Incomplete Dominance

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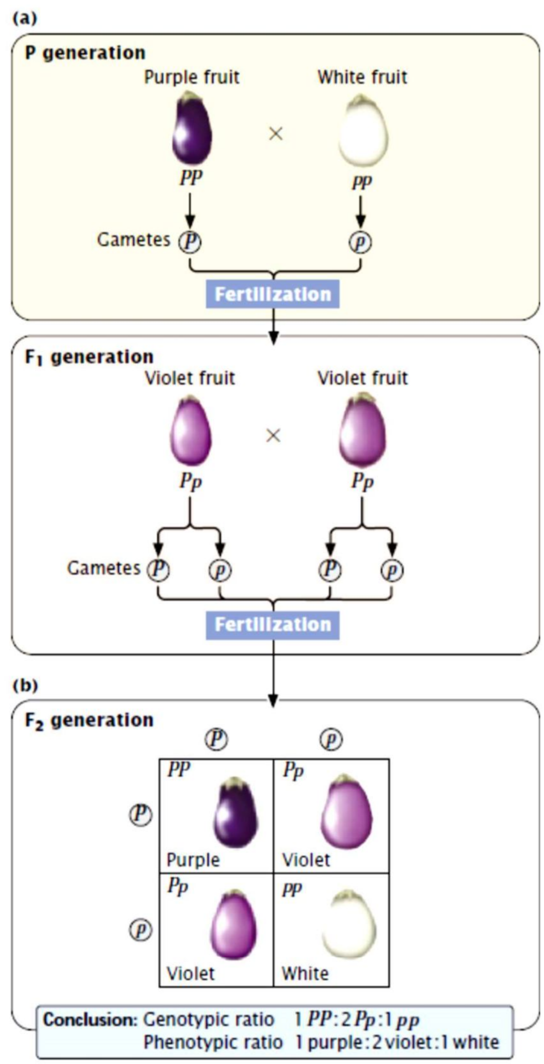
The 7 characters in pea plants that Mendel studied extensively all exhibited dominance, but Mendel did realize that not all characters have traits that exhibit dominance. He conducted some crosses concerning the length of time that pea plants take to flower. When he crossed two homozygous varieties differing in their flowering time by an average of 20 days, the length of time taken by the F_1 plants to flower was intermediate between those of the two parents. When the heterozygote has a phenotype intermediate between the phenotypes of the two homozygotes, the trait is said to exhibit **incomplete dominance.**



Incomplete dominance is exhibited in several organisms. For example, the fruit color of eggplants. When a homozygous plant that produces purple fruit (*PP*) is crossed with a homozygous plant that produces white fruit (*pp*), all the heterozygous F_1 (*Pp*) produce violet fruit. When the F_1 are crossed with each other, of the F_2 are $1/4$ purple (*PP*), $1/2$ are violet (*Pp*), and $1/4$ are white (*pp*). This 1:2:1 ratio is different from the 3:1 ratio of the dominance. When a trait displays incomplete dominance, the genotypic ratios and phenotypic ratios of the offspring are the *same,* because each genotype has its own phenotype. It is impossible to obtain eggplants that are pure breeding for violet fruit, because all plants with violet fruit are heterozygous.

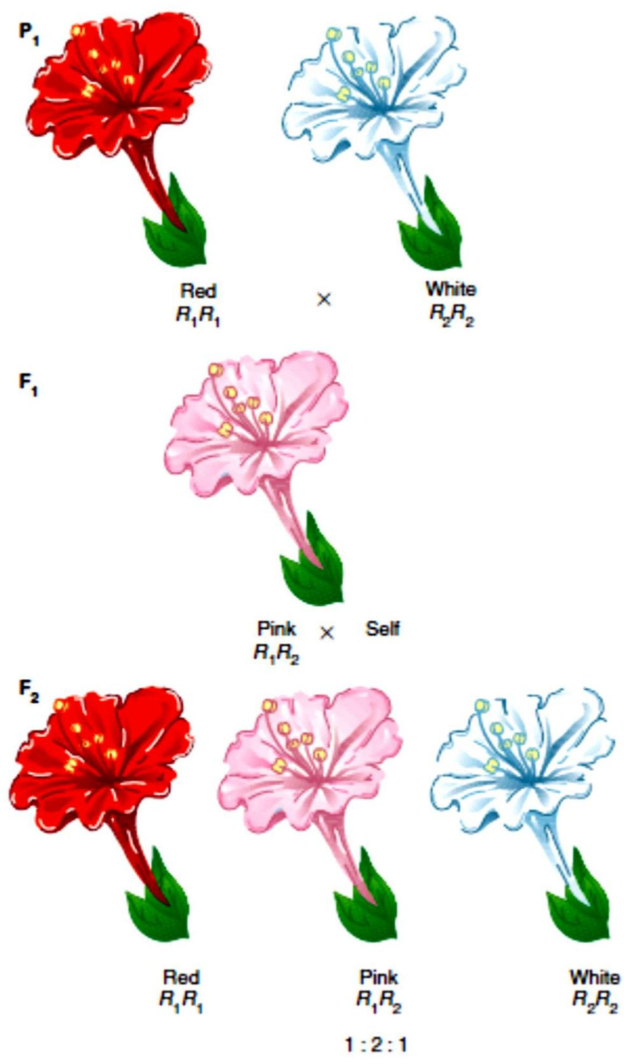
Another example is feather color in chickens. A cross between a homozygous black chicken and a homozygous white chicken produces F_1 chickens that are gray. If these gray F_1 are intercrossed, they produce F_2 birds in a ratio of 1 black: 2 gray: 1 white.

Leopard white spotting in horses is incompletely dominant over unspotted horses: *LL* horses are white with numerous dark spots, heterozygous *Ll* horses have fewer spots, and *ll* horses have no spots.

Incomplete dominance is shown when the heterozygote has a phenotype intermediate between the phenotypes of the two homozygotes.

In **partial dominance** or **incomplete dominance,** the phenotype of the heterozygote falls between those of the two homozygotes. Using four-o'clock plants (*Mirabilis jalapa*), we can cross a plant that has red flower petals with another that has white flower petals; the offspring will have pink flower petals. If these pink-flowered F_1 plants are crossed, the F_2 plants appear in a ratio of 1:2:1, having red, pink, or white flower petals, respectively.

The pink-flowered plants are heterozygotes that have a petal color intermediate between the red and white colors of the homozygotes. In this case, one allele (R_1) specifies red pigment color, and another allele specifies no color (R_2; the flower petals have a white background color). Flowers in heterozygotes (R_1R_2) have about half the red pigment of the flowers in red homozygotes (R_1R_1) because the heterozygotes have only one copy of the allele that produces color, whereas the homozygotes have two copies.



It is now clear that dominance and recessiveness are phenomena dependent on which alleles are interacting and on what phenotypic level we are studying. For example, in **Tay-Sachs disease**, homozygous recessive children usually die before the age of three after suffering severe nervous system degeneration; heterozygotes seem to be normal.

As with many genetic diseases, the culprit is a defective **enzyme**. Afflicted homozygotes have no enzyme activity, heterozygotes have about half the normal level, and, of course, homozygous normal individuals have the full level. In the case of **Tay-Sachs disease**, the defective enzyme is **hexoseaminidase-A**, needed for proper lipid metabolism. Two heterozygotes can now know that there is a 25% chance that any child they bear will have the disease. They can make an educated decision as to whether or not to have children.