Quantitative Genetics

Polygenic Inheritance

discontinuous variation.

continuous variation,

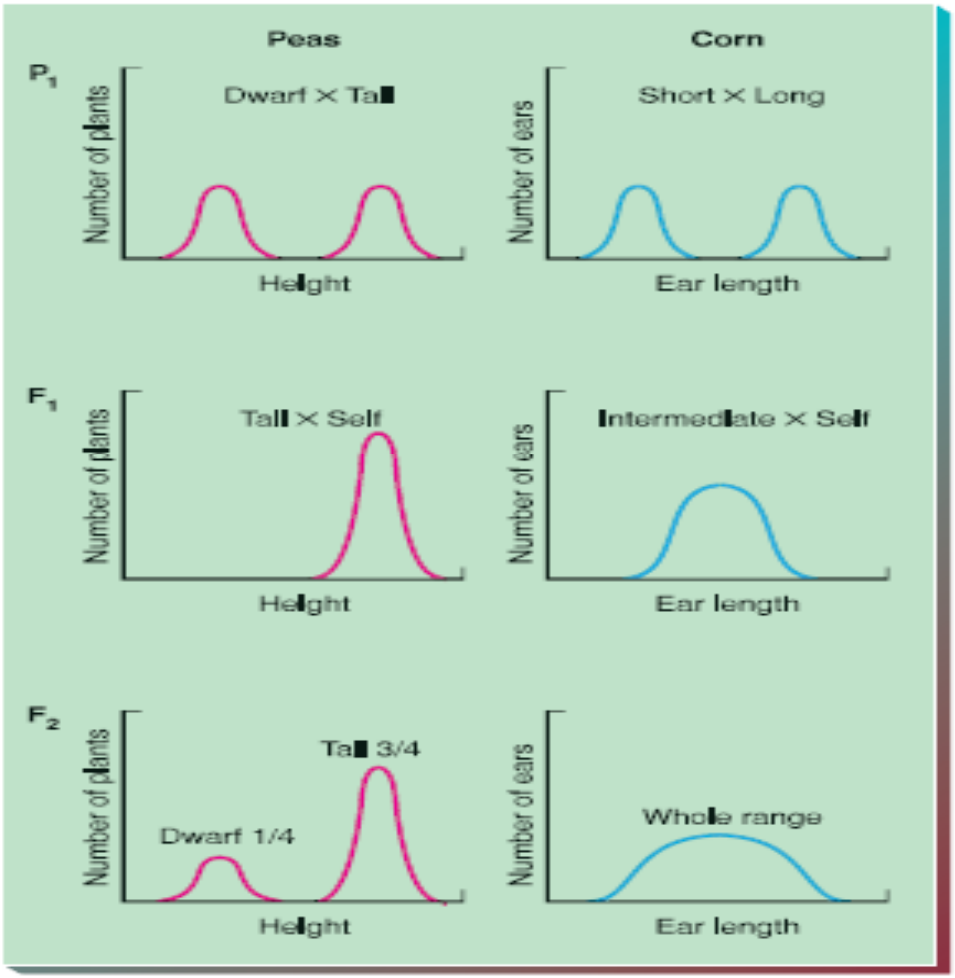


Figure 18.1 Comparison of continuous variation (ear length in corn) with discontinuous variation (height in peas).

Polygenic Inheritance

Traits exhibiting continuous variation are usually controlled by two or more genes.

All of the genes influencing the phenotype have an **additive effect** on the phenotype: each gene adds to the phenotype.

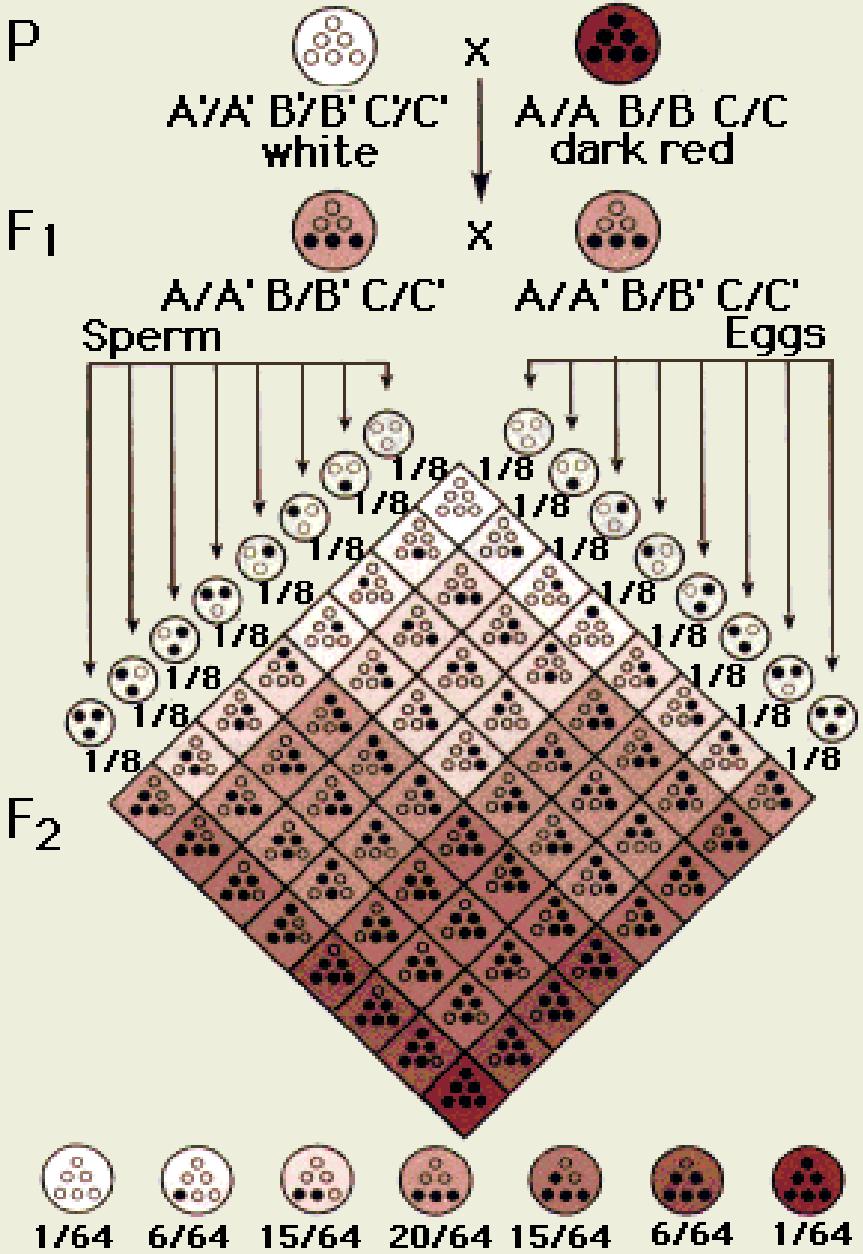
This effect can be quantified.

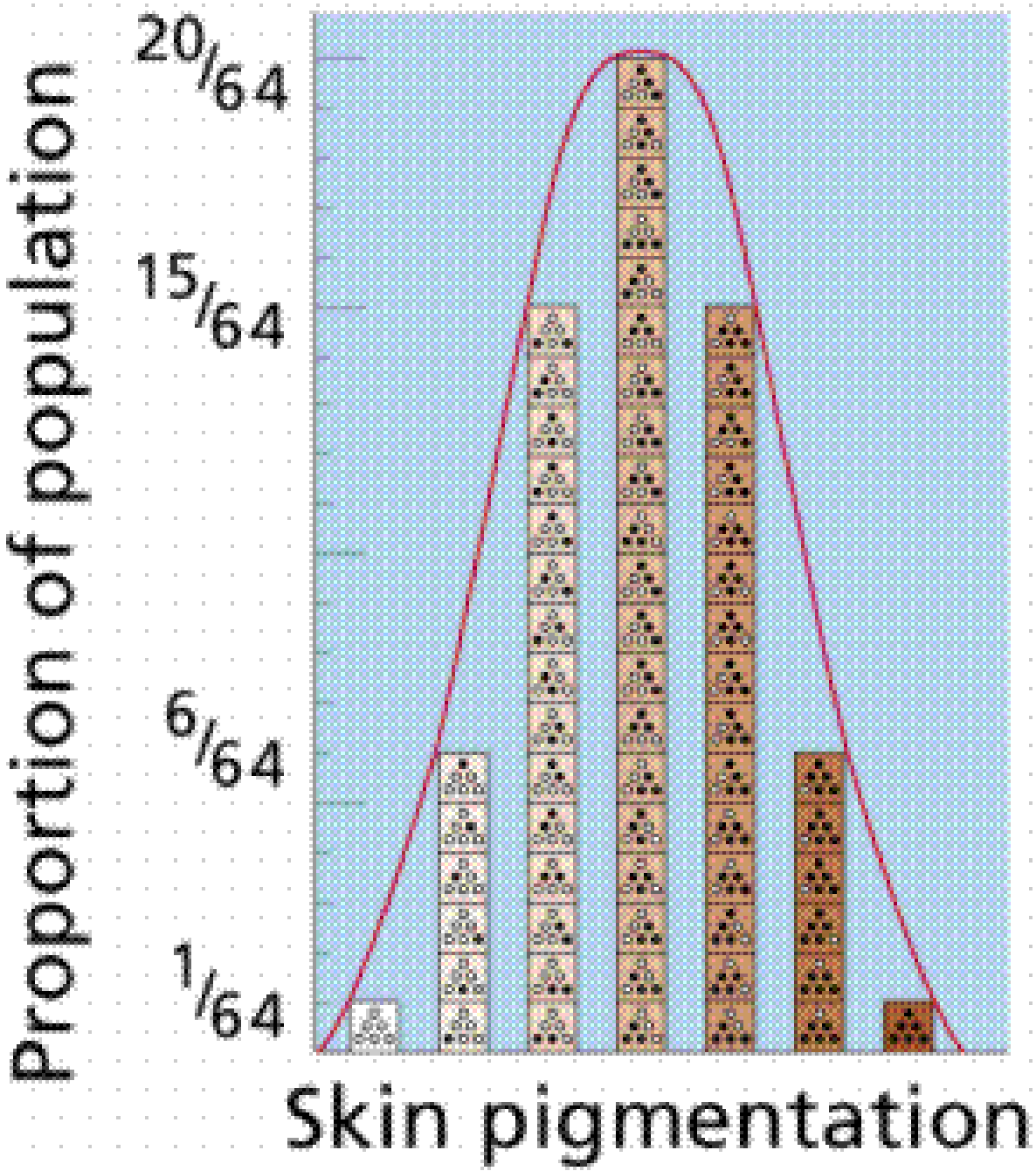
Polygenic Inheritance

An example: wheat berry color.

Cross true-breeding plants with white berries to true-breeding plants with dark red berries.

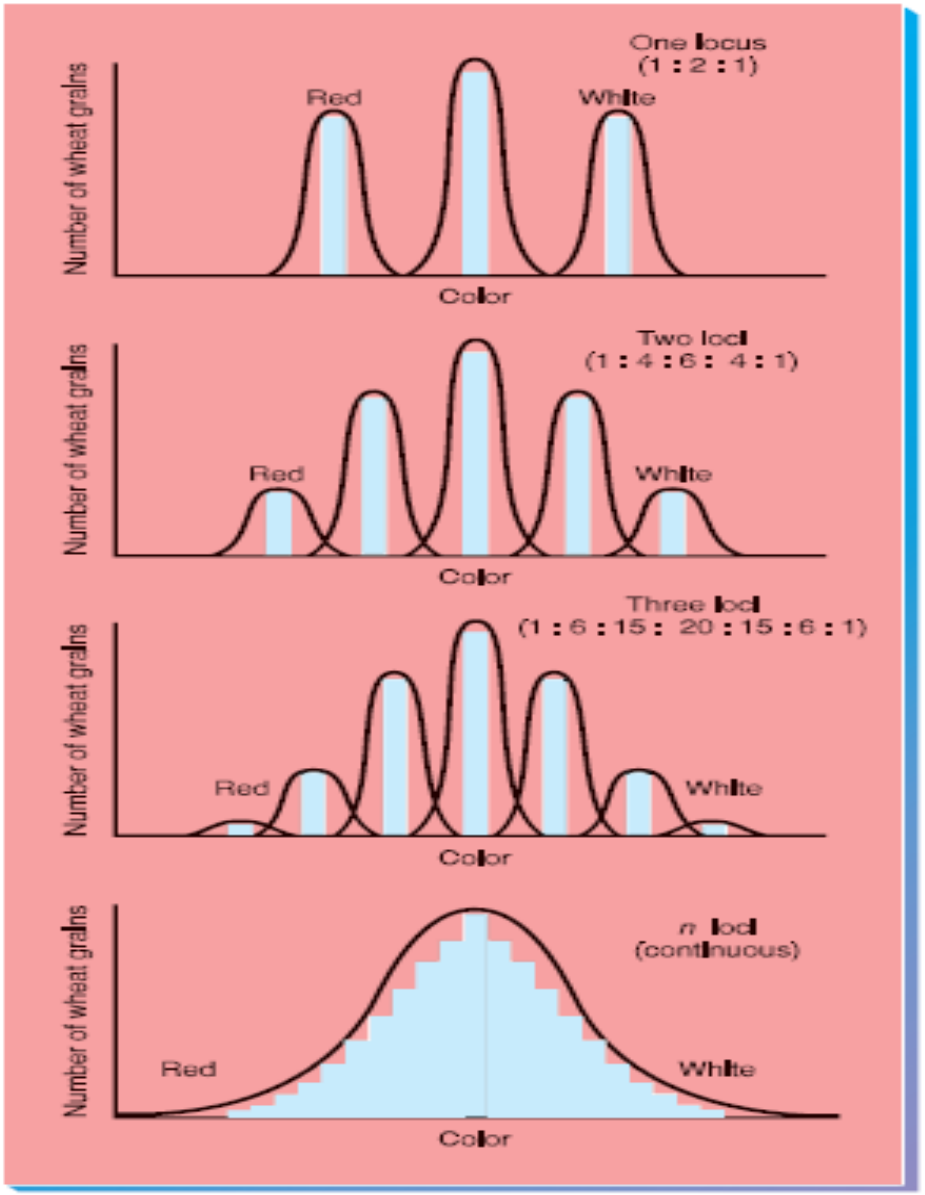
The resulting F_1 all exhibit an intermediate color. When the F_1s are crossed, the result is a range of color.


P
A'/A' B'/B' C'/C'
white
x
A/A B/B C/C
dark red
F1
A/A' B/B' C/C'
x
A/A' B/B' C/C'
Sperm
Eggs
1/8
F2
1/64
6/64
15/64
20/64
15/64
6/64
1/64



This is called a **bell curve**, and demonstrates a **normal distribution**

Change in shape of the distribution as increasing numbers of genes



The Basis of Additive Inheritance

1. Characteristics can be quantified (measured, counted, weighed, etc.)
2. Two or more genes, at different places in the genome, influence the phenotype in an additive way (polygenic).
3. Each locus may be occupied by an additive allele that does contribute to the phenotype, or a non-additive allele, which does not contribute.

The Basis of Additive Inheritance

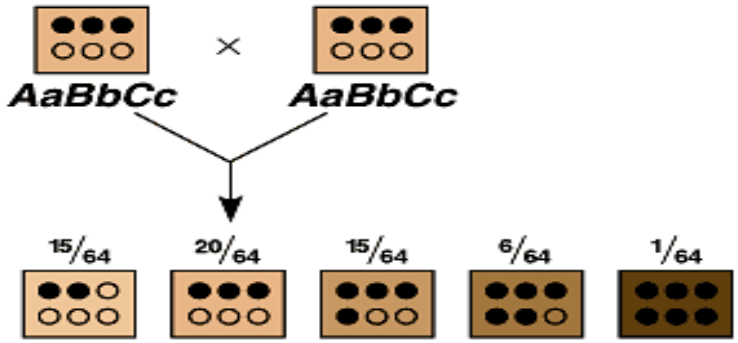
4. The total effect of each allele on the phenotype, while small, is roughly equal to the effects of other additive alleles at other gene sites.
5. Together, the genes controlling a single character produce substantial variation in phenotype.
6. Analysis of polygenic traits requires the study of large numbers of progeny from a population of organisms.

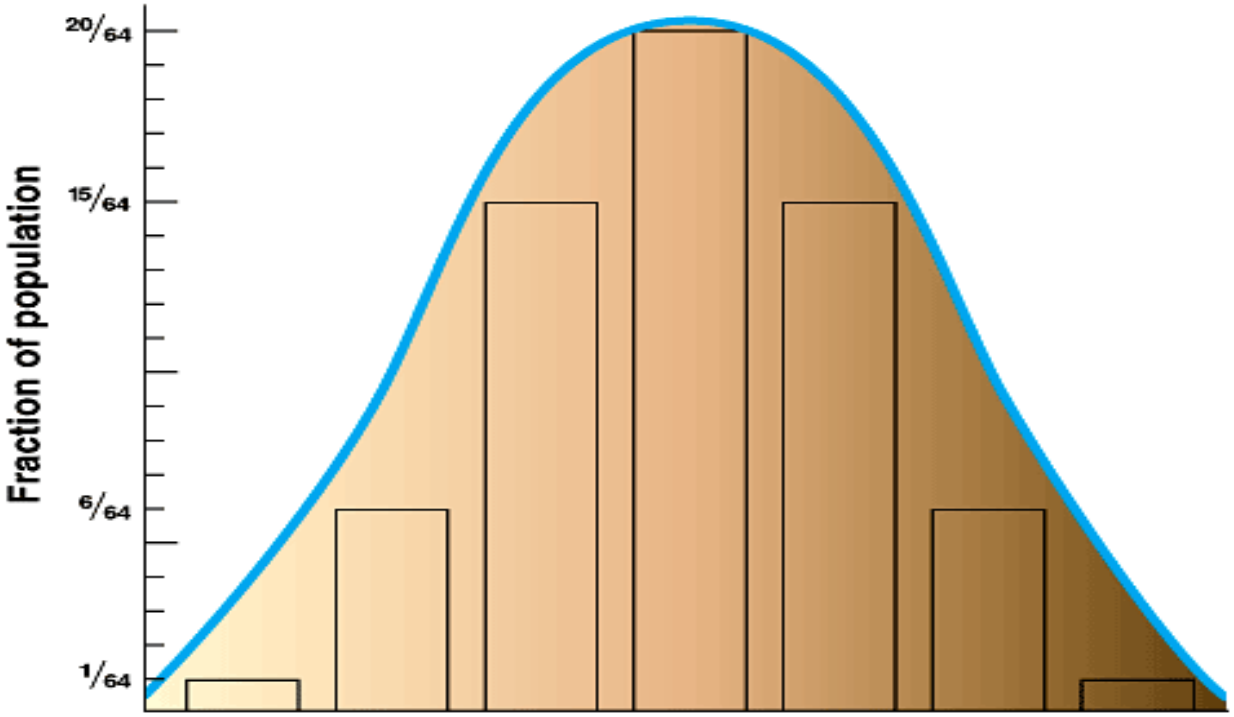
Human polygenic traits

- Height
- Weight
- Eye Color
- Intelligence
- Skin Color
- Many forms of behavior

Skin color in Human

- Skin color is due primarily to the presence of a pigment called melanin
- skin color in humans is controlled by at least 3 different genes
- each gene has 2 alleles, (light/dark)
- *AABBCC* (dark) and *aabbcc* (light)
- Cross between 2 *AaBbCc* (intermediate) produces wide range of shades
- *It is believed that more than 20 genes affect skin colour in humans*

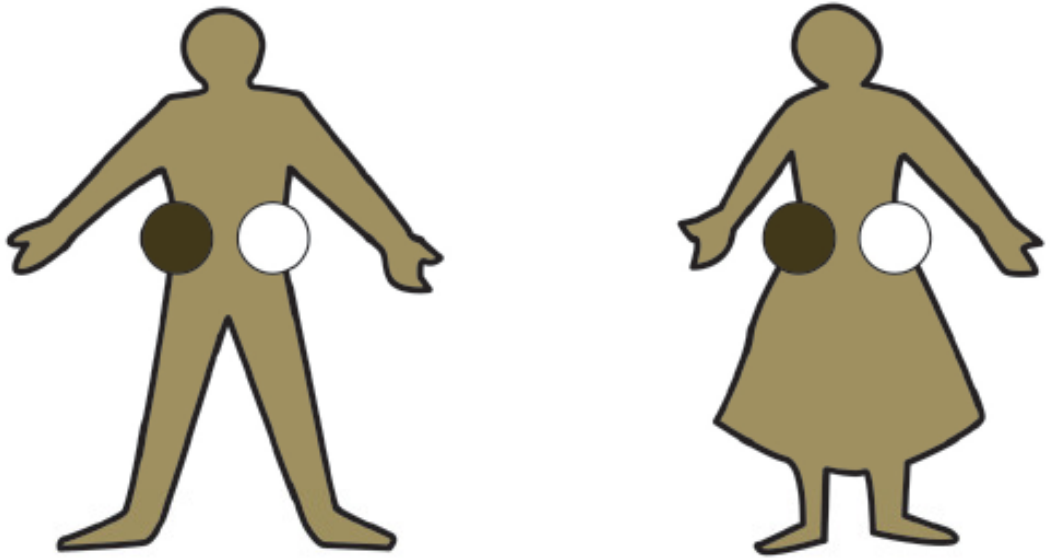

AaBbCc
×
AaBbCc
1/64
6/64
15/64
20/64
15/64
6/64
1/64


Fraction of population
20/64
15/64
6/64
1/64

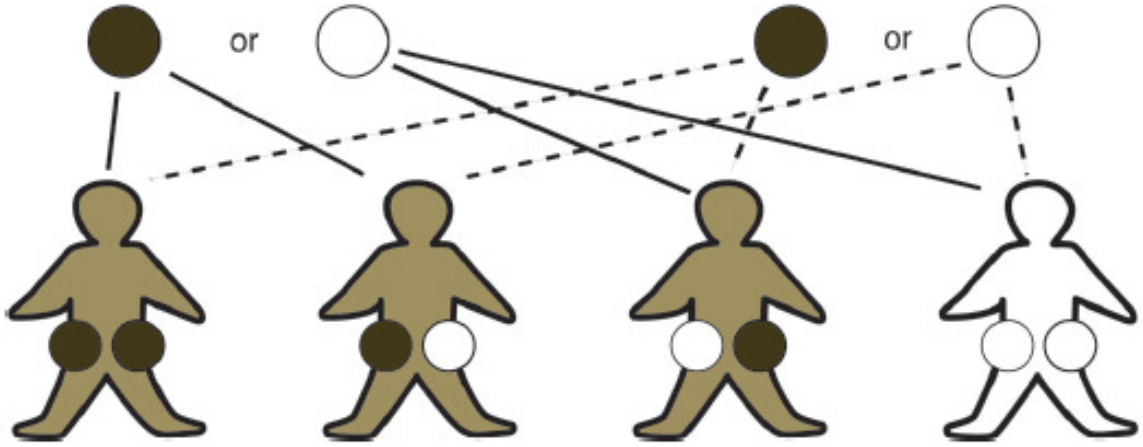
Monogenic

- *Albinism is a monogenic trait,*
- *it follows a Mendelian pattern of recessive inheritance under the control of a single primary gene.*
- *The parents (albinism carriers) both carry a gene variant that prevents melanin production*
- *they each also have a melanin-producing variant, they have pigmented skin.*
- *Depending on which variant their children inherit from each parent, they will be non-carriers, carriers or have no skin pigment (albino).*

Monogenic Inheritance - Albinism one gene



Reproductive cells



Determining the Number of Genes

The number of genes may be calculated *if*

--the proportion of F2 individuals expressing *either* of the two most *extreme* (i.e. parental) phenotypes can be determined according to the following formula:

$1/4^n$=proportion of offspring *either* red or white

Determining the Number of Genes

In our previous example, 1/64 of the F2 wheat berries were *either* red or white.

$$\frac{1}{4^n} = \frac{1}{64}$$

Then, solve for *n*, which in this case, is 3.

Another Method to Determine the Number of Genes: The (2*n* + 1) Rule

If *n* = the number of gene pairs, then (2*n* + 1) will determine the total number of categories of phenotypes.

In our example, there were 7 phenotype classes:

$$(2n + 1) = 7$$

$$\frac{(7-1)}{2} = \frac{6}{2} = 3$$

Table 18.1 Generalities from an Additive Model of Polygenic Inheritance

	One Locus	Two Loci	Three Loci	*n* Loci
Number of gamete types produced by an F_1 multihybrid	2 (*A*, *a*)	4 (*AB*, *Ab*, *aB*, *ab*)	8 (*ABC*, *ABc*, *AbC*, *Abc*, *aBC*, *aBc*, *abC*, *abc*)	2^n
Number of different F_2 genotypes	3 (*AA*, *Aa*, *aa*)	9 (*AABB*, *AABb*, *AAbb*, *AaBB*, *AaBb*, *Aabb*, *aaBB*, *aaBb*, *aabb*)	27 (*AABBCC*, *AABBCc*, *AABBcc*, *AABbCC*, *AABbCc*, *AABbcc*, *AAbbCC*, *AAbbCc*, *AAbbcc*, *AaBBCC*, *AaBBCc*, *AaBBcc*, *AaBbCC*, *AaBbCc*, *AaBbcc*, *AabbCC*, *AabbCc*, *Aabbcc*, *aaBBCC*, *aaBBCc*, *aaBBcc*, *aaBbCC*, *aaBbCc*, *aaBbcc*, *aabbCC*, *aabbCc*, *aabbcc*)	3^n
Number of different F_2 phenotypes	3	5	7	$2n + 1$
Number of F_2 as extreme as one parent or the other	1/4 (*AA* or *aa*)	1/16 (*AABB* or *aabb*)	1/64 (*AABBCC* or *aabbcc*)	$1/4^n$
Distribution pattern of F_2 phenotypes	1:2:1	1:4:6:4:1	1:6:15:20:15:6:1	$(A + a)^{2n}$

Significance of Polygenic Control

Most traits in animal breeding and agriculture are under polygenic control:

Height, weight, stature, muscle composition, milk and egg production, speed, etc.

Genotype Plus Environment

Note that genotype (fixed at fertilization) establishes the range in which a phenotype may fall, but environment influences how much genetic potential will be realized.

(So far, we have assumed no influence of environment on the cross examples used)

Biometry

Biometry is the quantitative study of biology and utilizes statistical inference to analyze traits exhibiting continuous variation.