies: organisms share homologies even when other structures may be better suited to function. For instance, whether a tetrapod walks, swims or flies, the basic structure of the limb is the same (it is pentadactyl, with radius & ulna, humerus, and carpels). History (inheritance) determines what evolution has to work with; structures are not perfectly engineered for function; they must be modifications of what came before, not wholly new structured "designed" for function.
8. Vestigial organs: it is enough in evolution that an organ is not bad for an organisms to have it persist, even though not needed. Thus, vestigial legs in boas, vestigial pelvis in whales are historical left-overs from ancestors that had legs. They may, however, have a current function unrelated to their original adaptation.
9. Chemistry: all organisms share the same fundamental chemical processes of DNA encoded protein synthesis (except some viruses which use RNA). Though the proteins made are different, the chemical processes to make the proteins are virtually identical. Hard to explain except by descent form a common ancestor.

10. Different homologies are correlated, and can be classified hierarchically. That is, we can say for one trait "this comes from this", but for another trait "this is a new thing". When put with a time scale, this clearly shows descent with modification.
11. The order of organisms in the fossil record suggests evolutionary relationships. That is, amphibians appear after fish but before reptiles which appear before mammals in the fossil record; if fish had evolved into mammals which then evolved into amphibians, gills would have to have been lost in mammals and then gained again in amphibians. This violates Occam's Razor — the principle that the simplest explanation is the best.
12. The fossil record — what is a fossil? It is a trace of an organism. Rock strata on bottom are oldest in most cases; organisms most removed from present organisms are found in bottommost rocks. How can one explain change through rock layers leading to present organisms without evolution or miracles?

D. Summary of the problems and evidence:

1. Any theory must explain the following:
    - a. order and composition of fossil record
    - b. adaptation and imperfectness of adaptation
    - c. homologies
    - d. variation under domestication
    - e. ring species
    - f. observed organic change — in nature and in lab
2. Evidence:
    - a. evolution explains order and composition of fossil record — organisms most similar to those living should be in the most recent rock strata
    - b. adaptation is explained by natural selection; imperfectness of adaptation by having to use previous organisms as starting material
    - c. homologies explained by common descent
    - d. variation under domestication explained by selection being artificial, not natural
    - e. ring species explained by the same kinds of variation that occur between populations being sufficient in kind that a larger degree of such variation is sufficient to make different species
    - f. observed organic change in nature and lab explained by natural or artificial selection on a variable genetic background.