combinations. From these genotypes, we infer a phenotypic ratio of 9 round/yellow:3 round/green:3 wrinkled/yellow:1 wrinkled/green (Figure 9.8). These are the offspring ratios we would expect, assuming we performed the crosses with a large enough sample size. The law of independent assortment also indicates that a cross between yellow, wrinkled (*YYrr*), and green, round (*yyRR*) parents would yield the same F_1 and F_2 offspring as in the *YYRR* x *yyrr* cross.

The physical basis for the law of independent assortment can be explained by events that occur in meiosis I (Figure 9.9). Recall, during metaphase I of meiosis I the different homologous pairs line up arbitrarily on the metaphase plate, termed independent assortment. Which chromosome, paternal or maternal, will align on what side of the metaphase plate is unknown and leads to several different possible genetic arrangements (Figure 9.9). During anaphase I of meiosis I, homologous chromosomes are separated, and each gamete can contain any combination of both paternal and maternal chromosomes.

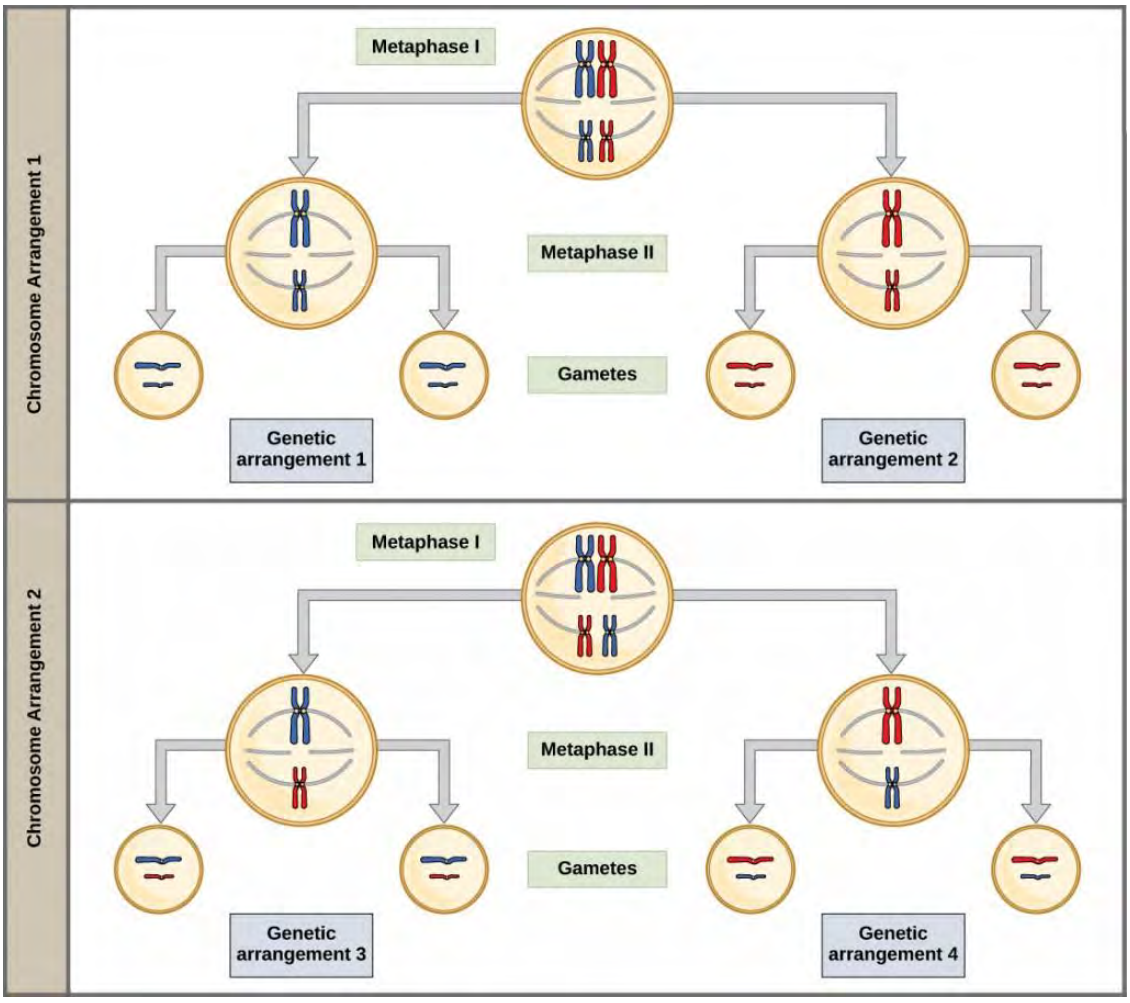

Figure 9.9 The random segregation into daughter nuclei that happens during the first division in meiosis can lead to a variety of possible genetic arrangements. (credit: Fowler et al. / Concepts of Biology OpenStax)

Check your knowledge

In pea plants, purple flowers (*P*) are dominant to white (*p*), and yellow peas (*Y*) are dominant to green (*y*). What are the possible genotypes and phenotypes for a cross between *PpYY* and *ppYy* pea plants?

Answer: The possible genotypes are PpYY, PpYy, ppYY, and ppYy. The former two genotypes would result in plants with purple flowers and yellow peas, while the latter two genotypes would result in plants with white flowers with yellow peas, for a 1:1 ratio of each phenotype.

Pedigrees

Mendel chose a model organism, the common garden pea plant, that he could easily manipulate through cross-fertilizations. This allowed him to observe and track different characteristics from one generation to the next. Humans also have characteristics that are genetically inherited. However, doing cross-fertilizations in humans is both unethical and impractical. Instead, geneticists can use a **pedigree** to study inheritance patterns of human genetic characteristics (Figure 9.10). A pedigree is chart used to study inheritance patterns of genetic characteristics.

How can a pedigree be used to study inheritance patterns? Let's look at an example of a recessive disorder, alkaptonuria, in which two amino acids, phenylalanine and tyrosine, are not properly metabolized (Figure 9.10). Individuals that have this condition may have darkened skin and brown urine. They may also suffer joint damage and other complications.

When looking at or generating a pedigree, phenotypic females are represented by circles, and phenotypic males are represented by squares. A horizontal line connecting a phenotypic male and a phenotypic female indicates a mating event. A vertical line represents any offspring that result from a mating event. In the pedigree below, individuals with the disorder are shown by solid blue circles or squares. Because we know the inheritance pattern of Alkaptonuria is autosomal recessive, we also know these affected individuals have the genotype *aa*. Unaffected individuals are indicated by unshaded or white circles or squares and have either genotype *AA* or *Aa*. Sometimes it is not possible using a pedigree to determine whether a person is *AA* or *Aa,* and in these cases, the genotype can be denoted as *A_* or by writing out both possibilities, "*AA* or *Aa*". Note that it is often possible to determine a person's genotype from the genotype of their offspring. For example, if neither parent has the disorder, but their child does, then both parents must be heterozygous for the gene to be passed down.

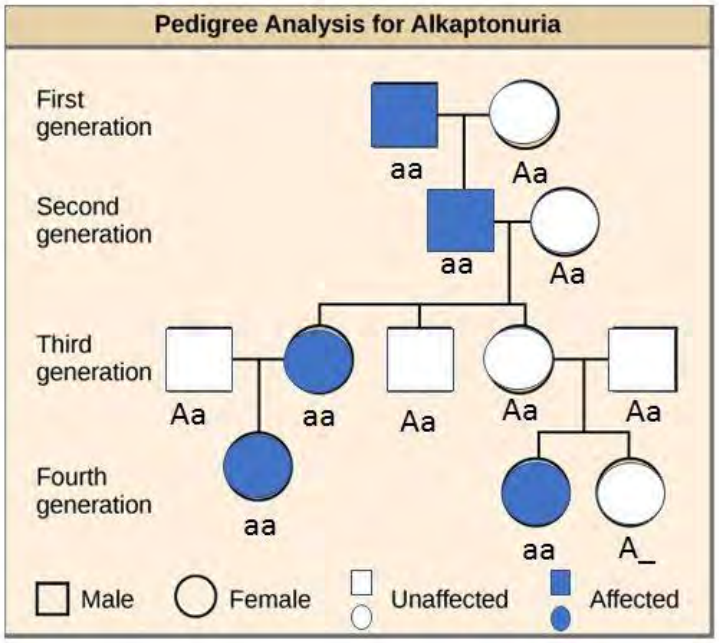

Figure 9.10 A pedigree is showing the recessive genetic disorder, alkaptonuria. (credit: Modified by Elizabeth O'Grady original work of Clark et al. / Biology 2E OpenStax)

Pedigrees can be generated by observing traits of individuals within a family or by looking for the gene using molecular biology techniques. In either case, pedigrees allow geneticists to look at patterns of inheritance within a family and predict genotypic probabilities.

Check your knowledge

In a pedigree, you are evaluating a filled in circle. Which best describes this person?

a. Phenotypic male who is unaffected
b. Phenotypic female who is unaffected
c. Phenotypic female who is affected
d. Phenotypic male who is affected

Punnet square: What is the genotype of the parents if all the offspring are dominant?

Answers: (c) and If all the offspring are dominant, at least one of the parents must be homozygous dominant for the trait. The second parent could be any genotype.