Mendel also worked with and crossed pea plants that differed in two characters, as is seen in the cross between a pea plant that has seeds with yellow colour and round shape and one that had seeds of green colour and wrinkled shape. Mendel found that the seeds resulting from the crossing of the parents, had yellow coloured and round shaped seeds.

Thus, yellow colour was dominant over green and round shape dominant over wrinkled. These results were identical to those that he got when he made separate monohybrid crosses between yellow and green seeded plants and between round and wrinkled seeded plants.

Let us use the genotypic symbols **Y** for dominant yellow seed colour and **y** for recessive green seed colour, **R** for round shaped seeds and **r** for wrinkled seed shape. The genotype of the parents can then be written as **RRYY** and **rryy**.

Based upon such observations on **dihybrid crosses,** Mendel proposed a second set of generalisations that we call Mendel's Law of Independent Assortment. The law states that 'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'.

Besides monohybrid crosses, Mendel also experimented on crossing varieties of peas that differed in *two* characteristics **(dihybrid crosses).** For example, he crossed two varieties of peas:

1. One homozygous variety of pea producing round seeds and yellow endosperm
2. Another homozygous variety producing wrinkled seeds and green endosperm

When he crossed the two varieties, all the F_1 progeny had round seeds and yellow endosperm.

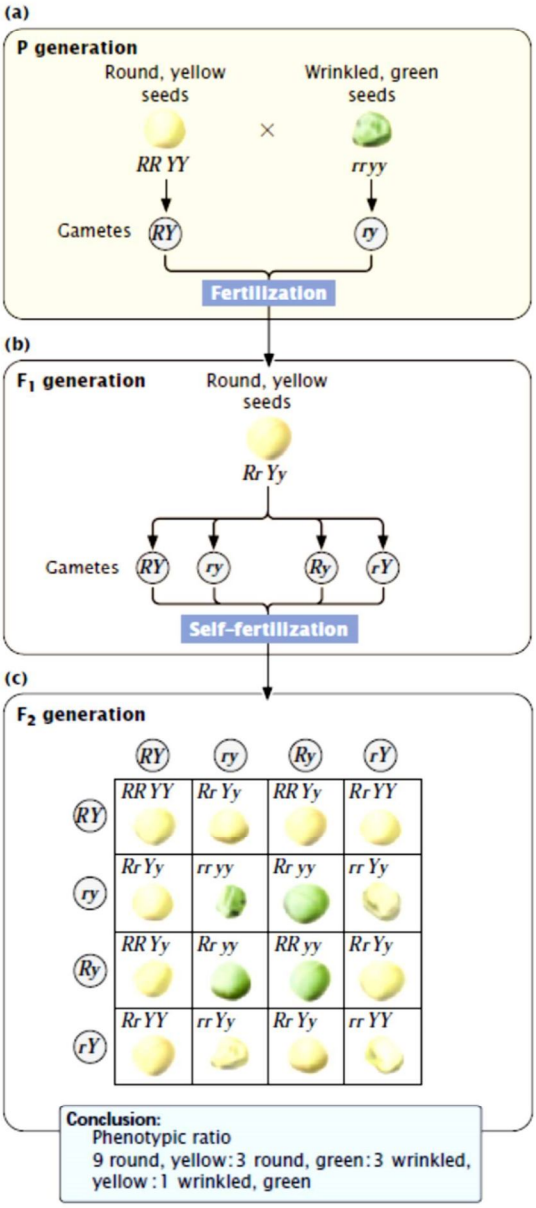
He then carried out self-fertilization experiment among the F_1 progeny and obtained the following progeny in the F_2:

Number	Seed Phenotypes	Ratios
315	round, yellow	315/556 = 9/15.88 = ≡9/16
108	round, green	108/556 = 3.08/15.88 = ≡3/16
101	wrinkled, yellow	101/556 = 2.88/15.88 = ≡3/16
32	wrinkled, green	32/556 = 0.91/15.88 = ≡1/16

Mendel recognized that these traits appeared approximately in a 9:3:3:1 ratio; that is, $^{9}/_{16}$ of the progeny were round and yellow, $^{3}/_{16}$ were wrinkled and yellow, $^{3}/_{16}$ were round and green, and $^{3}/_{16}$ were wrinkled and green.

Mendel carried out a number of dihybrid crosses for pairs of characteristics and always obtained a 9:3:3:1 ratio in the F_2. This gives Mendel's second law — the principle of independent assortment. This principle states that alleles at different loci separate independently of one another.

The principle of independent assortment is really an extension of the principle of segregation. The principle of segregation states



that the two alleles of a locus separate when gametes are formed; the principle of independent assortment states that, when these two alleles separate, their separation is independent of the separation of alleles at *other* loci.

Each plant possesses two alleles coding for each characteristic, so the parental plants must have had genotypes *RRYY* and *rryy*. The principle of segregation indicates that the alleles for each locus separate, and one allele for each locus passes to each gamete. The gametes produced by the round, yellow parent therefore contain alleles *RY,* whereas the gametes produced by the wrinkled, green parent contain alleles *ry.* These two types of gametes unite to produce the F_1, all with genotype *RrYy.* Because round is dominant over wrinkled and yellow is dominant over green, the phenotype of the F_1 will be round and yellow.

When Mendel self-fertilized the F_1 plants to produce the F_2, the alleles for each locus separated, with one allele going into each gamete. This is where the principle of independent assortment becomes important. Each pair of alleles can separate in two ways:

(1) *R* separates with *Y* and *r* separates with *y* to produce gametes *RY* and *ry* or

(2) *R* separates with *y* and *r* separates with *Y* to produce gametes *Ry* and *rY*

The principle of independent assortment tells us that the alleles at each locus separate independently; thus, both kinds of separation occur equally and all four type of gametes (*RY, ry, Ry,* and *rY*) are produced in equal proportions. When these four types of gametes are combined to produce the F_2 generation, the progeny consist of round and yellow, wrinkled and yellow, round and green, and wrinkled and green, resulting in a 9:3:3:1 phenotypic ratio.