Patterns of Inheritance

Chapter 12

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Early Ideas of Heredity

Before 20th century,

2 concepts: basis for ideas about heredity:

1) heredity occurs within species

2) traits transmitted directly from parent to offspring

Led to belief: inheritance matter of ***blending*** traits from parents

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Early Ideas of Heredity

Botanists 18th & 19th centuries produced hybrid plants

When hybrids crossed with each other, some of offspring resembled original strains, rather than hybrid strains

Evidence contradicted idea that traits are directly passed from parent to offspring

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Early Ideas of Heredity

Gregor Mendel (1822-1884)

-studied pea plants because:

1. other research showed pea hybrids could be produced
2. many pea varieties available
3. peas are small plants & easy to grow
4. peas can **self-fertilize** or be **cross-fertilized**

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1866: Mendel published "hereditary factors" passed from parent to offspring

1859: Darwin published Theory of Evolution by Natural Selection

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Laws of Mendelian Genetics

- 1) **Law of Independent Segregation**

  during gamete formation each member of allelic pair separates from other member to form the genetic constitution of gamete

- 2) **Law of Independent Assortment**

  during gamete formation the segregation of alleles of one allelic pair independent of segregation of alleles of another allelic pair

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Early Ideas of Heredity

Mendel's experimental method:

1. produce **true-breeding** strains for each trait
2. cross-fertilize true-breeding strains having alternate forms of a trait
   -perform **reciprocal crosses** as well
3. allow hybrid offspring to self-fertilize & count # of offspring showing each form of the trait

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Monohybrid Crosses

Monohybrid cross: a cross to study only 2 variations of a single trait

Mendel produced true-breeding pea strains for 7 different traits

-each trait 2 alternate forms (variations)

-Mendel cross-fertilized the 2 true-breeding strains for each trait

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Monohybrid Crosses

F$_1$ generation (1st filial generation): offspring produced by crossing 2 true-breeding strains

For every trait Mendel studied, all F$_1$ plants resembled only 1 parent

-no plants with characteristics intermediate between 2 parents produced

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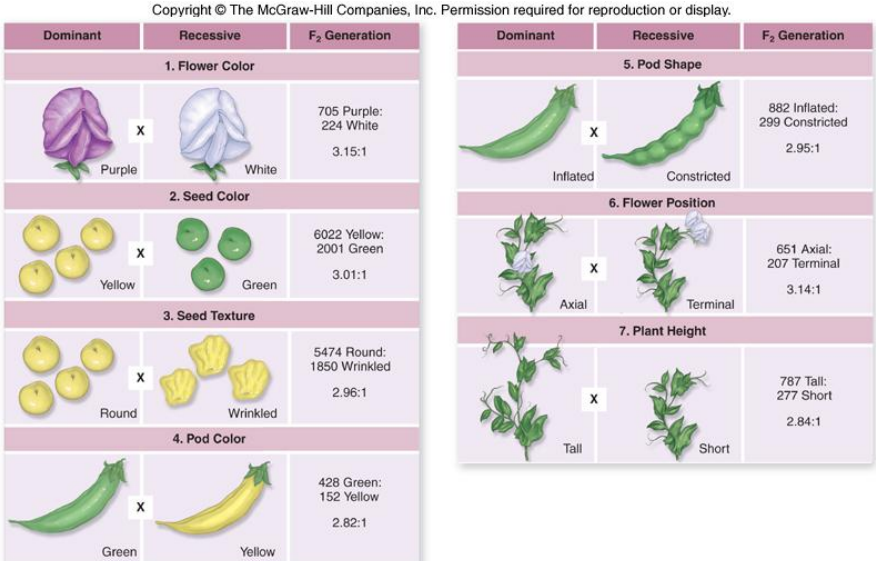

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Monohybrid Crosses

F_1 generation: offspring resulting from a cross of true-breeding parents

F_2 generation: offspring resulting from self-fertilization of F_1 plants

dominant: form of each trait expressed in the F_1 plants

recessive: form of trait not seen in F_1 plants

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Monohybrid Crosses

F_2 plants exhibited both forms of trait in a very specific pattern:

¾ plants with dominant form

¼ plant with recessive form

Dominant to recessive ratio was 3 : 1

Mendel discovered ratio actually:

1 true-breeding dominant plant

2 not-true-breeding dominant plants

1 true-breeding recessive plant

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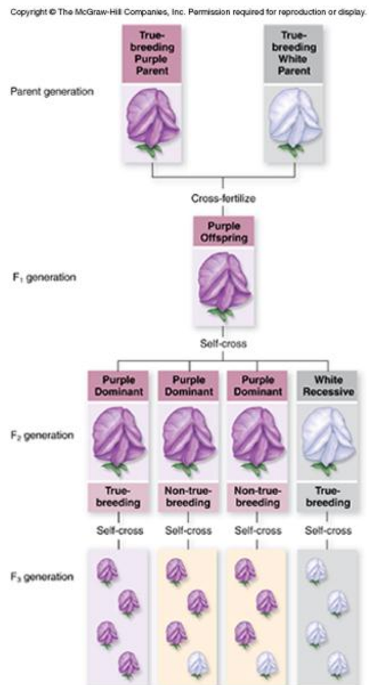

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Monohybrid Crosses

gene: information for a trait passed from parent to offspring

alleles: alternate forms of a gene

homozygous: having 2 of same allele

heterozygous: having 2 different alleles

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Monohybrid Crosses

genotype: total set of alleles of an individual

PP = homozygous dominant

Pp = heterozygous

pp = homozygous recessive

phenotype: outward appearance of an individual

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Monohybrid Crosses

Principle of Segregation

Two alleles for a gene segregate during gamete formation & rejoined at random, one from each parent, during fertilization

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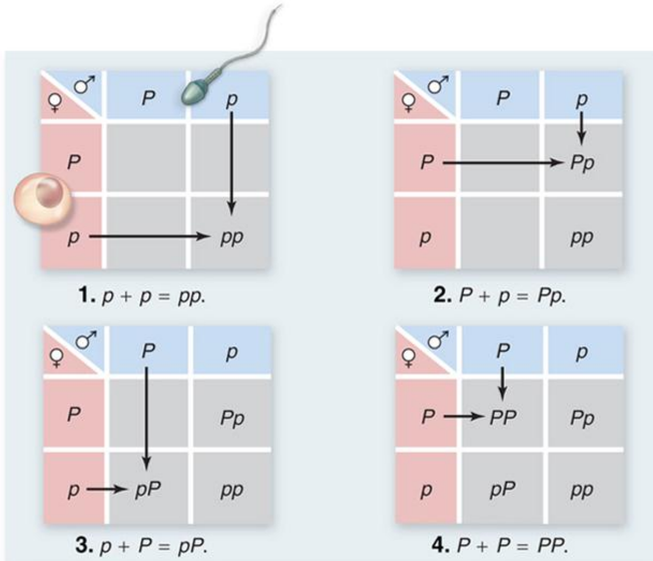

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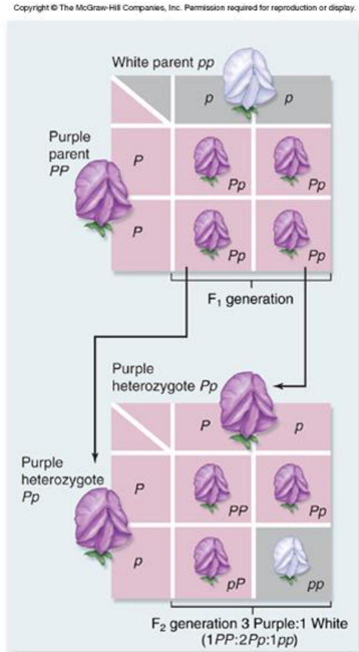

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Monohybrid Crosses

Some human traits controlled by a single gene

-some of these exhibit dominant inheritance

-some of these exhibit recessive inheritance

Pedigree analysis track inheritance patterns in families

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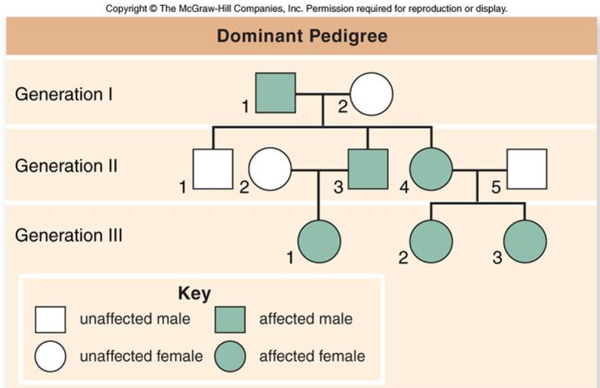

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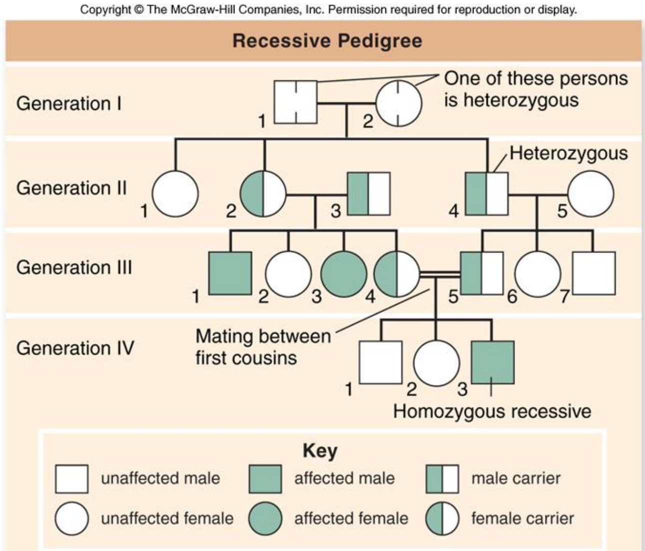

Dihybrid Crosses

Dihybrid cross: examination of 2 separate traits in a single cross

-for example: RR YY x rryy

F_1 generation of a dihybrid cross (RrYy) shows only dominant phenotypes for each trait

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Dihybrid Crosses

F_2 generation produced by crossing members of F_1 generation with each other or allowing self-fertilization of F_1

-e.g. RrYy x RrYy

F_2 generation shows all four possible phenotypes in a set ratio:

9 : 3 : 3 : 1

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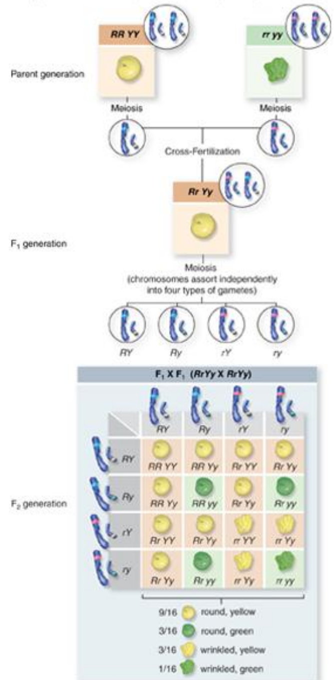

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Dihybrid Crosses

Principle of Independent Assortment

In a dihybrid cross, alleles of each gene assort independently.

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Probability – Predicting Results

Rule of addition: probability of 2 mutually exclusive events occurring simultaneously is sum of their individual probabilities

When crossing Pp x Pp, probability of producing Pp offspring is

probability of obtaining Pp (1/4), PLUS

probability of obtaining pP (1/4)

$\frac{1}{4} + \frac{1}{4} = \frac{1}{2}$

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Probability – Predicting Results

Rule of multiplication: probability of 2 independent events occurring simultaneously is PRODUCT of their individual probabilities

When crossing Rr Yy x RrYy, probability of obtaining rr yy offspring is:

probability of obtaiing rr = ¼

probability of obtaining yy = ¼

probability of rr yy = ¼ x ¼ = 1/16

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Testcross

Testcross: cross used to determine genotype of an individual with dominant phenotype

-cross individual with unknown genotype (e.g. P_) with a homozygous recessive (pp)

-phenotypic ratios among offspring are different, depending on genotype of unknown parent

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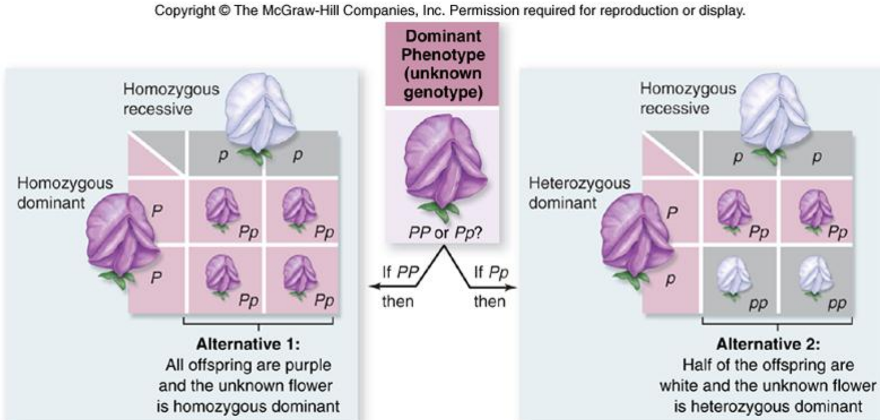

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Extensions to Mendel

Mendel's model of inheritance assumes that:

-each trait controlled by a single gene

-each gene only 2 alleles

-clear dominant-recessive relationship between alleles

Most genes do not meet these criteria

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Extensions to Mendel

Polygenic inheritance occurs when multiple genes involved in controlling phenotype of a trait

Phenotype: an accumulation of contributions by multiple genes

Traits show **continuous variation** & referred to as **quantitative traits**

e.g. – human height, eye, skin, hair color

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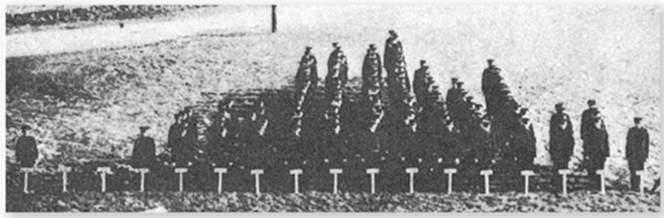

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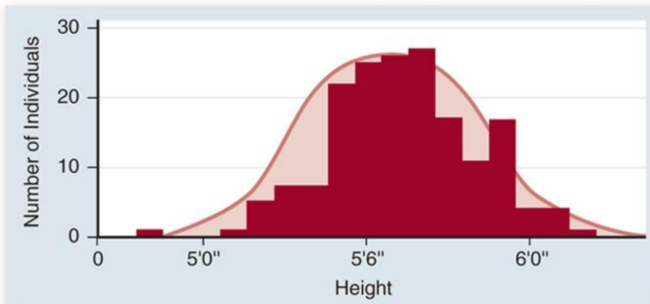

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Extensions to Mendel

Pleiotropy refers to an allele which has more than one effect on the phenotype

Seen in human diseases such as

1) cystic fibrosis

2) sickle cell anemia

Multiple symptoms traced back to one defective allele

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Extensions to Mendel

Incomplete dominance: heterozygote: intermediate in phenotype between 2 homozygotes

Codominance: heterozygote shows some aspect of phenotypes of both homozygotes

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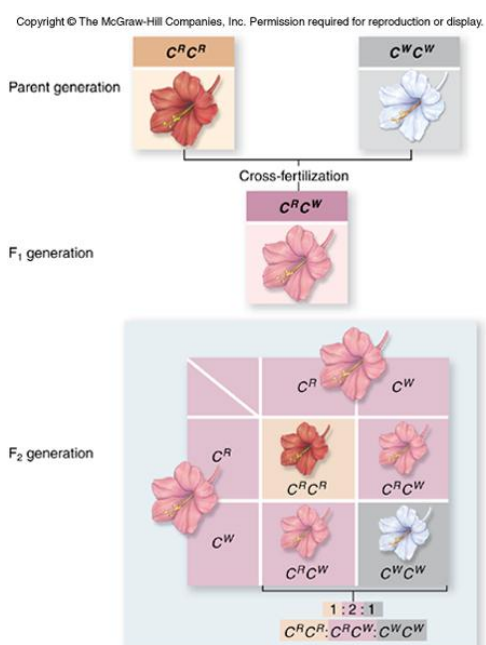

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Extensions to Mendel

Human ABO blood group system demonstrates:

-multiple alleles: 3 alleles of *I* gene (I^A, I^B, & i)

-codominance: I^A & I^B dominant to i but codominant to each other

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	Alleles	Blood Type	Sugars Exhibited	Donates and Receives
	I^AI^A, I^Ai (I^A dominant to i)	A	Galactosamine	Receives A and O Donates to A and AB
	I^BI^B, I^Bi (I^B dominant to i)	B	Galactose	Receives B and O Donates to B and AB
	I^AI^B (codominant)	AB	Both galactose and galactosamine	Universal receiver Donates to AB
	ii (i is recessive)	O	None	Receives O Universal donor

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Extensions to Mendel

Expression of some genes can be influenced by environment

e.g.: coat color in Himalayan rabbits & Siamese cats

-an allele produces an enzyme allowing pigment production only at temperatures <30°C

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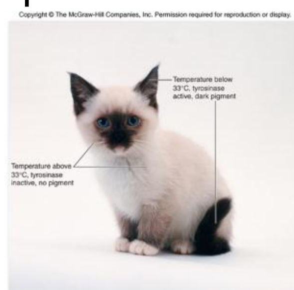

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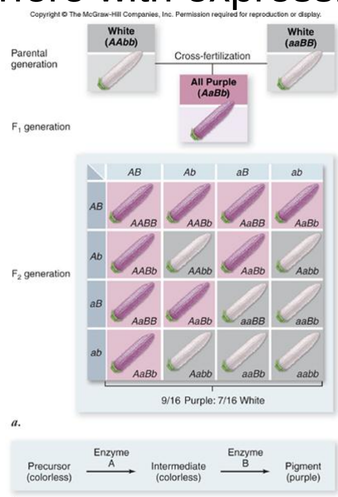
Extensions to Mendel

Products of some genes interact with each other & influence phenotype of individual

Epistasis: 1 gene can interfere with expression of another gene



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