Module 16: Speciation

- **Geographic isolation** (e.g. Galapagos) also found where we disturb natural habitats with roads
- This causes **Allo** (other) **Patric** (father) speciation
- Eventually reproductive isolation will result: different breeds will not be able to procreate
- There is another more rare form of speciation: **Sympatric** ("same father"), from polyploidy, ("many chromosomes")

Island example:

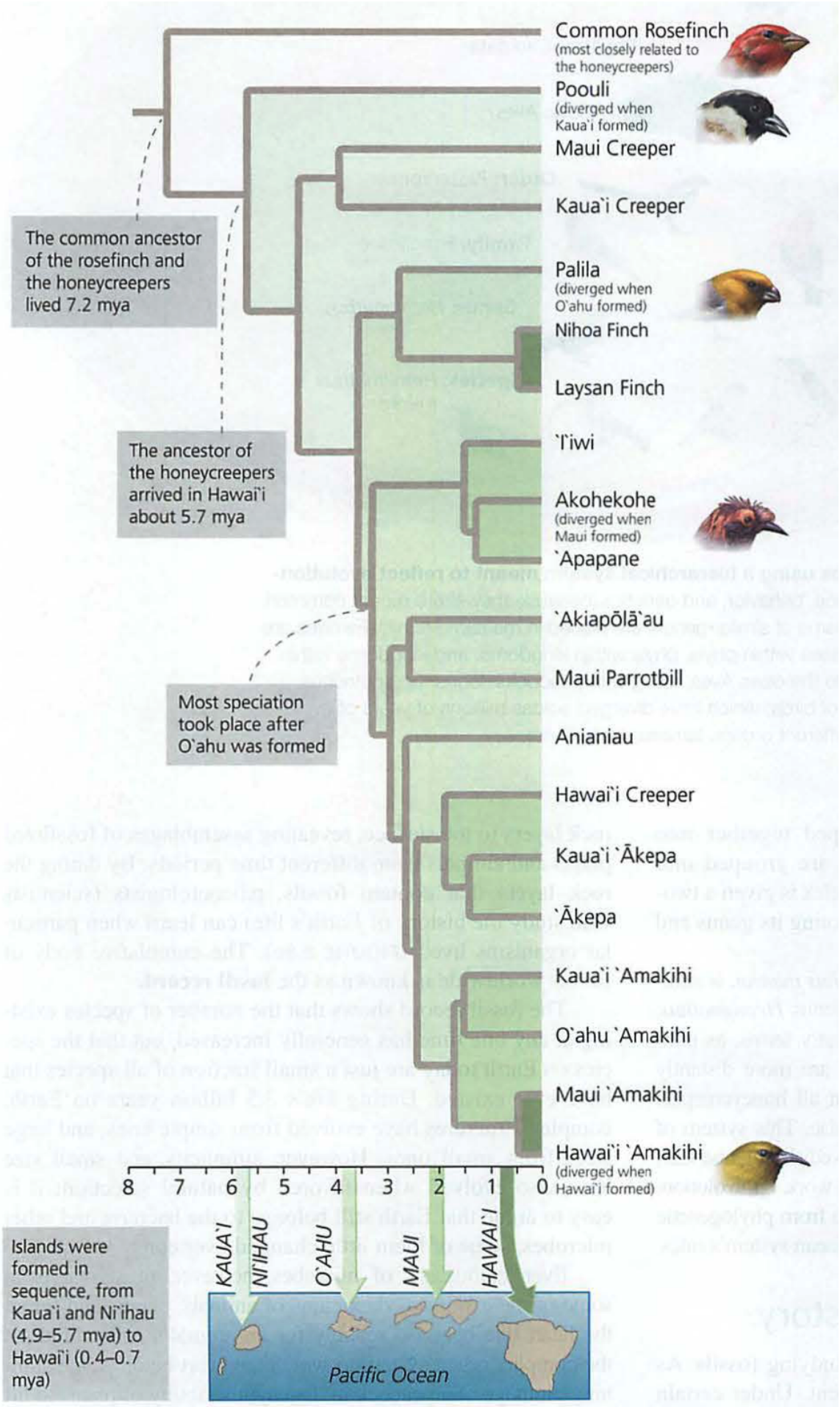


FIGURE 1 Using gene sequences, researchers generated this phylogenetic tree showing relationships among the Hawaiian honeycreepers. They then matched the history of the birds' diversification with the known geologic history of the islands' formation. *Adapted from Lerner, H.R.L., et al. 2011. Multilocus resolution of phylogeny and timescale in the extant adaptive radiation of Hawaiian honeycreepers.* Curr. Biol. *21: 1838–1844.*

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Polyploidy is a condition in which an organism has more than two complete sets of chromosomes. While most organisms are diploid, meaning they have two sets of chromosomes (one from each parent), polyploid organisms can have three (triploid), four (tetraploid), or even more sets of chromosomes. This phenomenon is particularly common in plants but can also occur in some animals, fungi, and other organisms.

There are two main types of polyploidy:

1. **Autopolyploidy**: This occurs when an organism has multiple sets of chromosomes from the same species. Autopolyploidy often results from errors during cell division, such as nondisjunction, where chromosomes fail to separate properly. The result is an increase in chromosome number within a single species.
2. **Allopolyploidy**: This occurs when chromosomes from two different species combine. It usually happens through hybridization, where two different species mate, and their chromosomes combine to form a hybrid organism. If chromosome doubling then occurs, the hybrid becomes fertile and can reproduce.

Benefits and Challenges of Polyploidy

- **Advantages**: Polyploidy can introduce genetic variation, which may improve resilience, adaptability, and growth in certain environments. Polyploid plants, for instance, can have larger cells, which may lead to larger fruits, flowers, or other advantageous traits.
- **Challenges**: Polyploidy can create difficulties in reproduction, especially if the chromosomes don’t pair correctly during meiosis. This can result in infertility in some polyploid organisms, although certain mechanisms can evolve to overcome this.

Examples of Polyploidy in Nature

Many crops, like wheat, cotton, and strawberries, are polyploid. For example, commercial wheat is hexaploid (six sets of chromosomes), giving it traits like increased grain size and robustness that are favorable for agriculture.

- **GMO**: see roundup ready corn and wheat, freeze proof tomatoes and others.
  - Not to be confused with Dwarf Wheat and Norman Borlaug (see population chapters for more on this).
  - Dwarf wheat was a simple hybrid, not a GMO.
  - Look up "gene guns" and CRISPR

A genetically modified organism (GMO) is an organism—whether plant, animal, or microorganism—whose genetic material has been altered using genetic engineering techniques. This modification typically involves adding, deleting, or changing specific genes to produce desired traits, such as resistance to pests, tolerance to herbicides, or improved nutritional content.

How GMOs Are Created

The process of creating a GMO typically involves the following steps:

1. **Gene Identification**: Scientists identify the specific gene responsible for the desired trait. For example, a gene that provides resistance to a particular pest may be isolated from another organism.
2. **Gene Insertion**: Using genetic engineering techniques, this gene is inserted into the DNA of the organism being modified. This process often involves using bacteria or other vectors to carry the gene into the target organism's cells.
3. **Selection and Testing**: Cells that successfully incorporate the new gene are grown and tested to confirm that they exhibit the desired trait. If successful, these cells are developed into complete organisms.
4. **Breeding and Cultivation**: The genetically modified organisms are then bred to create generations that carry the trait.

Applications of GMOs

GMOs are widely used in various fields:

- **Agriculture**: Many GM crops are engineered to resist pests, tolerate herbicides, and withstand environmental stresses like drought. Examples include Bt corn, which produces a protein toxic to certain insects, and Roundup Ready soybeans, which tolerate specific herbicides.
- **Medicine**: Genetically modified bacteria and other microorganisms are used to produce insulin, human growth hormones, vaccines, and other pharmaceuticals. Gene therapy, a medical application of genetic engineering, involves modifying a patient's own cells to treat or cure genetic disorders.
- **Environmental Applications**: GMOs are used for environmental purposes, such as creating bacteria that can break down oil spills or detoxify contaminated soils.

Benefits and Concerns of GMOs

- **Benefits**: GMOs can improve crop yields, reduce the need for chemical pesticides, enhance food quality and nutrition, and address specific health needs in pharmaceuticals. GM crops can also help improve food security, especially in regions with challenging

growing conditions.
- **Concerns**: Potential risks include unintended environmental impacts, such as the development of herbicide-resistant weeds or impacts on biodiversity. There are also debates about the safety of GM foods for human consumption and concerns about the control of GMO technology by a few large companies.

Regulation and Labeling

GMOs are regulated differently across countries. In the United States, the USDA, FDA, and EPA oversee GMO safety and production. Some countries, including the European Union, have stricter regulations and require labeling on foods containing GMOs.

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