

## POLYGENIC INHERITANCE

The term “polygenic inheritance” is used to refer to the inheritance of quantitative traits, traits which are influenced by multiple genes, not just one. In addition to involving multiple genes, polygenic inheritance also looks at the role of environment in someone's development.

Because many traits are spread out across a continuum, rather than being divided into black and white differences, polygenic inheritance helps to explain the way in which these traits are inherited and focused. A related concept is [pleiotropy](#), an instance where one gene influences multiple traits.

Early Mendelian [genetics](#) focused on very simple genetic traits which could be explained by a single gene. For example, a flower might appear in either orange or yellow form, with no gradation between the colors. By studying plants and the ways in which they mutated, early researchers were able to learn more about the gene which determined flower color. However, by the early twentieth century, people were well aware that most traits are far too complex to be determined by a single gene, and the idea of polygenic inheritance was born.

One easily understood example of polygenic inheritance is height. People are not just short or tall; they have a variety of heights which run along a spectrum. Furthermore, height is also influenced by environment; someone born with tall genes could become short due to [malnutrition](#) or illness, for example, while someone born with short genes could become tall through genetic therapy. Basic genetics obviously wouldn't be enough to explain the wide diversity of human heights, but polygenic inheritance shows how multiple genes in combination with a person's environment can influence someone's [phenotype](#), or physical appearance.

Skin color is another example of polygenic inheritance, as are many congenital diseases. Because polygenic inheritance is so complex, it can be a very absorbing and frustrating field of

study. Researchers may struggle to identify all of the genes which play a role in a particular phenotype, and to identify places where such genes can go wrong. However, once researchers do learn more about the circumstances which lead to the expression of particular traits, it can be a very rewarding experience.

In pleiotropy, on the other hand, *one* gene is responsible for multiple things. Several congenital syndromes are examples of pleiotropy, in which a flaw in one gene causes widespread problems for a person. For example, sickle cell [anemia](#) is a form of pleiotropy, caused by a distinctive mutation in one gene which leads to a host of symptoms. In addition to causing mutations, pleiotropy also occurs in perfectly normal genes, although researchers tend to use it to track and understand mutations in particular.

## **INHERITANCE**

The acquisition of traits, characteristics and disorders from parents to their children by transmission of genetic information. Genes come in pairs: one originating from the father, the other from the mother. If an individual presents only the hereditary characteristics determined by one gene of the pair on an autosomal chromosome, that gene is called **dominant**. Conditions caused by such genes are said to show **autosomal dominant inheritance**.

If the individual does not present the hereditary characteristics unless both genes in a pair are of the same type, then the gene is called **recessive**. Conditions caused by such genes are said to show **autosomal recessive inheritance**.

## **Mendel's Laws**

Mendel discovered that when crossing white flower and purple flower plants, the result is not a blend. Rather than being a mix of the two, the offspring was purple flowered. He then conceived the idea of heredity units, which he called "factors", one of which is a recessive characteristic and the other dominant. Mendel said that factors, later called genes, normally occur in pairs in ordinary body cells, yet segregate during the formation of sex cells. Each member of the pair becomes part of the separate sex cell. The dominant gene, such as the purple flower in Mendel's plants, will hide the recessive gene, the white flower. After Mendel self-fertilized the F1 generation and obtained the 3:1 ratio, he correctly theorized that genes can be paired in three different ways for each trait: AA, aa, and Aa. The capital "A" represents the dominant factor and lowercase "a" represents the recessive. (The last combination listed above, Aa, will occur roughly twice as often as each of the other two, as it can be made in two different ways, Aa or aA.)

Mendel stated that each individual has two factors for each trait, one from each parent. The two factors may or may not contain the same information. If the two factors are identical, the individual is called homozygous for the trait. If the two factors have different information, the individual is called heterozygous. The alternative forms of a factor are called alleles. The genotype of an individual is made up of the many alleles it possesses. An individual's physical appearance, or phenotype, is determined by its alleles as well as by its environment. An individual possesses two alleles for each trait; one allele is given by the female parent and the other by the male parent. They are passed on when an individual matures and produces gametes: egg and sperm. When gametes form, the paired alleles separate randomly so that each gamete

receives a copy of one of the two alleles. The presence of an allele doesn't promise that the trait will be expressed in the individual that possesses it. In heterozygous individuals the only allele that is expressed is the dominant. The recessive allele is present but its expression is hidden.

Mendel summarized his findings in two laws; the **Law of Segregation** and the **Law of Independent Assortment**.

### **Law of Segregation (The "First Law")**

The Law of Segregation states that when any individual produces gametes, the copies of a gene separate so that each gamete receives only one copy. A gamete will receive one allele or the other. The direct proof of this was later found following the observation of [meiosis](#) by two independent scientists, the German botanist, Oscar Hertwig in 1876, and the Belgian zoologist, Edouard Van Beneden in 1883. In meiosis, the paternal and maternal chromosomes get separated and the alleles with the traits of a character are segregated into two different gametes.

OR

The two coexisting alleles of an individual for each trait segregate (separate) during gamete formation so that each gamete gets only one of the two alleles. Alleles again unite at random fertilization of gametes.

### **Law of Independent Assortment (The "Second Law")**

The Law of Independent Assortment, also known as "Inheritance Law" states that alleles of different genes assort independently of one another during gamete formation. While Mendel's experiments with mixing one trait always resulted in a 3:1 ratio (Fig. 1) between dominant and

recessive phenotypes, his experiments with mixing two traits (dihybrid cross) showed 9:3:3:1 ratios

## **BREEDING**

**Plant breeding** is the art and science of changing the genetics of [plants](#) for the benefit of mankind.<sup>[1]</sup> Plant breeding can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics for propagation, to more complex molecular techniques.

**Animal breeding** is a branch of [animal science](#) that addresses the evaluation (using [best linear unbiased prediction](#) and other methods) of the genetic value (estimated breeding value, EBV) of domestic livestock. Selecting animals for breeding with superior EBV in growth rate, egg, meat, milk, or wool production, or have other desirable traits has revolutionized agricultural livestock production throughout the world.

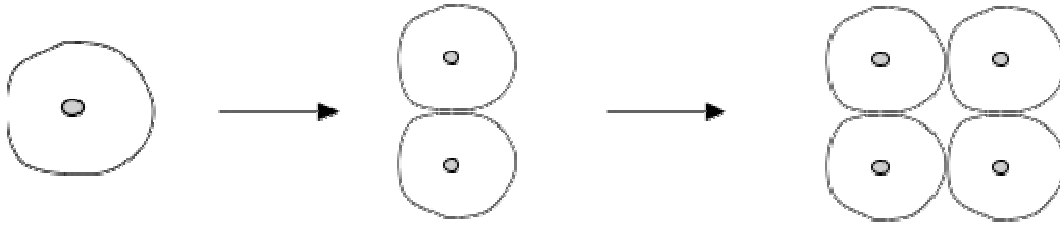
### **The two methods of reproduction**

**Asexual reproduction** means reproducing without the interaction of two sexes or genders, whereas **sexual reproduction** involves the fusion of two special cells called **gametes**, one from a **male** source and one from a **female** source.

### **Asexual reproduction**

Before a cell divides, its nucleus divides. Each chromosome is copied, and each nucleus receives the same genetic material: genes, made of DNA.

As each cell divides into two, the resulting "daughter" cells are therefore exact copies of one another.



This process is responsible for the increase in number of cells which occurs during **normal growth and development**, and when tissues are replaced following injury.

Normal cell division is also the basis for **asexual reproduction**. Only one type of cell is involved, with no input from another individual. Because no new genetic material is introduced, there is no variation in the resulting offspring.

Since the offspring from this process contain the same genetic material as one another (and the same as the original single parent), they can be described as a **clone**.

### **Examples of asexual reproduction**

#### *Asexual reproduction in plants*



There are many examples of asexual reproduction in plants, e.g. the spider plant *Chlorophytum* which produces plantlets on stolons branching from buds in the parent plant. These are genetically identical and will grow to look alike, provided that they are raised in the same environment.

What features of the plant's environment would be need to be standardised (for them to look the same)?

Many plants used for food can be **propagated**, i.e increased in number, by the method of asexual reproduction.

Note: Do not confuse asexual reproduction with (sexual) reproduction in flowering plants, which often combine both male and female parts in the same flower.

**Fruits** and **seeds** are produced as a result of **sexual reproduction**.

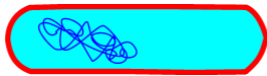
Some parts of plants become enlarged as a result of normal cell division and this is called **vegetative growth**. This is often linked with surviving adverse weather conditions and keeping food reserves for the plant in order to grow again the next season. These plants are called **vegetables**, and Man often uses these reserves for himself.

Each of the examples of food plants below use asexual and sexual reproduction in different ways





*Asexual reproduction in bacteria*



Bacteria reproduce asexually by a simpler process known as **binary fission**.

*Asexual reproduction in animals*



Asexual reproduction is much less common in animals, but it is often seen in simpler animals e.g. *Hydra*.

Identical twins are produced by a form of asexual reproduction when the ball of cells making up the embryo breaks into two, and each implants in the uterus and grows independently (after the normal sexual form of reproduction, obviously!)

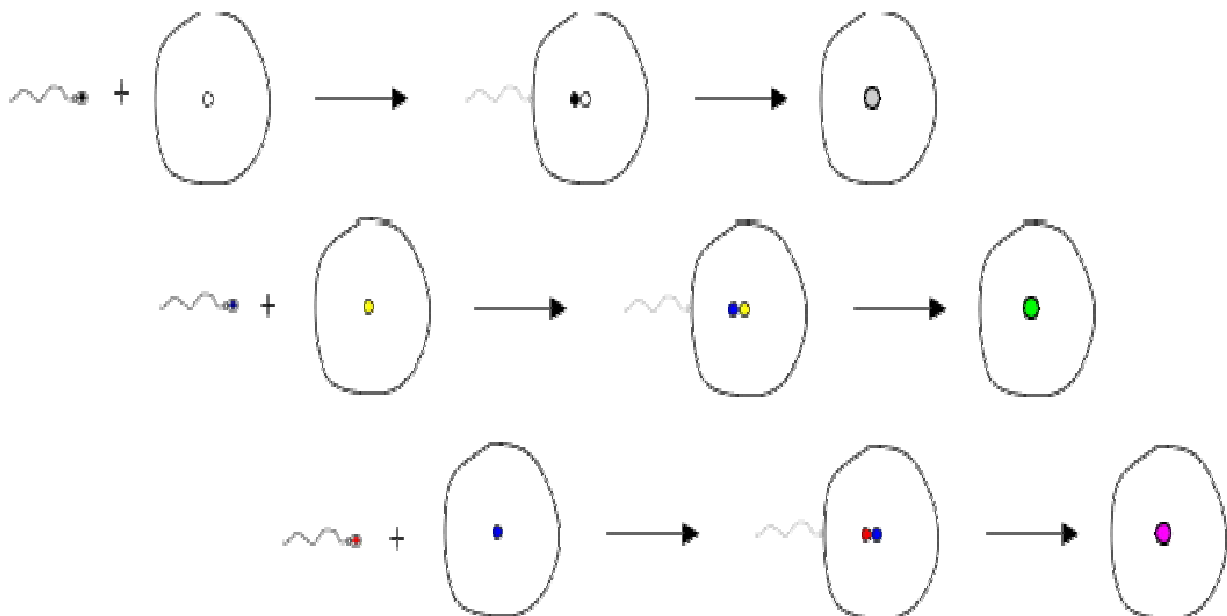
In animal lifecycles, asexual reproduction sometimes alternates with sexual reproduction.

### ***Sexual reproduction***

Both male and female sex cells (sperms and eggs in animals, pollen and ovules in plants) are produced by a special cell division process which halves the number of chromosomes in each resulting cell. The chromosome separation process ensures that each sex cell has a **unique combination of genes** in its nucleus.

Fertilisation is also a **random process** and so when the nuclei fuse the resulting fertilised egg (zygote) has an individual genetic makeup.

In contrast to asexual reproduction, sexual reproduction introduces **variation** into offspring. This is an essential feature in order for **evolution** to take place.



## Further development after fertilisation

This zygote then divides again and again using the normal process of cell division, producing cells containing genes which are exact copies of the original. So each cell of the embryo, and the adult organism into which it develops, contains cells which are genetically identical. This is fortunate because the body's immune system will target any "foreign" cells (normally invading microbes) which differ from the others.

However as each organ develops, the cells within it (collectively known as tissues) become **specialised** for their particular tasks, e.g. muscle cells, nerve cells, red and white blood cells, and they "read" and use only part of their genetic information to do this.

As they have **differentiated** into these different cell types, it appears that they have lost the ability to divide again into other cell types. A few unspecialised cells (e.g. stem cells) retain the ability to do this.

## Summary of differences

	<b>Asexual reproduction</b>	<b>Sexual reproduction</b>
Number of parents	1 (either male or female)	2 (male and female)
Makeup of offspring	genetically identical (to parent and other offspring)	genetically different
Cell division process	normal cell division following nuclear division (by mitosis)	special cell division following nuclear division (by meiosis) producing sex cells (gametes): after fertilization subsequent divisions: normal
Advantages	quick - good for bulking up of	produces variation - the basis of evolution

	numbers to colonise new areas	
Disadvantages	disease may affect all	slower - needs special processes to bring together gametes and protect zygote, embryo etc during development
Life cycle	useful when conditions ideal for growth	may be synchronised with (end of ?) growing season

Reference: [http://www.biotopics.co.uk/genes1/asexual\\_and\\_sexual\\_reproduction.html](http://www.biotopics.co.uk/genes1/asexual_and_sexual_reproduction.html)