GENE ACTION

PHENOTYPE = the type (form or appearance) and performance (function) of an individual that can be measured.

Genes express themselves phenotypically in two general ways (1) non-additive and (2) additive.

Genes may express themselves differently when alone or when they are in different combinations in the individual.

NON-ADDITIVE GENE ACTION

Different combinations of genes result in different phenotypes. However, the effects of the alleles result in *modification*.

(1) DOMINANCE-RECESSIVENESS – one gene overcomes the influence of the second gene

Genotype	Phenotype
BB	black
Bb	black
bb	red

MATINGS:

Parents	Offspring
BB (black) X BB (black)	All BB
Bb X BB	1 BB; 1 Bb
Bb X Bb	1 BB; 2 Bb; 1 bb (red)
Bb X bb	1 BB; 1 bb
bb X BB	All Bb
bb X bb	All bb

Dominant genes are USUALLY *desirable* in their effects, while recessive genes are USUALLY *detrimental.*

VARIABLE EXPRESSIVITY

Genes don't always express themselves identically in two different individuals.

Shades of black, shades of red, etc.

Two general factors may be responsible for variable expressivity:

1. EXTERNAL FACTORS: environment – sunlight, climate, nutrition, health, etc.

2. INTERNAL FACTORS: hormones,

Modifying Genes – those genes which modify (change) the expression of other genes in the same individual.

P = G + E + (GXE)

G = same

E = external factors

(GXE) = internal factors

(2) PARTIAL DOMINANCE (no dominance; lack of dominance): one gene is not completely dominant to its allele. Both genes are expressed in the phenotype. The heterozygote is phenotypically different from either homozygote.

Genotype	Phenotype
RR	red
Rr	roan
rr	white

MATINGS:

Parents	Offspring
RR X RR	All red
RR X Rr	1RR (red); 1Rr (roan)
Rr X Rr	1RR (red); 2Rr (roan); 1rr (white)
Rr X rr	1 Rr (roan); 1rr (white)
rr X RR	All Rr (roan)
rr X rr	All white

Basically, we have 1 PHENOTYPE for each GENOTYPE. Phenotype accurately identifies the genotype.

(3) OVERDOMINANCE: the heterozygous genotype has an advantage over both the homozygous dominant and the homozygous recessive.

AA<Aa>aa

AA = fast (SI 100) X aa = fast (SI 98) ➔ Aa = Faster (SI 105)

**Part of the explanation for HYBRID VIGOR, and the basis for crossbreeding, outcrossing, "nicking", etc.

Crossbreeding = mating 2 unrelated lines.
TB X Draft
Outcrossing = mating 2 distantly related lines
TB X QH
Nicking = mating 2 homozygous lines that are relatively closely related.
TB X TB

(4) EPISTASIS – one pair of genes on one pair of chromosomes affects the phenotypic expression of another pair of genes carried on the same pair of chromosome or on a different pair of chromosomes.

B- = black; bb = red Chromosome #1
WW = no pigment (lethal); Ww = white pigment; ww = colored pigment Chromosome #2

Genotype	Phenotypes
BBWW	albino (lethal)
BBWw	white
BBww	Black
BbWW	albino (lethal)
BbWw	white
Bbww	black
bbWW	albino (lethal)
bbWw	white
bbww	red

In nature, epistasis involves many pairs of genes and many different kinds of interactions among the genes.

Epistasis is thought to have an important influence on traits related to "VIGOR" and/or PHYSICAL FITNESS.

Common utilization of both epistasis and overdominance involves creation of INBRED lines and then finding out which LINES combine (**nick)** to consistently produce superior offspring for the desired trait(s).

**It may be possible to cross two different breeds and produce a *genetic defect* in their offspring that is NEVER (or seldom) observed in the purebreds because of the epistatic action of two or more pairs of genes.

ADDITIVE GENE ACTION: there is no sharp distinction between genotypes. Numerous gradual differences appear between the two extremes. Requires at least two or more gene pairs influencing the same trait (***POLYGENIC TRAIT***).

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Genes may be considered to be:

CONTRIBUTING – each gene make a positive contribution to the trait
NEUTRAL – each gene contributes nothing
DETRIMENTAL – each gene detracts from the trait

A, B, C – contribute 10# to weaning weight
a, b, c – neutral

Genotype	Weaning Weight
aabbcc	400#
Aabbcc	410#
AaBbcc	420#
AabbCc	420#
AAbbcc	420#
AABBCC	460#

Additive gene action affects most of the economically important traits in farm animals: growth rate, milk production, conformation, carcass quality, muscle mass, size, speed, etc.

These traits are POLYGENIC and are also probably influenced by non-additive genes as well.

Polygenic traits influenced primarily by **additive** gene action are usually **highly heritable.**

Polygenic traits influenced primarily by **non-additive** gene action are usually **lowly heritable.**

Polygenic traits that are influenced by **both** are usually **moderately heritable.**

CAUSES OF VARIATION IN GENE ACTION

1. Multiple alleles – there may be MORE THAN TWO alternative genes for a specific locus.

A, a, A', a', A", a", A*

AA = red; Aa = pink; aa = white

AA' = black; A'a = black

A'a' = black w/ white center; Aa' = pink w/ white center

2. Linkage of genes – the presence of two **non-allelic genes** on the SAME CHROMOSOME affecting the *same trait*.

Since they are on the same chromosome, the two unrelated genes tend to travel together during gamete formation and, therefore, tend to be **inherited together**.

The two "linked traits" tend to be inherited as a single package.

3. Sex-Linked – genes carried on the **X-chromosome**.

XX = female. Each gene has an allele. Therefore, all traits are influenced by a PAIR of genes.

XY = male. The Y-chromosome is SHORTER than the X. There are genes carried on the X than have no allele on the Y. Thus the X gene is always expressed.

IN addition, the "angled part of the Y-chromosome has no corresponding allele on the X. Thus, genes on this portion of the Y are always expressed.

4. Sex-Influenced – genes for sex influenced traits are carried on the AUTOSOMES and their expression is influenced by the sex of the individual. A male and female can have identical genotypes, but exhibit different traits. Usually the trait is dominant in the male and recessive in the female.

Genotype	Male Phenotype	Female Phenotype
HH	horned	horned
Hh	horned	hornless
hh	hornless	hornless

5. Sex-Limited – traits which are expressed only in one sex, i.e., milk production, semen quality, calving ease, scrotal width. Genes from both the sire and dam contribute to these traits. However, they are measurable only in one sex.