Patterns of Inheritance

UNIT 2 CHAPTER 10

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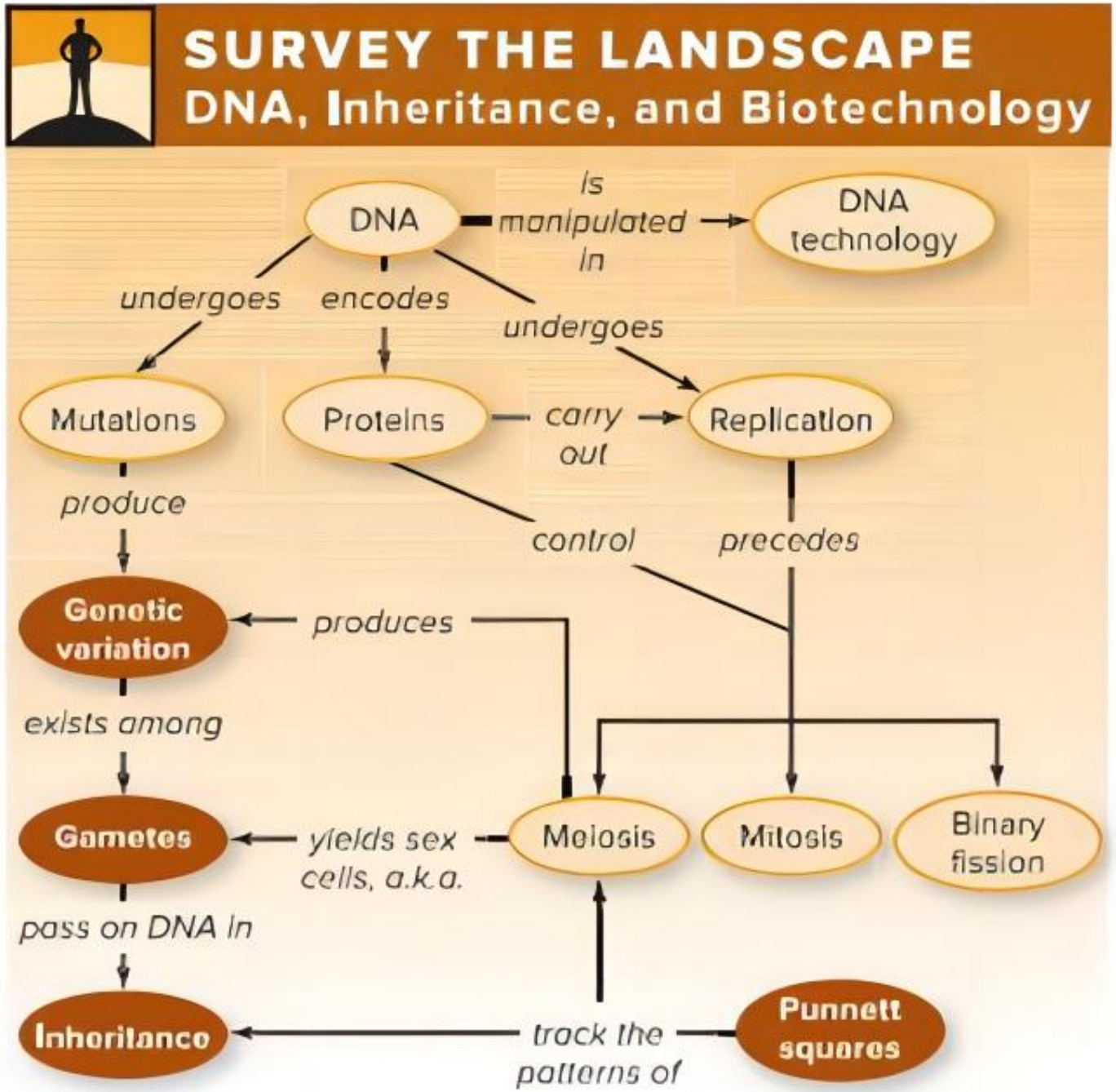
LEARNING OUTLINE (Chapter 10)

- 10.1 Chromosomes Are Packets of Genetic Information:A Review
- 10.2 Mendel's Experiments Uncovered Basic Laws of Inheritance
- 10.3 The Two Alleles of a Gene End Up in Different Gametes
- 10.4 Genes on Different Chromosomes Are Inherited Independently


SURVEY THE LANDSCAPE
DNA, Inheritance, and Biotechnology
DNA
is manipulated in
DNA technology
undergoes
encodes
undergoes
Mutations
Proteins
carry out
Replication
produce
control
precedes
Genetic variation
produces
exists among
Gametes
yields sex cells, a.k.a.
Meiosis
Mitosis
Binary fission
pass on DNA in
Inheritance
track the patterns of
Punnett squares

10.1 Chromosomes Are Packets of Genetic Information:A Review

- Human DNA includes about 25,000 genes.A gene is a portion of DNA whose sequence of nucleotides (A,C,G,and T)encodes a protein;the organism's proteins,in turn,help determine any of its characteristics.When a gene's nucleotide sequence mutates,the encoded protein—and the corresponding trait—may also change.Each gene can therefore exist as one or more alleles,or alternative forms,each arising from a different mutation.
- The DNA in the nucleus of a eukaryotic cell is divided among multiple chromosomes,which are long strands of DNA associated with proteins.Recall that a diploid cell contains two sets of chromosomes,with one set inherited from each parent.The human genome consists of 46 chromosomes,arranged in 23 pairs .Of these,22 pairs are autosomes, which are the chromosomes that are the same for both sexes.The single pair of sex chromosomes determines a person's sex:A female has two X chromosomes,whereas a male has one X and one Y.

10.1 Chromosomes Are Packets of Genetic Information:A Review

- With the exception of X and Y,the chromosome pairs are homologous .As described in chapter 9,the two members of a homologous pair of chromosomes look alike and have the same sequence of genes in the same positions.(A gene's locus is its physical place on the chromosome).But the two homologs may or may not carry the same alleles.Since each homolog comes from a different parent,each person inherits two alleles for each gene in the human genome.
- Furthermore,with the exception of identical twins,everyone inherits a unique combination of alleles for all of the genes in the human genome.

10.1 Chromosomes Are Packets of Genetic Information:A Review

- Meiosis is a specialized form of cell division that occurs in diploid germ cells and gives rise to haploid cells,each containing just one set of chromosomes. In humans,these haploid cells are gametes—sperm or egg cells.Fertilization unites the gametes from two parents,producing the first cell of the next generation.Gametes are the cells that convey chromosomes from one generation to the next,so they play a critical part in the study of inheritance.
- No one can examine a gamete and say for sure which allele it carries for every gene.As we shall see in this chapter,however,for some traits,we can use knowledge of a person's characteristics and family history to say that a gamete has a 100% chance, 50% chance, or 0% chance of carrying a specific allele.With this information for both parents, it is simple to calculate the probability that a child will inherit the allele.

10.2 Mendel's Experiments Uncovered Basic Laws of Inheritance

A. Dominant Alleles Appear to Mask Recessive Alleles

- Mendel noticed a similar mode of inheritance when he studied other pea plant characteristics:One trait seemed to obscure the other. Mendel called the masking trait dominant;the trait being masked was called recessive. Although Mendel referred to trails as dominant or recessive. Modern biologists reserve these terms for alleles.A dominant allele encodes a protein that exerts its effects whenever it is present;a recessive allele encodes a protein whose effect is masked if a dominant allele is also present. If a dominant allele is also present.When a gene has only two alleles, it is common to symbolize the dominant allele with a capital letter (such as Y for yellow)and the recessive allele with the corresponding lowercase letter (y for green).

10.2 Mendel's Experiments Uncovered Basic Laws of Inheritance

B. For Each Gene,a Cell's Two Alleles May Be Identical or Different

- Mendel chose traits encoded by genes with only two alleles,but some genes have hundreds of forms. Regardless of the number of possibilities,however,a diploid cell can have only two alleles for each gene.After all,each diploid individual has inherited one set of chromosomes from each parent,and each chromosome carries only one allele per gene.

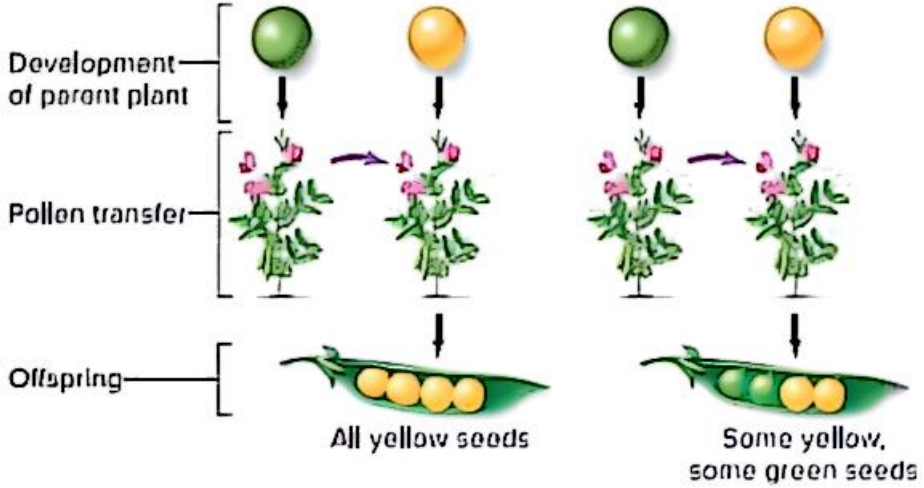


Figure 10.4 **Yellow Is Dominant.** When Mendel crossed a plant derived from a green seed with a plant grown from a yellow seed, the offspring could be all yellow, or they could be a mix of green and yellow peas. Crosses such as these led Mendel to conclude that yellow seed color is dominant over green.

10.2 Mendel's Experiments Uncovered Basic Laws of Inheritance

B. For Each Gene,a Cell's Two Alleles May Be Identical or Different

- For a given gene,a diploid cell's two alleles may be identical or different.The genotype expresses the genetic makeup of an individual,and it is written as a pair of letters representing the alleles.

- An individual that is homozygous for a gene has two identical alleles, meaning that both parents contributed the same gene version. If both of the alleles are dominant,the individual's genotype is homozygous dominant (written as YY,for example). If both alleles are recessive,the individual is homozygous recessiveoy). An individual with a heterozygous genotype,on the other hand,has two different alleles for the gene (Yy).That is,the two parents each contributed different genetic information.

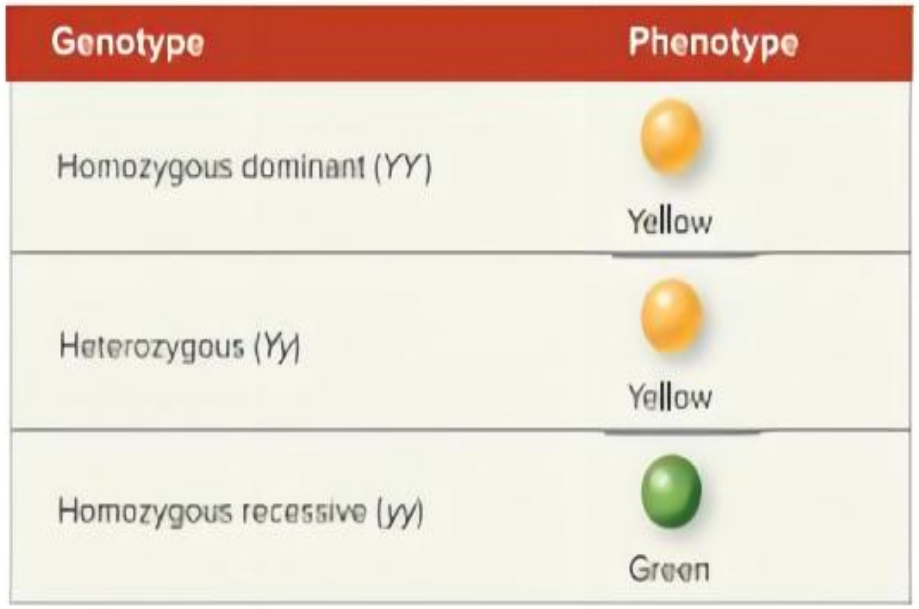


Figure 10.5 Genotypes and Phenotypes Compared. A pea's genotype for the "seed color" gene consists of the two alleles that the seed inherited from its parents. Its phenotype is its outward appearance: yellow or green.

10.2 Mendel's Experiments Uncovered Basic Laws of Inheritance

B. For Each Gene,a Cell's Two Alleles May Be Identical or Different

- The organism's genotype is distinct from its phenotype,or observable characteristics. Seed color,flower color,and stem length are examples of pea plant phenotypes that Mendel studied.Your own phenotype includes not only your height, eye color, shoe size, number of fingers and toes,skin color,and hair texture but also other traits that are not readily visible, such as your blood type or the specific shape of your hemoglobin proteins. Most phenotypes result from a complex interaction between genes and environment. Mendel, however, chose traits controlled exclusively by genes, Mendel's observation that some but not all yellow-seeded pea plants were true-breeding arises from the two possible genotypes for the yellow phenotype (homozygous dominant and heterozygous). All homozygous plants are true-breeding because all of their gametes contain the same allele. Heterozygous plants, however, are not true-breeding because they may pass on either the dominant or the recessive allele.These plants are hybrids.

10.3 The Two Alleles of a Gene End Up in Different Gametes

- Mendel used a systematic series of crosses to deduce the rules of inheritance, beginning with single genes.

The Simplest Punnett Squares Track the Inheritance of One Gene

- Mendel began with a P generation consisting of true-breeding plants derived from yellow seeds (YY)and true-breeding green-seeded plants (yy).The F1 offspring produced in this cross had yellow seeds (genotype Yy). The green trait therefore seemed to disappear in the F1 generation.
- Next,he used the F1, plants to set up a monohybrid cross: a mating between two individuals that are both heteruzygous for the same gene .The resulting F1 generation had both yellow and green phenotypes, in a ratio of 3:1; that is, for every three yellow seeds, he observed one green seed.

10.3 The Two Alleles of a Gene End Up in Different Gametes

- A Punnett square is a diagram that uses the genotypes of two parents to reveal which allele combinations their offspring may inherit.The Punnett square, for example, shows how the green phenotype reappeared in the F2 generation. Both parents are heterozygous (Yy) for the seed-color gene.Each therefore produces some gametes carrying the Y allele and some gametes carrying y. All three possible genotypes may therefore appear in the F2 generation,in the ratio 1 YY:2 Yy:l yy.The corresponding phenotypic ratio is three yellow seeds to one green seed,or3:1

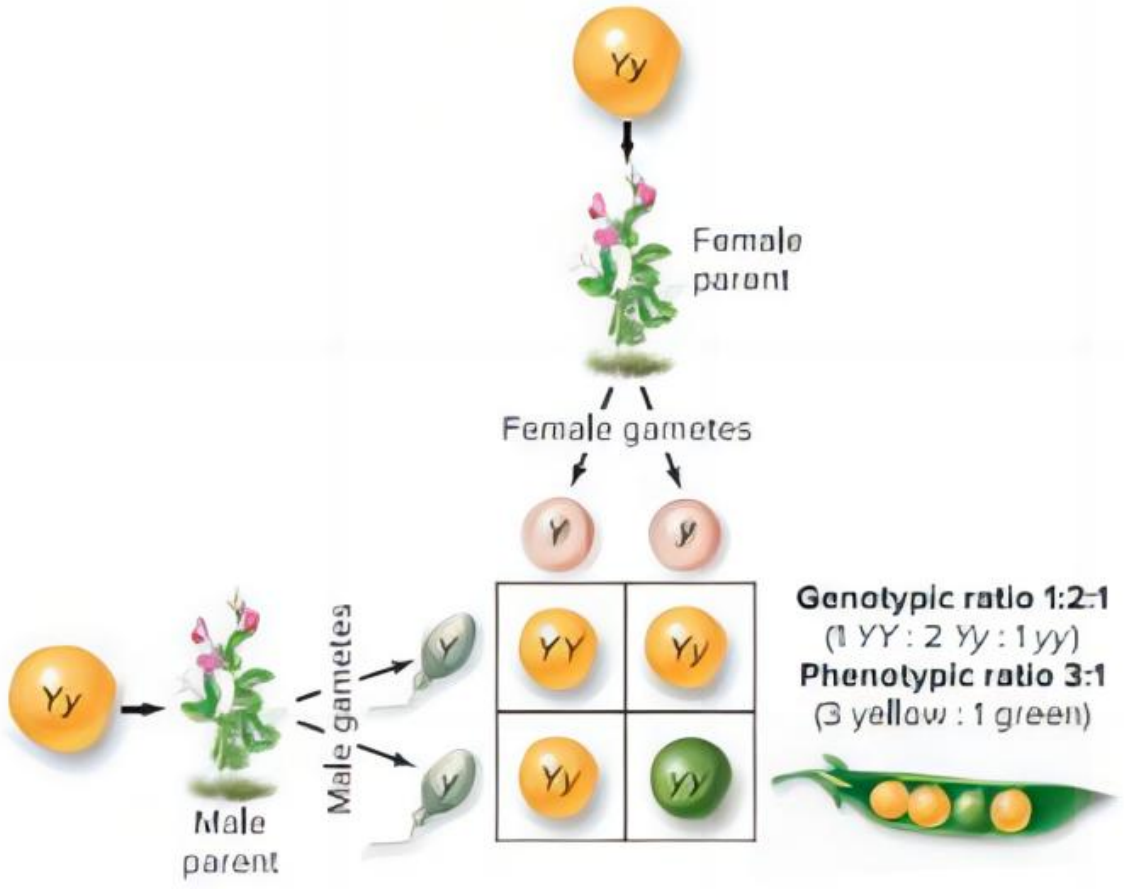


Figure 10.6 Punnett Square. This diagram depicts Mendel's monohybrid cross of two heterozygous plants grown from yellow seeds (*Yy*). The two possible types of female gametes are listed along the top of the square; the male gametes are listed on the left-hand side. The four compartments within the Punnett square contain the genotypes and phenotypes of all possible offspring.

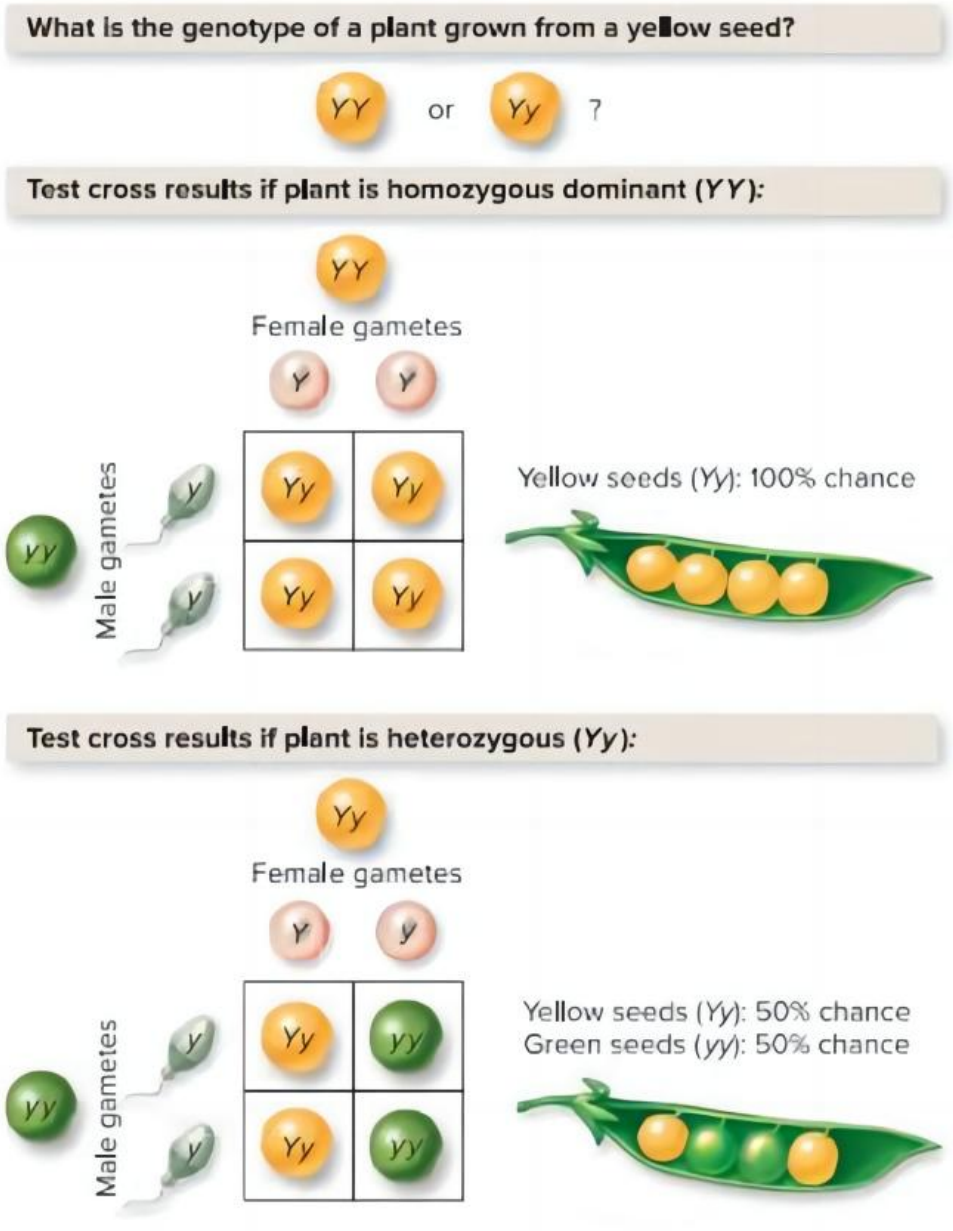


Figure 10.8 **Test Cross.** A test cross with a homozygous recessive (*yy*) plant reveals whether a pea plant grown from a yellow seed is homozygous dominant (*YY*) or heterozygous (*Yy*).

- Mendel's law of segregation arose from his studies of the inheritance of single traits. He next asked himself whether the same law would apply if he followed two characters at the same time. Mendel therefore began another set of breeding experiments in which he simultaneously examined the inheritance of two characteristics: pea shape and pea color.

Figure It Out

- If Mendel mated a true-breeding tall plant with a heterozoygous tall plant. what percentage of the offspring would also be tall?

10.3 The Two Alleles of a Gene End Up in Different Gametes

A.Tracking Two-Gene Inheritance May Require Large Punnett Squares

- A pea's shape may be round or wrinkled (determined by the R gene,with the dominant allele specifying round shape).At the same time,its color may be yellow or green (determined by the Y gene,with the dominant allele specifying yellow). As he did before,Mendel began with a P generation consisting of true-breeding parents. He crossed plants grown from wrinkled,green seeds with plants derived from round, yellow seeds. All F1offspring were heterozygous for both genes(Rr Yy)and therefore had round,yellow seeds.
- Next, Mendel crossed the F1plants with each other. A dihybrid cross is a mating between two individuals that are each heterozygous for the same two genes .Each Rr Yy individual in the F,generation produced equal numbers of gametes of four different types:R Y,Ry,r Y,and ry. After Mendel completed the crosses,he found four phenotypes in the F^2generation,reflecting all possible combinations of seed shape and color.The Punnett square predicts that the four phenotypes will occur in a ratio of 9:3:3:1.That is,9 of 16 offspring should have round,yellow seeds;3 should have round,green seeds;3 should have wrinkled,yellow seeds;and just I should have wrinkled,green seeds.This prediction almost exactly matches Mendel's results.

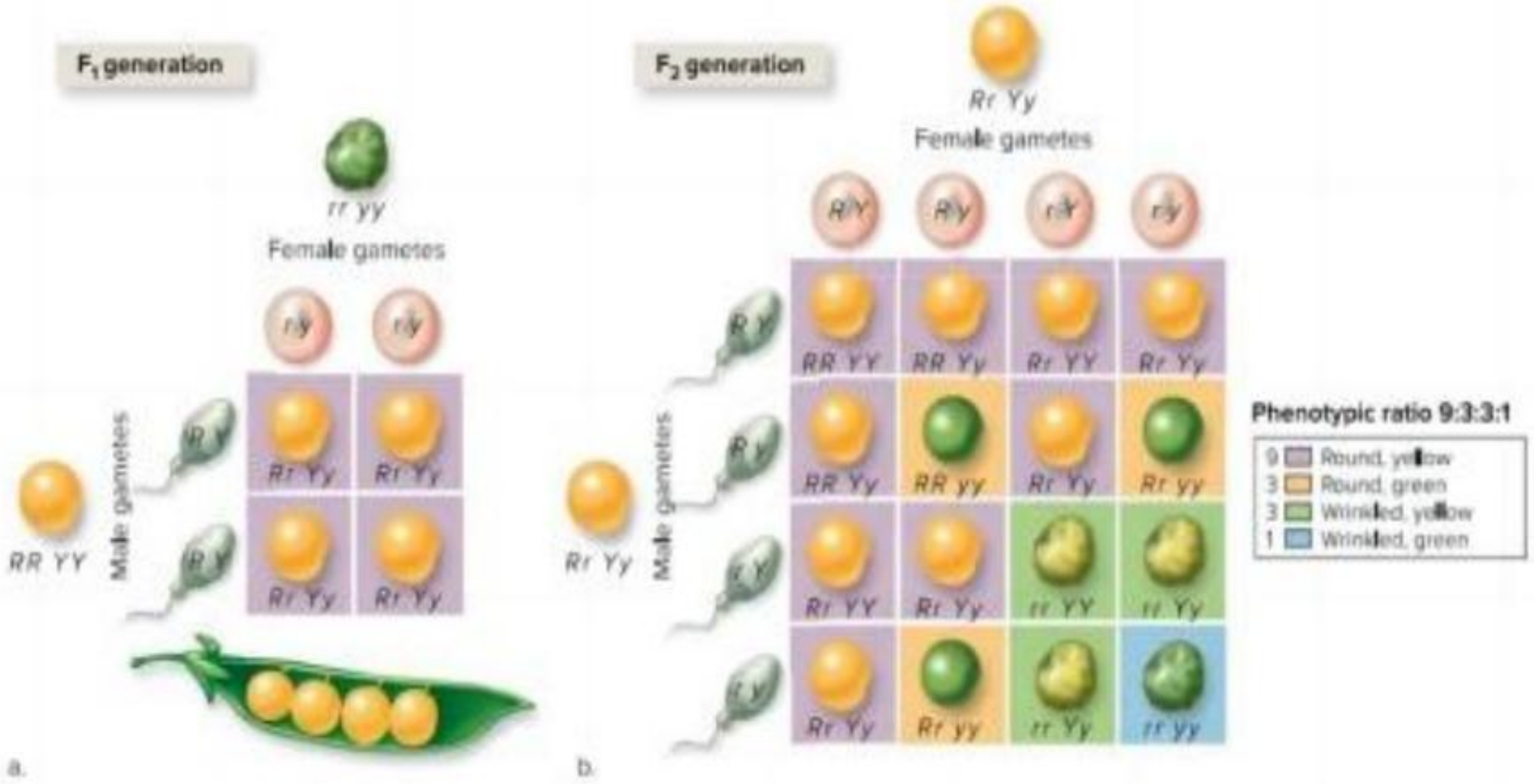


Figure 10.11 Generating a Dihybrid Cross. (a) In the parental generation, one parent is homozygous recessive for two genes; the other is homozygous dominant. The F_1 generation is therefore heterozygous for both genes. (b) A dihybrid cross is a mating between two plants from the F_1 generation. Phenotypes occur in a distinctive ratio in the resulting F_2 generation.

B.Meiosis Explains Mendel'sLaw of Independent Assortment

Based on the results of the dihybrid cross,Mendel proposed a second law of inheritance.The law of independent assortment states that during gamete formation, the alleles for one gene do not influence the alleles for another gene. That is, alleles Y and y are randomly packaged into gametes,independent of alleles R and r. With this second set of experiments,Mendel had again inferred a principle of inheritance based on meiosis.

C. The Product Rule Is a Useful Shortcut

- Punnett squares become cumbersome when analyzing more than two genes.A Punnett square for three genes has 64 boxes;for four genes,256 boxes.Fortunately,there is a shortcut that still relies on the rules of probability on which Punnett squares are based. According to the product rule,the probability that multiple independent events will occur simultaneously can be calculated by multiplying the chances of each event occurring alone.
- As an example,the product rule can predict the chance of obtaining wrinkled,green seeds (rr yy) from dihybrid (Rr Yy) parents.The probability that two Rr plants will produce rr offspring is 25%, or 1/4, and the chance of two Yy plants producing a yy individual is 1/4. According to the product rule,the chance of dihybrid parents (Rr Yy) producing homozygous recessive (rr yy) offspring is therefore 1/4 multiplied by 1/4,or 1/16. Now consult the 16-box Punnett square for Mendel'sdihybrid cross . As expected,only 1 of the 16 boxes contains rr yy.

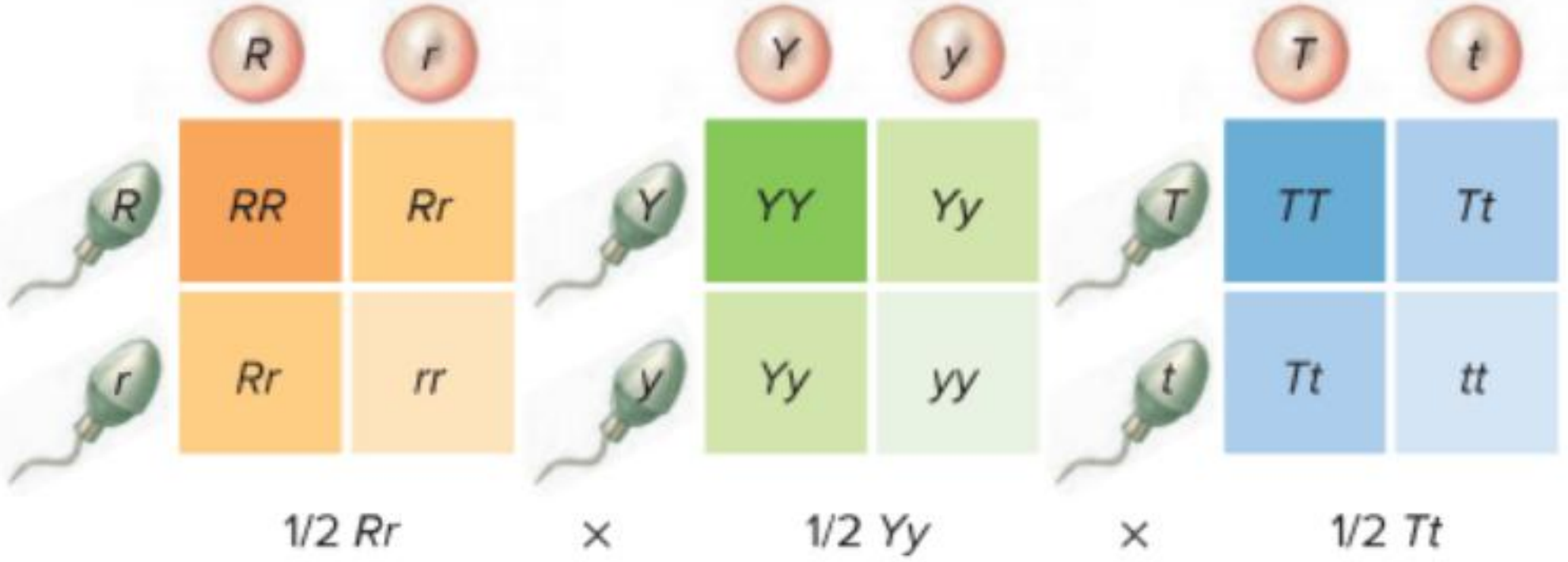


Figure 10.13 The Product Rule. What is the chance that two parents that are heterozygous for three genes (*Rr Yy Tt*) will give rise to an offspring with that same genotype? To find out, multiply the individual probabilities for each gene.

Team Work

According to the ABO classification system, the phenotype of human blood is IA IB, and the recessive one is i. A Type : IAIA, IAi; B Type : IBIB, IBi; AB Type : IA IB ; O Type : i iA father with type A blood and a mother with type B blood, t heir child with O type?

What happened? Use Punnett square to demostrate the rules and probability.

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