64
TWO-CHARACTER CROSS

Having satisfied himself with the test of his first law, Mendel went on to see if one characteristic influenced the way another one was inherited. He crossed plants that were pure-breeding for two different dominant traits with plants that were pure-breeding for the two opposite recessive traits.

Color titles A, B, C, D, and E (leaving A^1, B^1, C^1, and D^1 for later) and all their associated illustrations. Color the headings P_1 Phenotype and F_1 Phenotype.

As one of his experiments, Mendel *crossed* plants that were pure-breeding for *tallness* and *purple flowers* with plants that were pure-breeding for *dwarfness* and *white flowers.*

All of the plants in the first generation of offspring (F_1) showed both dominant traits, tall plant and purple flowers. None of the plants showed any recessive trait.

Color titles A^1, B^1, C^1, D^1, F, G, and H. Color the headings P_1 Genotype, P_1 Gametes, and F_1 Genotype (Dihybrid) and the associated illustrations.

Mendel reasoned that these results would be explained by his law of segregation, as illustrated by the gene symbols shown. The P_1 plants were pure-breeding, so the dominant plants must have been homozygous dominant with the genotype DDWW (P_1 genotype). (Mendel used AABB, but we are following the more common modern practice of using the first letters of the recessive traits, "d" for dwarf and "w" for white flower.) According to the law of segregation, the *genes* in each pair should separate into different *gametes.* Also, each gamete must have a gene for the height of the plant as well as a gene for the flower color, so each gamete must have one gene of each pair. Since the P_1 plants were both homozygous, every gamete of the dominant plant must therefore have one gene for each of the dominant traits (DW), while every gamete of the recessive plant must have one gene for each of the recessive traits (dw). When *cross-pollination* combined one gamete of each kind to form each new F_1 individual, the F_1 plants must all have been heterozygous for both traits (genotype DdWw).

Color the remainder of the plate as each part is discussed. Use pale colors for I, J, K, and L so as not to obscure the genotypes within the boxes.

Mendel then allowed the F_1 plants to self-pollinate. Since each of the F_1 plants is a hybrid for two characters and is in effect being crossed with itself, you will often find biology books referring to this self-pollination as a "dihybrid cross."

The F_2 generation resulting from this cross showed a ratio of nine tall plants with purple flowers (that is, both dominant traits) to three tall with white flowers (the first dominant and the second recessive) to three dwarf with purple flowers (the first recessive and the second dominant) to one dwarf with white flowers (both recessive). Mendel pointed out that this peculiar ratio of 9:3:3:1 would come about only if each of the two characters, height and flower color, were assorted into the gametes independently of each other. He summarized this in what is now called Mendel's second law, the law of independent assortment, which can be stated: "Genes for different characters assort into the gametes independently of one another."

When the F_1 individuals formed gametes, each of them must have formed four different kinds of gametes: DW, Dw, dW, and dw. With two parents each producing four different kinds of gametes, there are 16 possible pollination combinations. These are best worked out with a Punnett square as in Plate 63, since that will show every combination of one gamete from each parent.

You will note that every box labeled I has at least one dominant D gene and at least one dominant W gene. Nine of the 16 combinations fall into this category, and regardless of the second gene these plants receive for these characters, they will all be *tall* and have *purple flowers.*

Every box labeled J has at least one dominant D gene and two recessive w genes. Regardless of what the second gene for height may be, all of these will be *tall,* but they will all have *white flowers* because they are homozygous for the recessive trait. Three of the 16 possible combinations fall into this category.

Similarly, every box labeled K has two genes for dwarfness but at least one gene for purple flower, so these three combinations will produce plants that are *dwarf* with *purple flowers.*

Last, one combination (L) is homozygous recessive for both characters and will be *dwarf* with *white flowers.* All of this supports Mendel's view that genes for different characters assort independently of one another.

TWO-CHARACTER CROSS.

TALL PLANT$_A$/GENE$_{A'}$
DWARF PLANT$_B$/GENE$_{B'}$
PURPLE FLOWER$_C$/GENE$_{C'}$

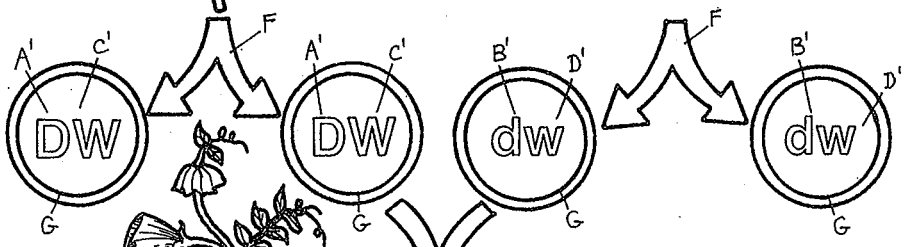
WHITE FLOWER$_D$/GENE$_{D'}$
CROSS$_E$
SEGREGATION$_F$
GAMETE$_G$
CROSS-POLLINATION$_H$

P_1 PHENOTYPE★

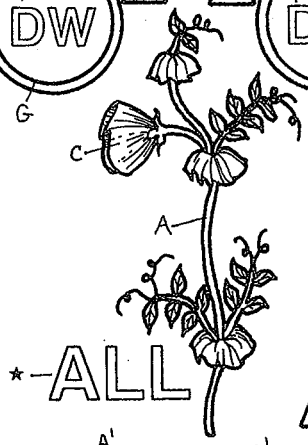
P_1 GENOTYPE★

DDWW (A' C') X E ddww (B' D')

P_1 GAMETES★



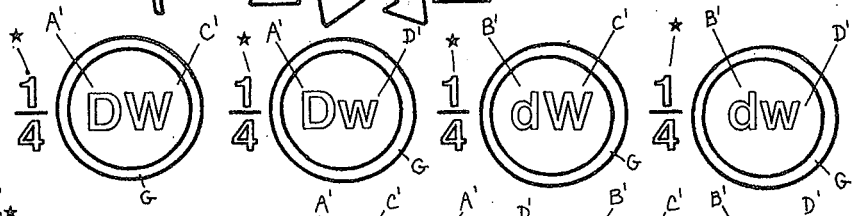
F_1 PHENOTYPE★



F_1 GENOTYPE (DIHYBRID)★

A' B' C' D'
DdWw

F_1 GAMETES★



PUNNETT SQUARE★
(F_2 GENOTYPES)★
F_2 PHENOTYPES★
TALL PURPLE$_I$
TALL WHITE$_J$
DWARF PURPLE$_K$
DWARF WHITE$_L$

	A' C' DW	A' D' Dw	B' C' dW	B' D' dw
A' C' DW	DDWW I	DDWw I	DdWW I	DdWw I
A' D' Dw	DDWw I	DDww J	DdWw I	Ddww J
B' C' dW	DdWW I	DdWw I	ddWW K	ddWw K
B' D' dw	DdWw I	Ddww J	ddWw K	ddww L

PHENOTYPIC RATIO★

9 : 3 : 3 : 1
I J K L