**Major Tenets of the Evolutionary Synthesis** (taken from Futuyma 1998)

The principal claims of the Evolutionary Synthesis are the foundations of modern evolutionary biology. They are known collectively as the Synthetic Theory, and serve as a synopsis of much of contemporary evolutionary theory. Many of these points have been extended, exemplified, clarified, or modified since the 1940s. Although some authors have challenged or even rejected some of these principles, the vast majority of evolutionary biologists today accepts them as valid and uses them as a foundation for evolutionary research.

1. The phenotype (observed physical characteristics) is different from the genotype (the set of genes carried by an individual), and the phenotypic differences among individual organisms can be due partly to genetic differences and partly to direct effects of the environment.
2. Environmental effects on an individual's phenotype do not affect the genes passed on to its offspring. That is, acquired characteristics are not inherited. However, the environment may affect the expression of an organism's genes.
3. Hereditary variations are based on particles—genes—that retain their identity as they pass through the generations; genes do not blend with other genes. This is true not only of those genes that have discrete effects on the phenotype (e.g., brown vs. blue eyes), but also of those that contribute to continuously varying traits (e.g., body size, intensity of pigmentation). Variation in continuously varying traits is largely based on several or many discrete genes, each of which affects the trait slightly (polygenic inheritance).
4. Genes mutate, usually at a fairly low rate, to alternative forms (alleles). The phenotypic effects of such mutations can range all the way from undetectable to very great. The variation that arises by mutation is amplified by recombination among alleles at different loci.
5. Environmental factors (e.g., chemicals, radiation) may affect the rate of mutation, but they do not preferentially direct the production of mutations that would be favorable in the organism's specific environment.

*Points 1-5 were important early contributions to the Synthetic Theory from laboratory genetics.*

6. Evolutionary change is a populational process: it entails, in its most basic form, a change in the relative abundances (proportions) of individual organisms with different genotypes (and hence, often, with different phenotypes) within a population (see Figure 2.2). Over the course of generations, the proportion of one genotype may gradually increase, and it may eventually entirely replace the other type. This process may occur within only certain populations, or in all the populations that make up a species (see point 11).
7. The rate of mutation is too low for mutation by itself to shift an entire population from one genotype to another. Instead, the change in genotype proportions within a population can occur by either of two principal processes: random fluctuations in proportions (random genetic drift) or nonrandom changes due to the superior survival and/or reproduction of some genotypes compared to others (natural selection). Natural selection and random genetic drift can operate simultaneously.
8. Even a slight intensity of natural selection can (under certain circumstances) bring about substantial evolutionary change in a relatively short time. Very slight differences between organisms can confer slight differences in survival or reproduction; hence natural selection can account for slight differences among species, and for the earliest stages of evolution of new traits.

*Points 6-8 were among the major contributions of the mathematical theory of population genetics.*

9. Selection can alter populations beyond the original range of variation by increasing the proportion of alleles that, by recombination with other genes that affect the same trait, give rise to new phenotypes. (This point is a contribution from genetic studies of agriculturally based plant and animal breeding.)
10. Natural populations are genetically variable: the individuals within populations differ genetically and include natural genetic variants of the kind that arise by mutation in laboratory stocks.
11. Populations of a species in different geographic regions differ in characteristics that have a genetic basis. The genetic differences among populations are often of the same kind that distinguish

individuals within populations. A genotype that is rare in one population may be predominant in another.

12. Experimental crosses between different species, and between different populations of the same species, show that most of the differences between them have a genetic basis. The difference in each trait is often based on differences in several or many genes (i.e., it is polygenic), each of which has a small phenotypic effect. This finding provides evidence that the differences between species evolve by small steps rather than by single mutations with large phenotypic effects.
13. Natural selection occurs in natural populations at the present time, often with considerable intensity.

*Points 9-13 were contributions from geneticists who studied natural populations.*

14. Differences among geographic populations of a species are often adaptive (hence, are the consequence of natural selection), because they are frequently correlated with relevant environmental factors.
15. Organisms are not necessarily different species just because they differ in one or more phenotypic characteristics; phenotypically different genotypes often are members of a single interbreeding population. Rather, different species represent distinct gene pools, which are groups of interbreeding or potentially interbreeding individuals that do not exchange genes with other such groups. This reproductive isolation of species is based on certain genetically determined differences between them. (This is one version of the biological species concept.) Hence, even a mutation that causes substantial change in some phenotypic feature does not necessarily represent the origin of a new species.
16. Nevertheless, there is a continuum in degree of differentiation of populations, with respect to both phenotypic difference and degree of reproductive isolation, from barely differentiated populations to fully distinct species. This observation provides evidence that an ancestral species differentiates into two or more different species by the gradual accumulation of small differences rather than by a single mutational step.
17. Speciation—the origin of two or more species from a single common ancestor—usually occurs through the genetic differentiation of geographically segregated populations. Geographic segregation is required so that interbreeding does not prevent incipient genetic differences from developing.
18. Among living organisms, there are many gradations in phenotypic characteristics among species assigned to the same genus, to different genera, and to different families or other higher taxa. This observation is interpreted as evidence that higher taxa arise through the prolonged, sequential accumulation of small differences, rather than through the sudden mutational origin of drastically new "types."

*Points 14-18 were contributed chiefly by systematists and naturalists of particular taxonomic groups.*

19. The fossil record includes many gaps among quite different kinds of organisms, as well as gaps between possible ancestors and descendants. Such gaps can be explained by the incompleteness of the fossil record. But the fossil record also includes examples of gradations from apparently ancestral organisms to quite different descendants. Together with point 18, this leads to the conclusion that the evolution of large differences proceeds by many small steps (such as those that lead to the differentiation of geographic populations and closely related species). Hence we can extrapolate from the genesis of small differences to the evolution of large differences among higher taxa, and can explain the latter by the same principles that explain the evolution of populations and species.
20. Consequently, all observations of the fossil record are consistent with the foregoing principles of evolutionary change (although they do not prove that these mechanisms provide a necessary and sufficient explanation). There is no need to invoke, and in some instances there is evidence against, non-Darwinian hypotheses such as Lamarckian mechanisms, orthogenetic evolution, vitalism ("inner drives"), or abrupt origins by major mutations.

*Points 19 and 20 were among the contributions of paleontologists.*