PATTERNS OF INHERITANCE

Objectives

1. Define heredity.
2. List at least four advantages of peas as a test organism for genetics studies.
3. Fully describe Mendel's experimental crosses and their results.
4. Identify P_1, F_1, and F_2 generations.
5. Define gene, allele, locus, genotype and phenotype.
6. State the principle of dominance, segregation and independent assortment.
7. Perform a Punnett Square. List all possible gametes from an individual. Determine genotypes and phenotypes from a Punnett Square.
8. Recognize incomplete dominance, partial dominance and codominance.
9. Recognize multiple alleles.
10. Recognize examples of polygenic inheritance, epistasis, and pleiotropy.
11. Recognize four systems of sex determination.
12. Define linkage and how it determines distances between genes.

Outline

A. Heredity
B. Mendelian Genetics
    1. Peas
    2. Experimental Design
        a. Parental (P_1) Generation
        b. First Filial (F_1) Generation
        c. Second Filial (F_2) Generation
    3. Model for Genetic Inheritance
        a. Mendelian Hypotheses
        b. Punnett Square
        c. Law of Independent Assortment
        d. Test Crosses
C. Beyond Mendelian Genetics
    1. Other Levels of Dominance
    2. Multiple Alleles
    3. Pleiotropy
    4. Polygenic Traits
    5. Epistasis
    6. External Factors
D. Chromosomal Basis of Inheritance
    1. Linkage
E. Sex Determination
    1. Sex Linkage

A. Heredity

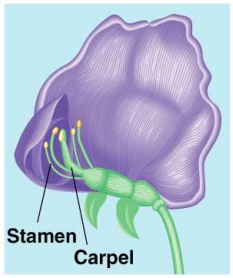
- Passing traits from parent to offspring
- Genetics
    - Pangenes
    - Blending

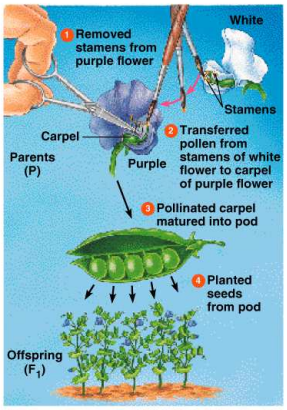
B. Mendelian Genetics

- Gregor Mendel
    - Augustinian monk and naturalist
    - Grew crops for monastary
        - Performed experiments on side

1. Peas

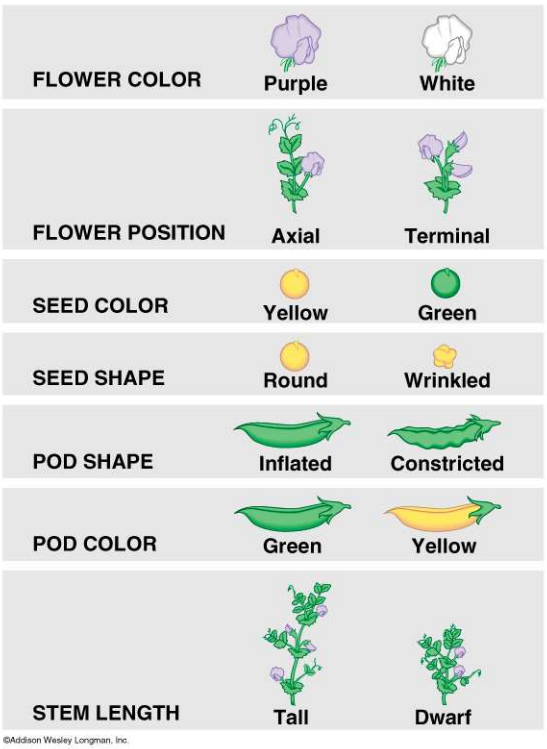
- Advantages
    - Inexpensive
    - Fairly small
    - Produce many flowers and fruits
        - ∴Can produce large numbers
        - ∴Can analyze statistically
    - Self-fertilizing
        - Can control breeding
        - Many true-breeding varieties
- Disadvantages
    - One generation per year
- Modern test organisms
    - Yeast
    - Fruit flies
    - *Arabidopsis*
    - Corn





2. Experimental Design
a. Parental (P_1) Generation

- Seven discrete true-breeding traits
    - No intermediate variant
    - Easy to distinguish
        - e.g., seed form, seed color
- Cross-pollinated opposite true-breeders
    - Monohybrid cross
    - "X" designates cross
        - e.g., ROUND X WRINKLED



b. First Filial (F_1) Generation

- Offspring from P_1 cross
- All F_1 displayed only one of two traits
    - e.g., ALL offspring were ROUND
    - Expressed trait – dominant
    - Trait not observed – recessive
- F_1 generation self-pollinates

c. Second Filial (F_2) Generation

- Offspring from F_1 selfing

- Ratio – ¾ dominant, ¼ recessive
  - e.g., 5474 round, 1850 wrinkled

- Repeated experiment with other traits
  - Always 3 dominant: 1 recessive

- While recessive trait not seen in F_1, recessive variant still present

3. Model for Genetic Inheritance

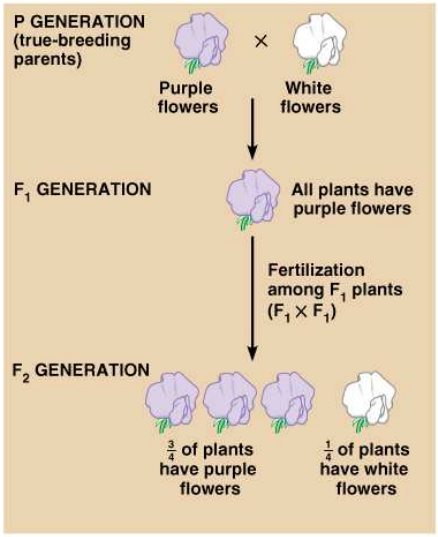
- How can a trait disappear in one generation, then reappear in ¼ of next?

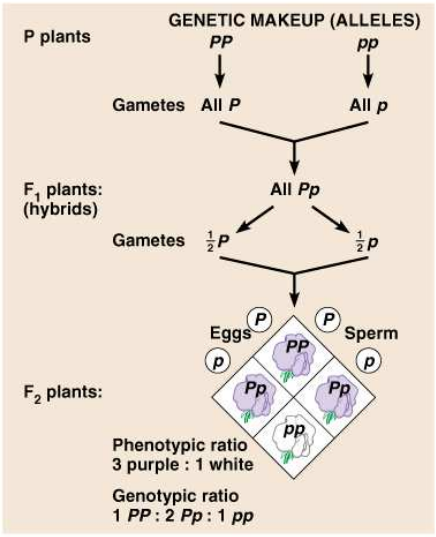
a. Mendelian Hypotheses

- Alternate forms of genes
  - Allele
  - Locus (pl. loci)
- Offspring has two genes for each trait
  - Receives one from each parent
    - Homozygous
    - Heterozygous
- Gametes carry only one allele for trait
  - Principle of Segregation
  - Fertilization restores two copies
- One factor prevents expression of other
  - Principle of Dominance

b. Punnett Square

- Does hypothesis fit data?
  - e.g., ROUND X WRINKLED
    - P_1 – Round (RR) X wrinkled (rr)
    - F_1 – All Round (Rr)
    - F_2 – ¾ Round : ¼ wrinkled
    - ¼ RR : ½ Rr : ¼ rr





- Phenotype

- Genotype

c. Law of Independent Assortment

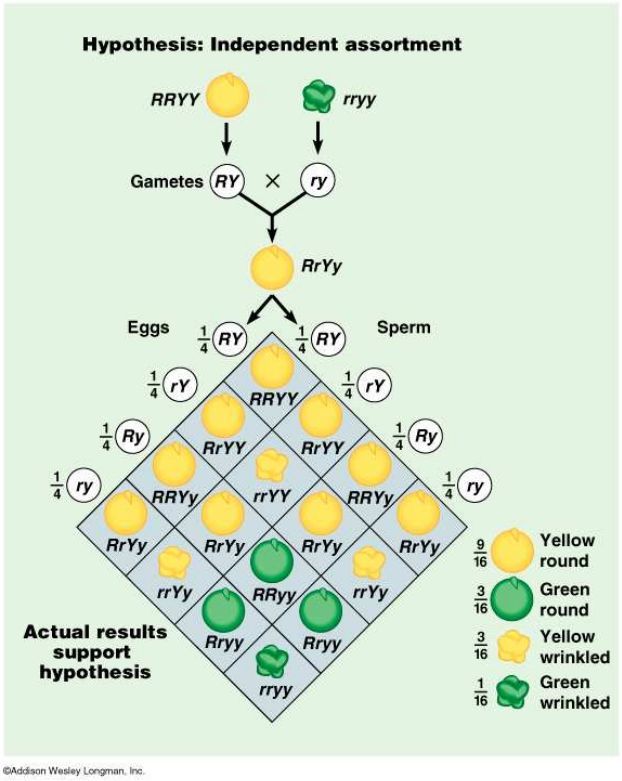
- Dihybrid Cross

- Cross-pollinated P_1's that bred true for two alternate traits
  - e.g., Round Yellow (RRYY) seeds X wrinkled green (rryy) seeds

- ALL F_1 are Round and Yellow (RrYy)

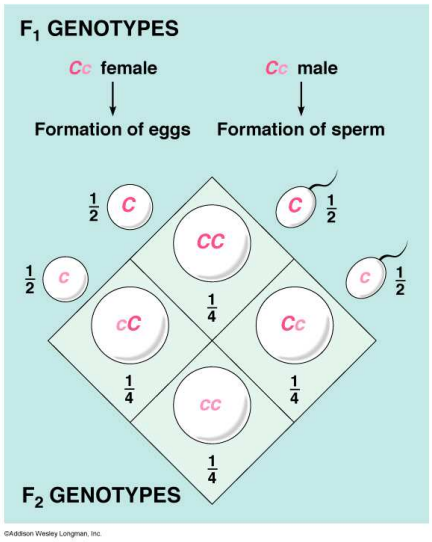
- F_1 self-pollinate

- F_2 offspring
  - 9/16 Round Yellow
  - 3/16 Round green
  - 3/16 wrinkled Yellow
  - 1/16 wrinkled green



d. Test Crosses

- Determines genotype of dominant plant
- Test individual crossed with recessive
  - Recessive must be homozygous

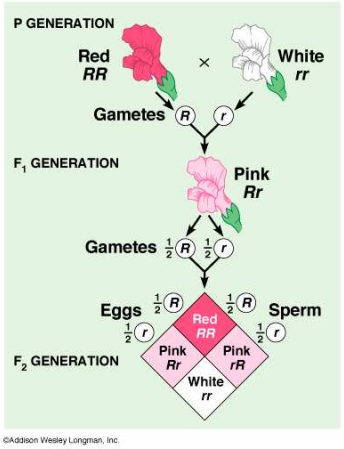


- Possibilities
- All offspring dominant
  - Test individual homozygous dominant

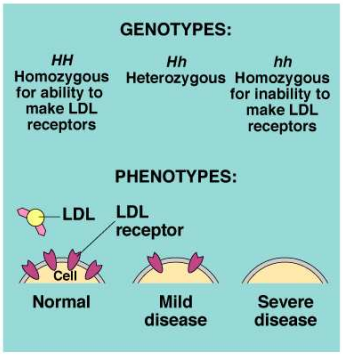
- ½ offspring dominant, ½ recessive
  - Test individual heterozygous

C. Beyond Mendelian Genetics
1. Other Levels of Dominance

- Incomplete dominance
  - e.g., red X white = pink



- Codominance



2. Multiple Alleles

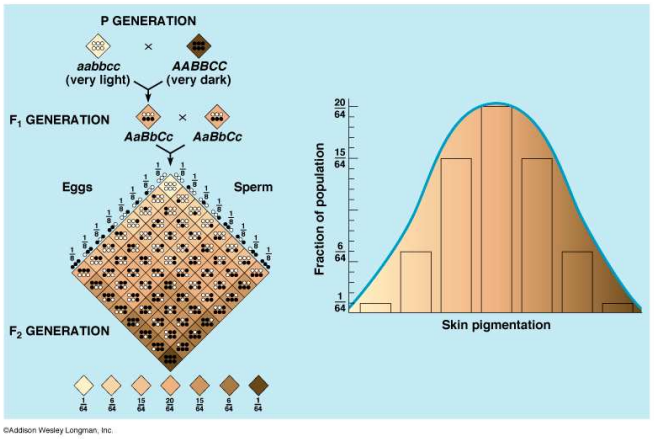
- e.g., ABO blood system
  - Three alleles present: I^A, I^B, i
    - I^A and I^B are codominant
    - Both I^A and I^B are dominant over i

3. Pleiotropy

- e.g., yellow mouse fur color gene
  - Trait 1 – Yellow fur (dominant)
  - Trait 2 – lethal effect (recessive)
    - Homozygous yy
    - Heterozygous Yy
    - Homozygous YY

4. Polygenic Traits

- e.g., seed color in wheat
  - Four genes with additive effect
  - Creates a continuum of traits



5. Epistasis

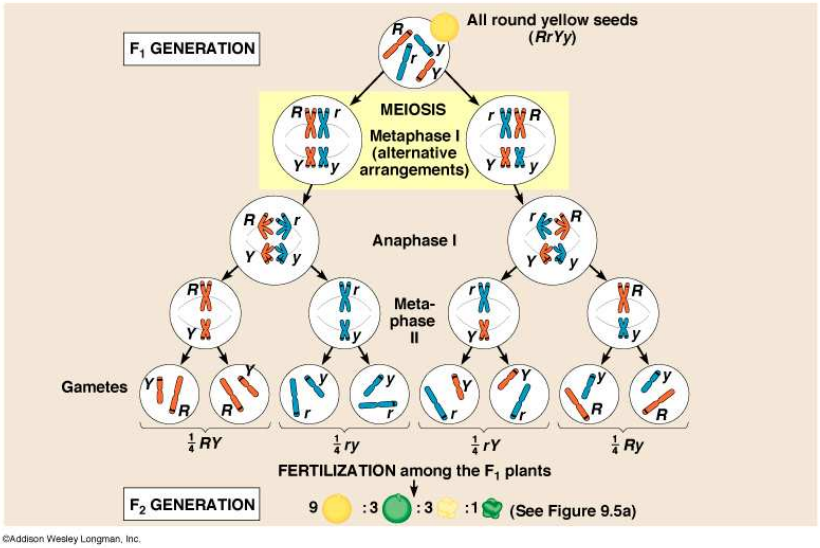
- e.g., mouse fur color
  - Locus 1
    - Color dominant over albino
  - Locus 2
    - Black dominant over brown
  - If locus 1 homozygous recessive (albino), locus two not expressed

6. External Factors

- Gene affected by environment
  - e.g., PKU
  - e.g., water plant leaf morphology
    - phenotypic plasticity

D. Chromosomal Inheritance

- Walter Sutton (1900's)
  - Independent assortment of chromosomes

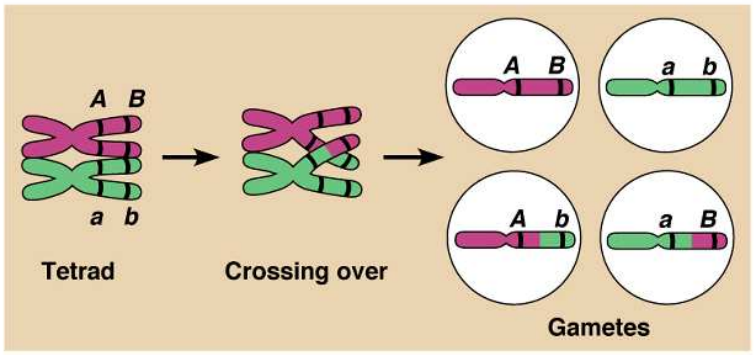


1. Linkage

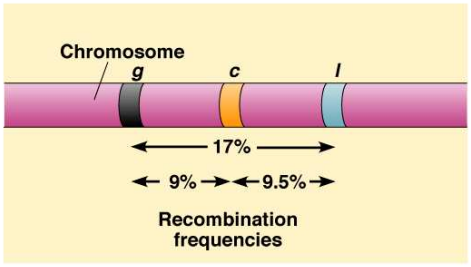
- Violates independent assortment
  - Phenotypic ratio not 9:3:3:1
  - Parental types too common

- Genes on same chromosome

- Crossing over allows rearrangement



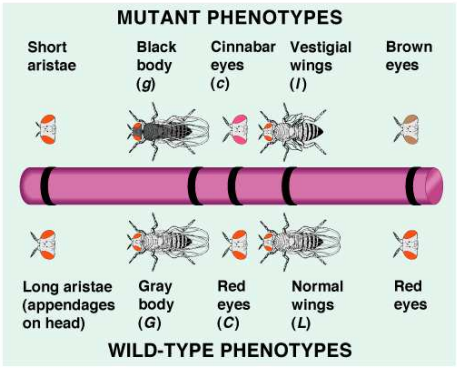
  - Recombination frequency



    - Determines distance between genes

    - Closer genes have lower frequencies

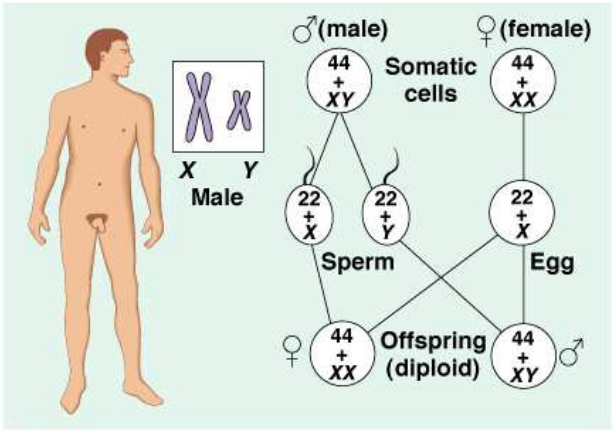
      - Used to map loci



E. Sex Determination

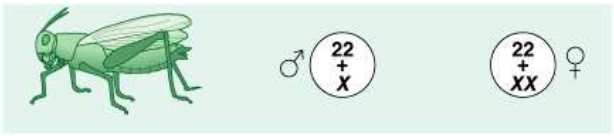
- Autosomes

- Sex chromosomes
  - X-Y system
    - XX – Female
    - XY – Male

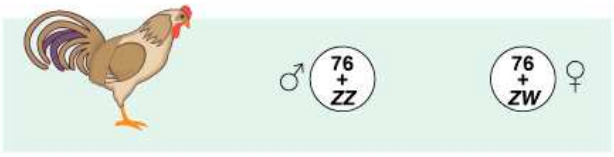


  - Z-W system
    - ZZ – Male
    - ZW – Female

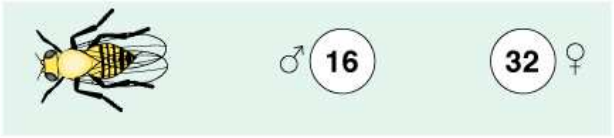
  - X-O system
    - O – absence of chromosome
    - XO – Male
    - XX – Female



  - Haplodiploidy
    - haploid – Male
    - diploid – Female



- Environmental Sex Determination



  - Sex switching

1. Sex Linkage

- Genes associated with gender
- X chromosome
  - Larger, carries many important genes
  - Found in all humans
- Y chromosome
  - Much smaller than X
  - Does not carry all genes on X
  - Carries maleness genes
- Some critical genes on X but not on Y
- Some illnesses more common in males
  - red-green colorblindness, hemophilia
    - Recessive traits
- Females
  - Expressed in homozygous recessive
  - Carrier – Heterozygous
- Males
  - Allele always expressed