Chapter 22—Descent With Modification

… Or If It Ain’t Broke, Why Not Fix It.

A Bit About Darwin

- Darwin had the freedom to explore extensively on shore while the crew surveyed the coast.
- He collected thousands of specimens of the exotic and diverse flora and fauna of South America.
  - Darwin explored the Brazilian jungles, the grasslands of the Argentine pampas, the desolation of Tiera del Fuego, and the heights of the Andes.

- Darwin noted that the plants and animals of South America were very distinct from those of Europe.
- Organisms from temperate regions of South America were more similar to those from the tropics of South America than to those from temperate regions of Europe.
- Further, South American fossils more closely resembled modern species from that continent than those from Europe.

- The origin of the fauna of the Galapagos, 900 km west of the South American coast, especially puzzled Darwin.
- On further study after his voyage, Darwin noted that while most of the animal species on the Galapagos lived nowhere else, they resembled species living on the South American mainland.
- It seemed that the islands had been colonized by plants and animals from the mainland that had subsequently diversified on the different islands.

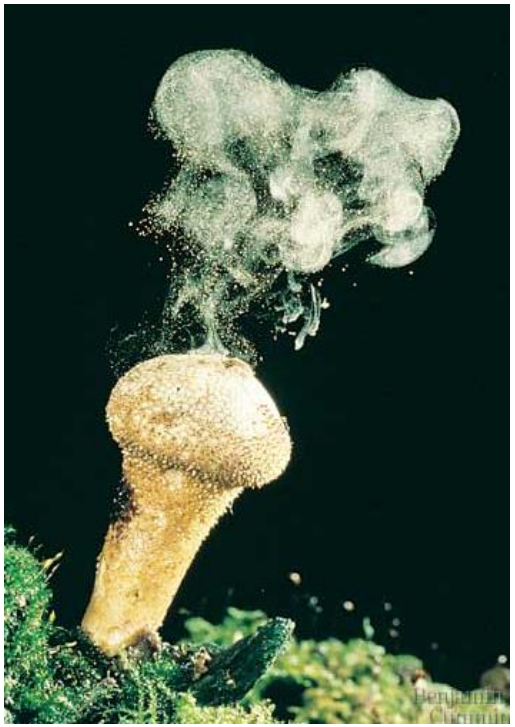
- After his return to Great Britain in 1836, Darwin began to perceive that the origin of new species and adaptation of species to the environment were closely related processes.
- For example, clear differences in the beak among the 13 types of finches that Darwin collected in the Galapagos are adaptations to the foods available on their home islands.

Evolutionary Theory The Beginning of Darwin's Idea

- Central to Darwin's view of the evolution of life is **descent with modification**.
- In descent with modification, all present day organisms are related through descent from unknown ancestors in the past.
- Descendents of these ancestors accumulated diverse modifications or adaptations that fit them to specific ways of life and habitats.

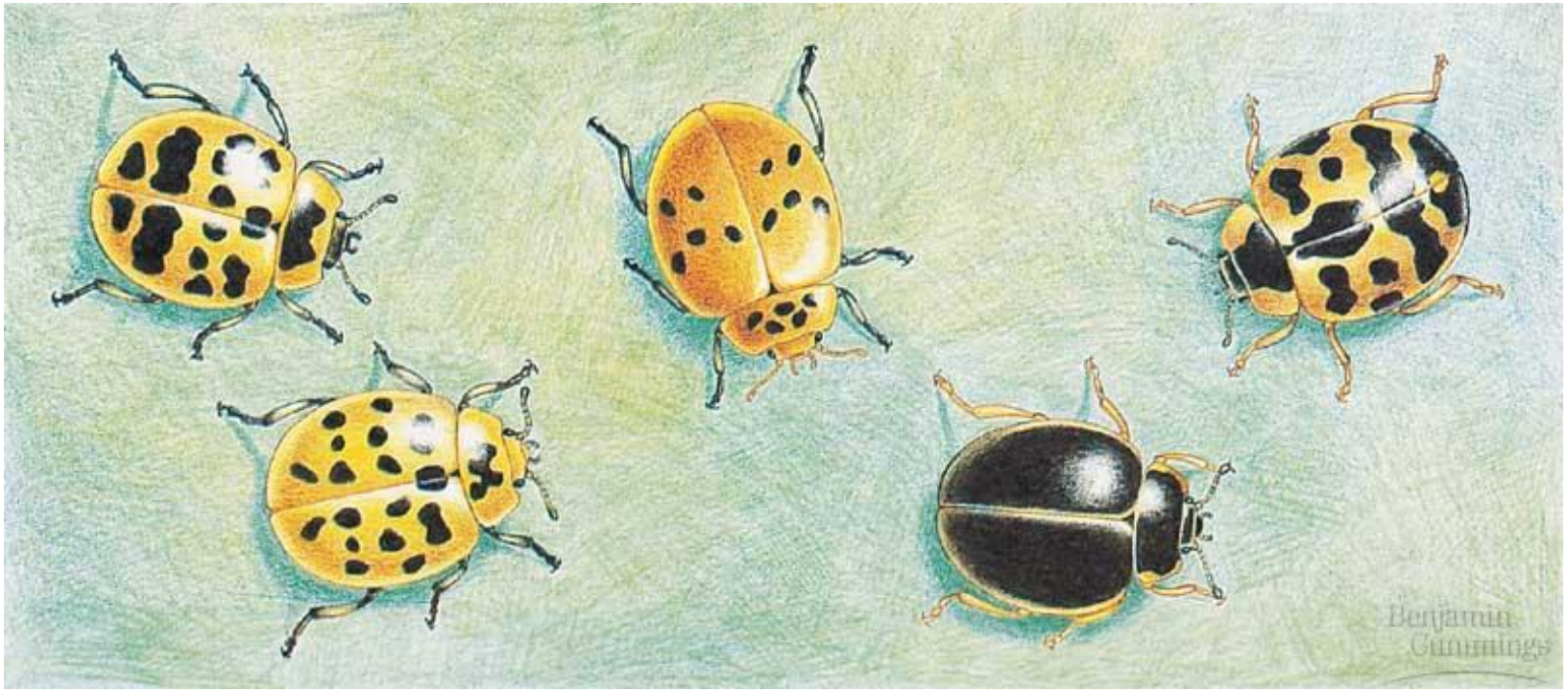
- The other major point that Darwin pioneered is a unique mechanism of evolution - the theory of natural selection.
- Ernst Mayr, an evolutionary biologist, has dissected the logic of Darwin's theory into three inferences based on five observations.
- These observations include tremendous fecundity, stable populations sizes, limited environmental resources, variation among individuals, and heritability of some of this variation.

- Observation #1: All species have such great potential fertility that their population size would increase exponentially if all individuals that are born reproduced successfully.
- Observation #2: Populations tend to remain stable in size, except for seasonal fluctuations.



- Observation #3: Environmental resources are limited.
- Inference #1: Production of more individuals than the environment can support leads to a struggle for existence among the individuals of a population, with only a fraction of the offspring surviving each generation.

- Observation #4: Individuals of a population vary extensively in their characteristics; no two individuals are exactly alike.



- Observation #5: Much of this variation is heritable.

- Inference #2: Survival in the struggle for existence is not random, but depends in part on the hereditary constitution of the individuals.
  - Those individuals whose inherited characteristics best fit them to their environment are likely to leave more offspring than less fit individuals.
- Inference #3: This unequal ability of individuals to survive and reproduce will lead to a gradual change in a population, with favorable characteristics accumulating over the generations.

- Darwin's main ideas can be summarized in three points.
- *Natural selection is differential success in reproduction* (unequal ability of individuals to survive and reproduce).
- *Natural selection occurs through an interaction between the environment and the variability inherent among the individual organisms making up a population.*
- *The product of natural selection is the adaptation of populations of organisms to their environment.*

Darwin's Evolution Mechanics

- Darwin's views on the role of environmental factors in the screening of heritable variation were heavily influenced by **artificial selection**.
- Humans have modified a variety of domesticated plants and animals over many generations by selecting individuals with the desired traits as breeding stock.

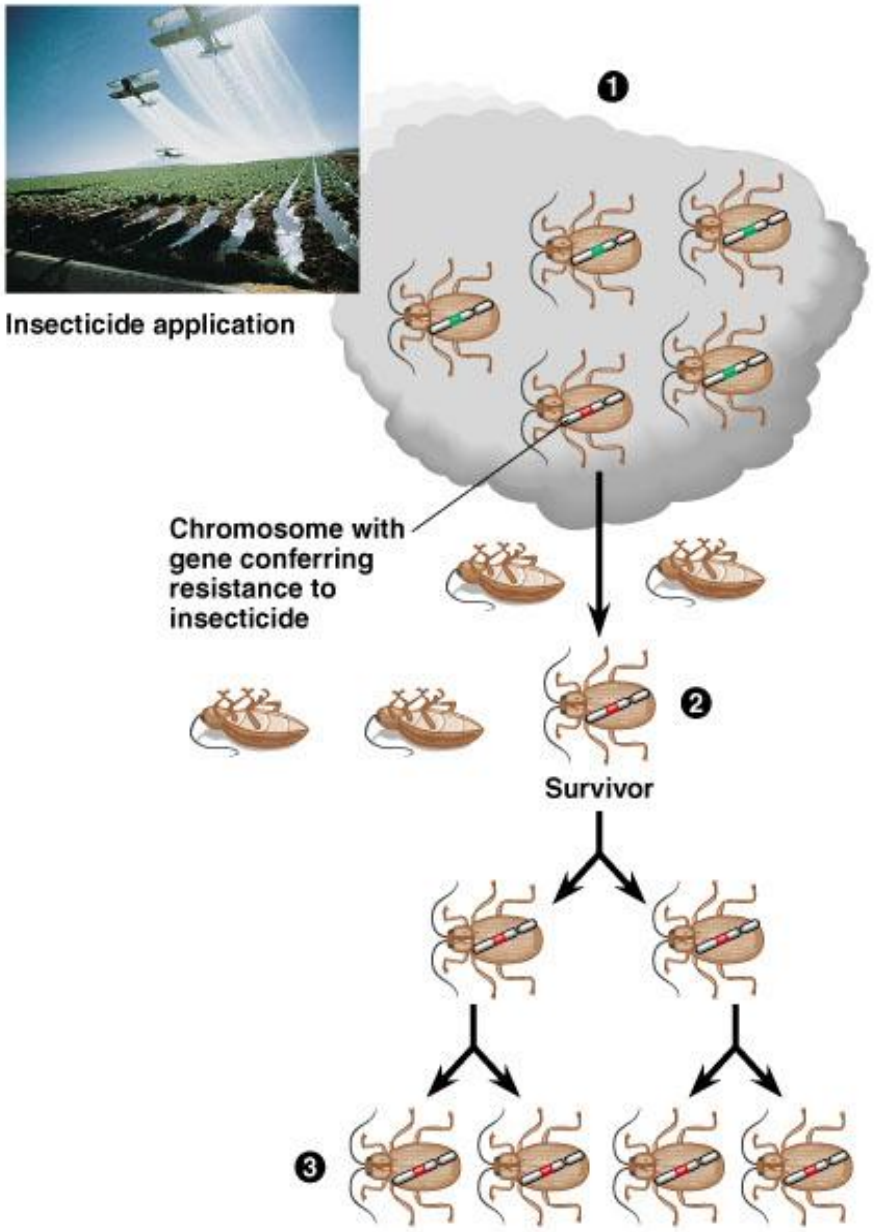
- The Darwinian view of life has two main features.
  - (1) The diverse forms of life have arisen by descent with modification from ancestral species.
  - (2) The mechanism of modification has been natural selection working over enormous tracts of time.

- If artificial selection can achieve such major changes in a relatively short time, then natural selection should be capable of major modifications of species over hundreds or thousands of generations.
- Darwin envisioned the diversity of life as evolving by a gradual accumulation of minute changes through the actions of natural selection operating over vast spans of time.

- While natural selection involves interactions between individual organisms and their environment, it is not individuals, but populations that evolve.
- Populations are defined as a group of interbreeding individuals of a single species that share a common geographic area.
- Evolution is measured as the change in relative proportions of heritable variation in a population over a succession of generations.

- Natural selection can only amplify or diminish heritable variations, not variations that an individual acquires during its life, even if these variations are adaptive.
- Also, natural selection is situational.
  - Environmental factors vary in space and time.
  - Therefore, adaptations for one set of environmental conditions may be useless or even detrimental under other circumstances.

Evidence


Insecticide application
1
Chromosome with gene conferring resistance to insecticide
2
Survivor
3

- While researchers have developed many drugs to combat the human immunodeficiency virus (HIV), drug-resistant strains evolve rapidly in the HIV population infecting each patient.
- Natural selection favors those characteristics in a variable population that fit the current, local environment.
- The evolution of drug resistance or pesticide resistance differ only in speed, not in basic mechanism, from other cases of natural selection.

- For patients treated with the drug 3TC, which interferes with genome replication in HIV, 3TC-resistant strains become 100% of the population of HIV in just a few weeks.