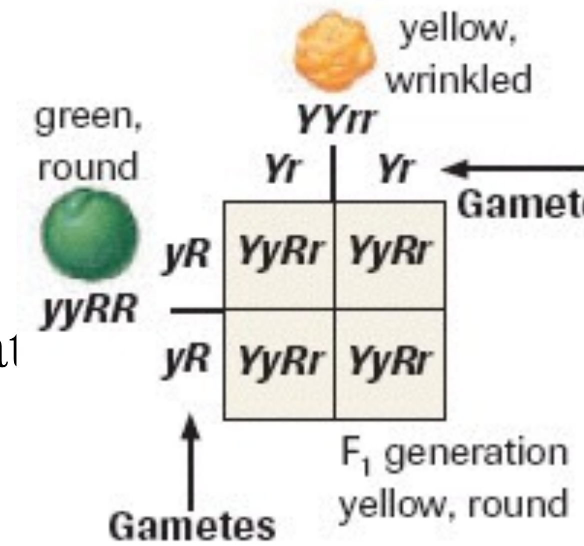
Dihybrid Crosses and Polygenic Traits

Outcomes:

1. Describe evidence for segregation and independent assortment of genes.
2. Quantitatively interpret and predict patterns and trends of inheritance in dihybrid crosses, using punnett squares.
3. Explain the relationship between variability and the number of genes controlling a trait (polygenic traits)

Dihybrid Cross

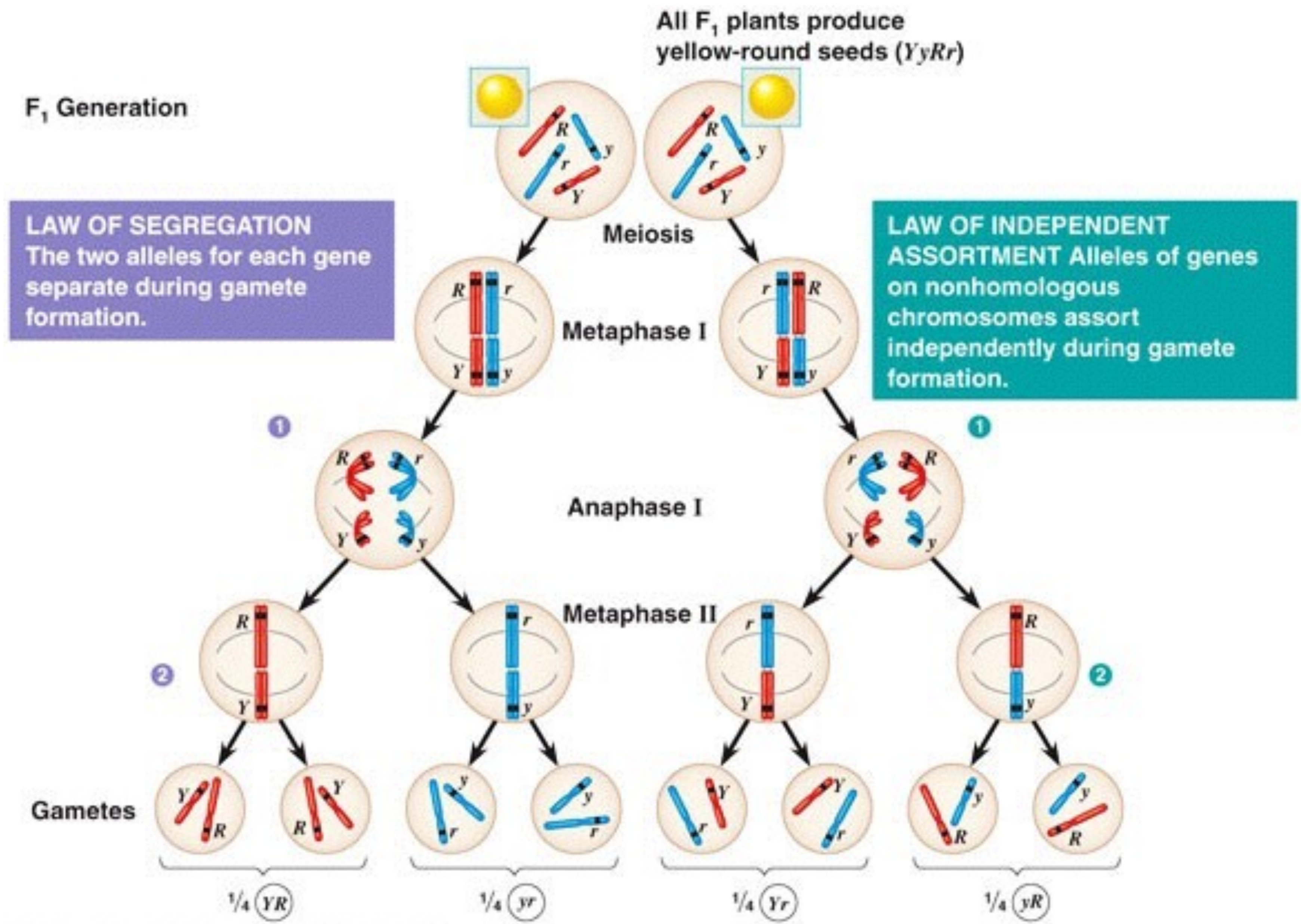


- Cross that involves individuals with 2 independent traits that are present in alternat forms
- Mendel: garden peas
  - to see if traits inherited independently or with each other
- Crossed 2 homozygous (pure-breeding) plants
  - one for both dominant traits, one for recessive
  - YYRR x yyrr
- All were heterozygous for both traits
  - principle of dominance applies

Law of Independent Assortment

- States that genes that are located on different chromosomes assort independently
- During segregation: chromosomes migrate to opposite poles
- Each chromosome carries own genes
- Four possible combinations of gametes

Independent Assortment



All F1 plants produce yellow-round seeds (YyRr)
F1 Generation
LAW OF SEGREGATION The two alleles for each gene separate during gamete formation.
Meiosis
Metaphase I
LAW OF INDEPENDENT ASSORTMENT Alleles of genes on nonhomologous chromosomes assort independently during gamete formation.
Anaphase I
Metaphase II
Gametes
1/4 YR
1/4 yr
1/4 Yr
1/4 yR

Mendel

- Took F1 plants (YyRr), allowed to self-fertilize
- Assumed independent assortment
- Parents each produce 4 types of gametes
- Calculated ratio of F2 as 9:3:3:1 out of a possible 16 offspring

Gametes	*YR*	*yR*	*Yr*	*yr*
YR	*YYRR*	*YyRR*	*YYRr*	*YyRr*
yR	*YyRR*	*yyRR*	*YyRr*	*yyRr*
Yr	*YYRr*	*YyRr*	*YYrr*	*Yyrr*
yr	*YyRr*	*yyRr*	*Yyrr*	*yyrr*

Dihybrid Cross Example 1

- Assume that in certain plants yellow fruit (YY or Yy) is dominant over green (yy) and disk-shaped (DD or Dd) is dominant over sphere-shaped (dd). List the possible phenotypes for the F1 for the following cross:
  P1: YyDd x YyDd

Dihybrid Cross Example 2

- Using the same information from Example 1, give the possible phenotypes for the following cross:
  P1: YyDd x Yydd

Dihybrid Cross Example 3

- A yellow disk-shaped parent and a green disk-shaped parent are crossed. State the genotypes of the parents when the offspring produced are:
  3 green disk-shaped
  1 green sphere-shaped
  3 yellow disk-shaped
  1 yellow sphere-shaped

Probability in Dihybrid Crosses

$$P = \frac{\text{number of ways a given outcome can occur}}{\text{total number of possible outcomes}}$$

- Uses of probability of different genotypes/phenotypes in progeny
  - predict types in progeny
  - tell whether two genes likely located on different chromosomes
- Dihybrid crosses: probability both occur at same time
- Assort independently: occur on different chromosomes, both allele occurrences are independent of each other
- Determine probability of each outcome separately, using separate Punnett Squares for each
- Multiply probabilities of each trait together to get probability of genotype that includes both traits

Probability in Dihybrid Crosses

SAMPLE exercise 1

In humans, free ear lobes are determined by the dominant allele *E*, and attached ear lobes by the recessive allele *e*. The dominant allele *W* determines a widow's peak hairline and the recessive allele *w* determines a straight hairline (**Figure 5**). The genes for these two traits are located on different chromosomes. Suppose a man with the genotype *EeWw* and a woman with the genotype *EeWw* are expecting a child. What is the probability that the child will have a straight hairline and attached ear lobes?

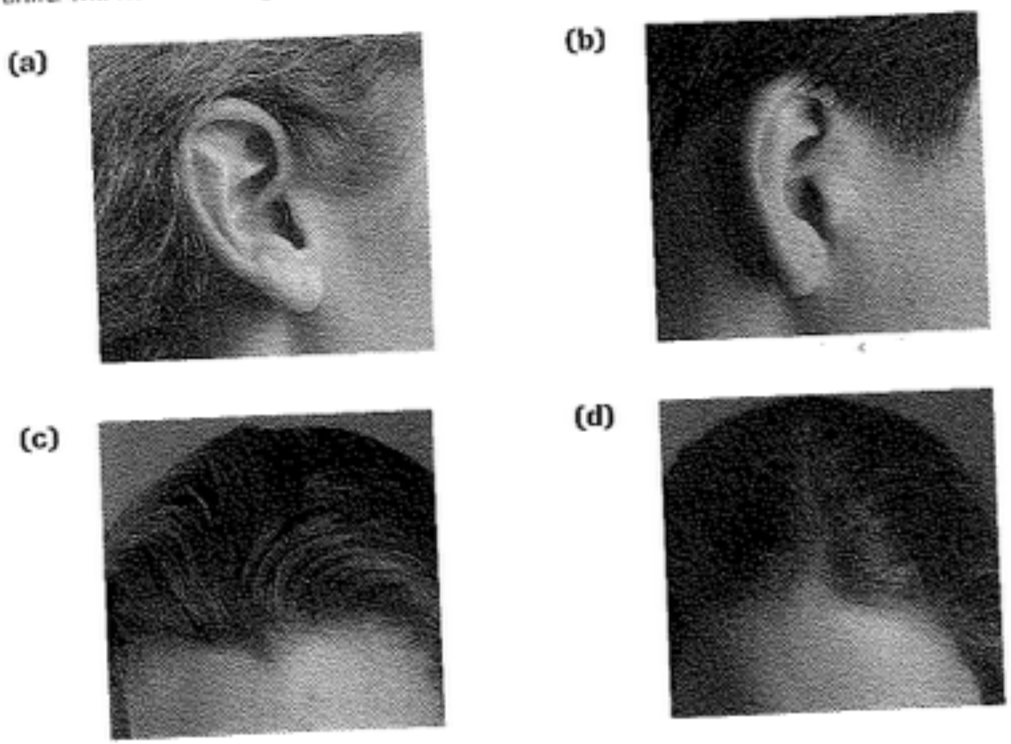


Figure 5
In humans, both ear lobe shape and hairline shape are inherited. The free ear lobe in **(a)** is dominant to the attached ear lobe in **(b)**, and the widow's peak in **(c)** is dominant to a straight hairline in **(d)**.

Solution

To have attached ear lobes and a straight hairline, the child must have the genotype *eeww*. Since the two genes are on separate chromosomes, the gene for ear shape and hairline shape will assort independently. The outcome that the child will receive two *e* alleles is, therefore, independent of the outcome that the child will receive two *w* alleles.

First, determine the probability of each of these outcomes separately, using a separate Punnett square for each gene. From **Figure 6 (a)**, we see the probability that the child will have attached ear lobes is one in four ($\frac{1}{4}$). From **Figure 6 (b)**, we see the probability that the child will have a straight hairline is also one in four ($\frac{1}{4}$).

(a)

	$\frac{1}{2}$ *E*	$\frac{1}{2}$ *e*
$\frac{1}{2}$ *E*	$\frac{1}{4}$ *EE*	$\frac{1}{4}$ *Ee*
$\frac{1}{2}$ *e*	$\frac{1}{4}$ *Ee*	$\frac{1}{4}$ *ee*

(b)

	$\frac{1}{2}$ *W*	$\frac{1}{2}$ *w*
$\frac{1}{2}$ *W*	$\frac{1}{4}$ *WW*	$\frac{1}{4}$ *Ww*
$\frac{1}{2}$ *w*	$\frac{1}{4}$ *Ww*	$\frac{1}{4}$ *ww*

Figure 6
Punnett squares showing monohybrid crosses between heterozygous parents for **(a)** free ear lobes and **(b)** for a widow's peak

Now multiple these probabilites to calculate the prbabliiteis of each event occurring in a dihybrid cross – for the combination of traits. The probability that the child with have genotype eeww is ¼ X ¼ = **1/16**

Practice

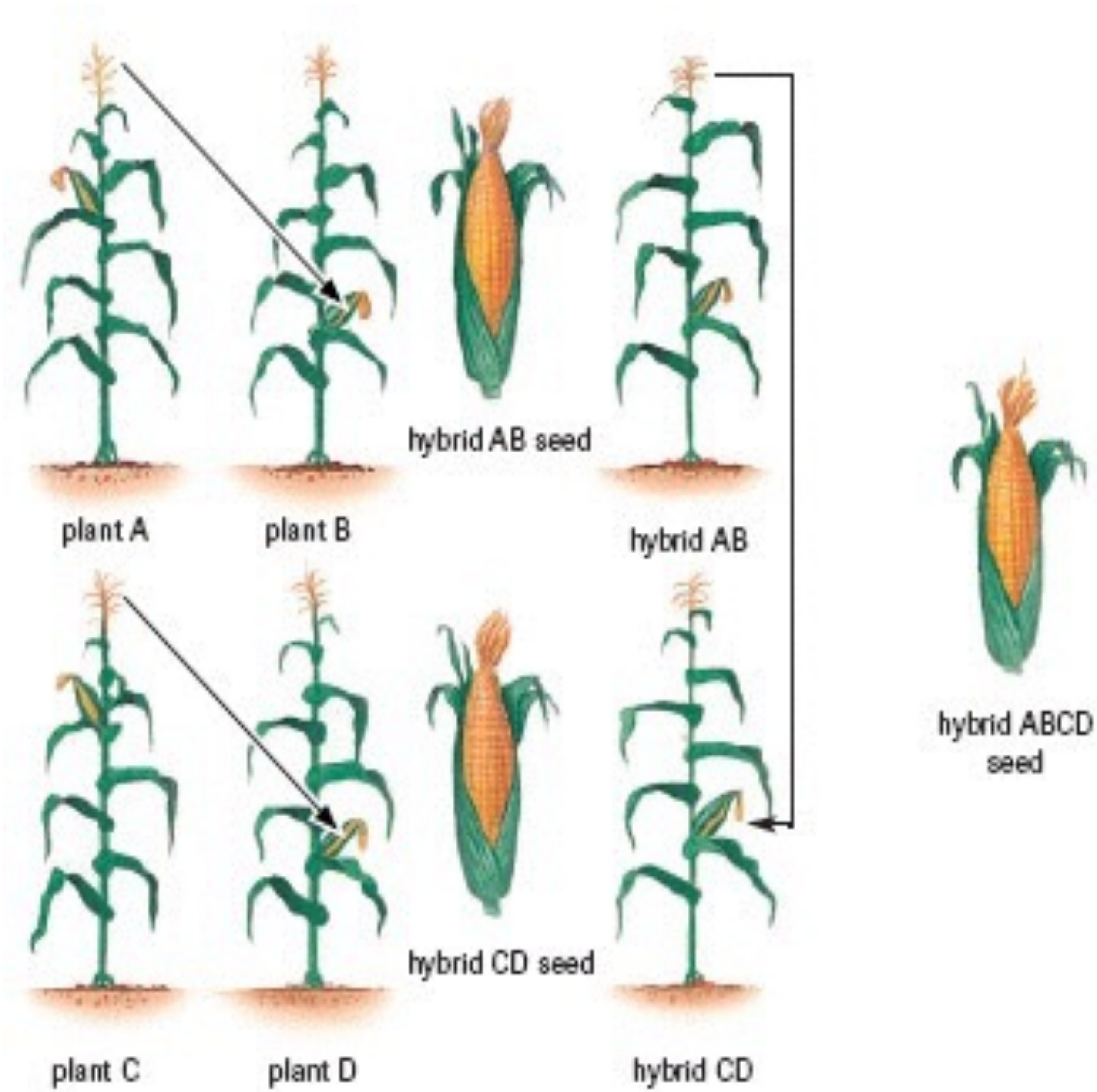
Calculate the probability that the couple will have a child with

a) A widow's peak and free ear lobes
b) A straight hair line and free ear lobes
c) A widow's peak and attached ear lobes

Selective Breeding

- Identifying individuals with desirable traits and using them as parents for next generation
- Aboriginal farmers: selective breeding to develop many crops
- Purebred dogs: inbreeding
  - similar phenotypes selected for breeding
  - desirable traits vary from breed to breed
  - results in less genetic variation however

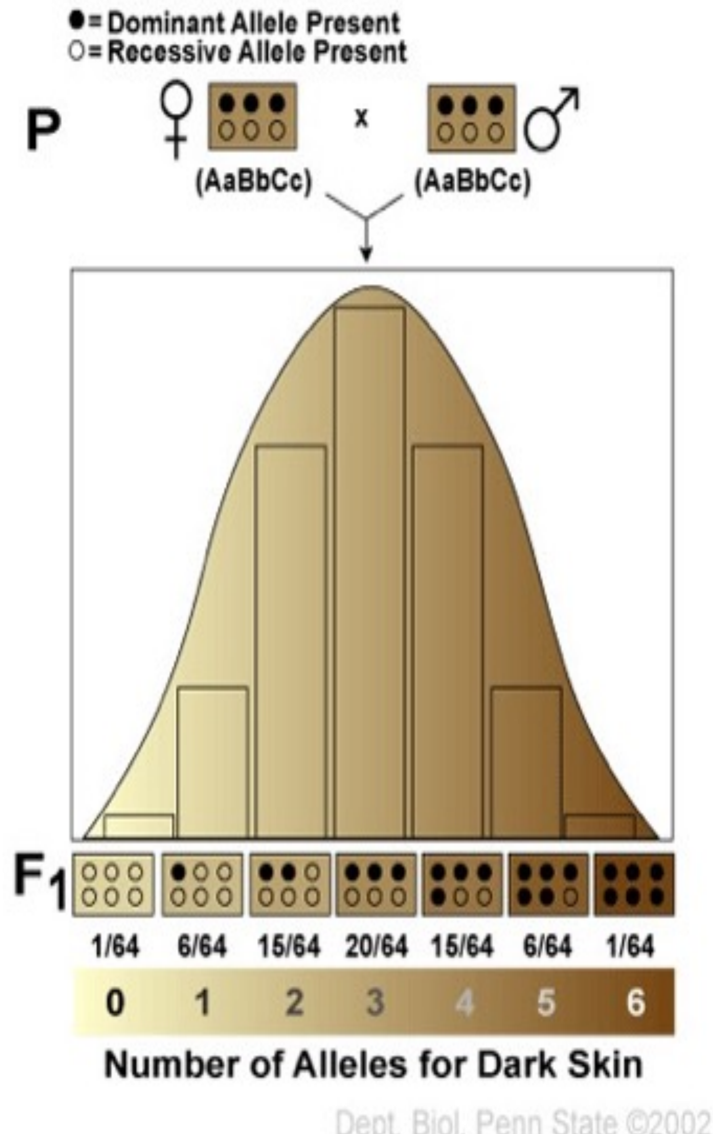
- Hybridization: opposite of inbreeding
  - attempts to blend desirable but different traits
  - ex) corn, hybrids generally more vigorous



- A: homozygous
- B: homozygous
- AB: hybrid
- C: homozygous
- D: homozygous
- CD: hybrid
- AB x CD
- ABCD: hybrid with desired traits and more vigorous

Polygenic Traits

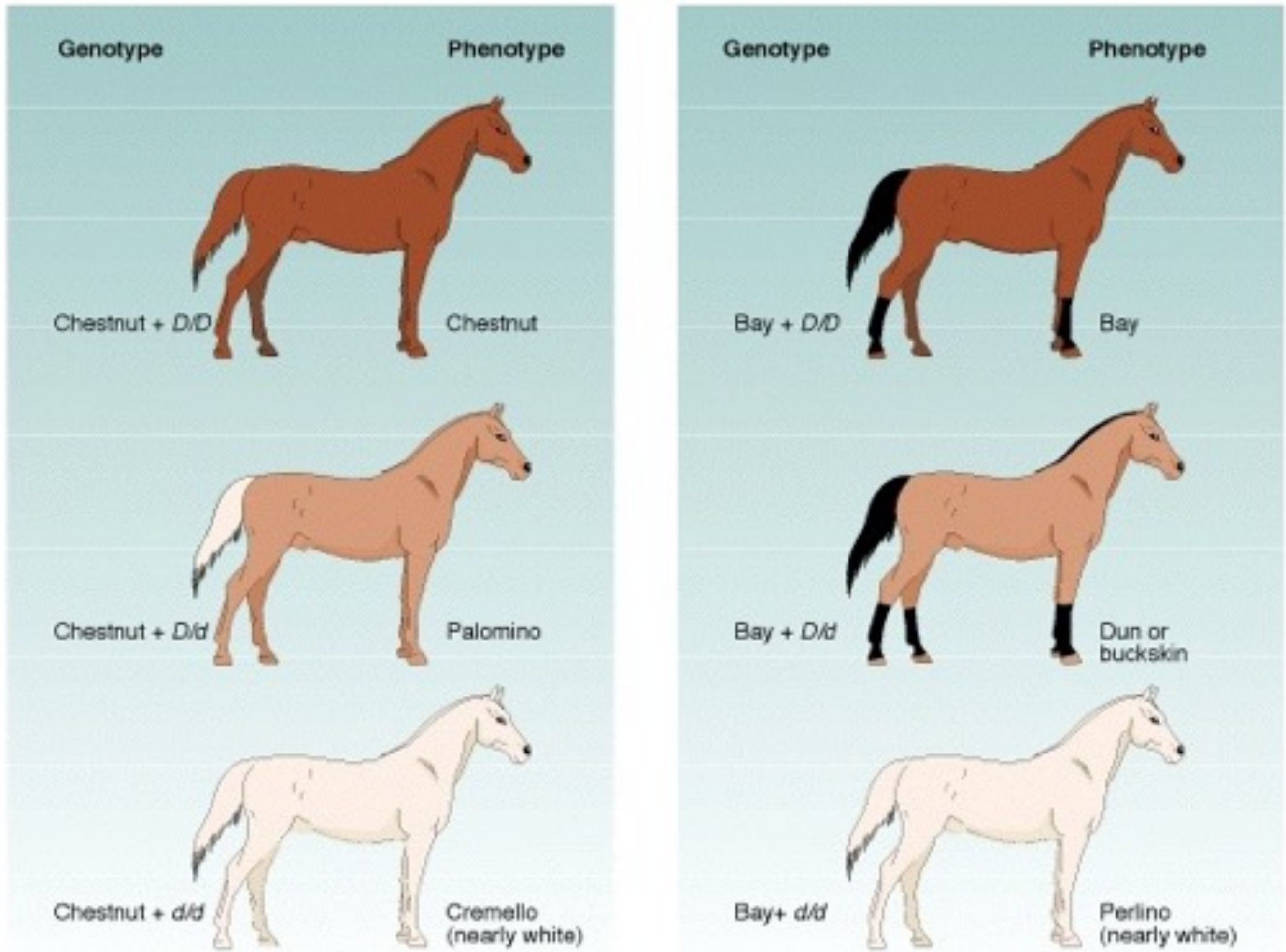
- When single traits determined by more than one gene
  ex) skin colour, eye colour, height
- Much more variability than those determined by single gene
  - each can have multiple alleles, show incomplete dominance or co-dominance, can be affected by environment
- Makes breeding for these traits difficult
- Sometimes 2 different genotypes interact to produce a phenotype that neither can produce by itself



- Epistatic Gene: interferes with expression of another gene

(A) Black labrador (*B_E_*) (B) Chocolate labrador (*bbE_*) (C) Yellow labrador (*_ _ee*)

- Gene for colour and another gene for amount of pigment



Polygenic Traits

- Observed phenotypic ratios vary from those traits that are not interacting
- Ex) Coat colour in dogs: epistatic (B allele affects coat colour, W affects pigments)
- B: black colour
- b: brown colour
- W: prevents colour
- w: does not prevent colour
- wwBb: black
- WwBb: white
- W allele masks effect of B colour gene
- Ex) humans: gene for albinism epistatic - interferes with genes that determine pigment formation