Observable Patterns of Inheritance

A Smorgasbord of Ears and Other Traits

A. Observable characters such as attached or unattached earlobes are the result of genes that come in slightly different molecular forms called alleles.

B. Analysis of these observable traits all started with Gregor Mendel and some peas growing in his monastery garden.

I. Mendel's Insight into Patterns of Inheritance

A. Introduction

1. By the late nineteenth century, natural selection suggested that a population could evolve if members show variation in heritable traits. Variations that improved survival chances would be more common in each generation–in time, the population would change or evolve.

2. The theory of natural selection did not fit with the prevailing view of inheritance–blending.

a. Blending would produce uniform populations; such populations could not evolve.

b. Many observations did not fit blending–for example, a white horse and a black horse did not produce only gray ones.

3. Gregor Mendel used experiments in plant breeding and a knowledge of mathematics to form his hypotheses.

B. Mendel's Experimental Approach

1. Mendel used the garden pea in his experiments.

a. This plant can fertilize itself; true-breeding varieties were available to Mendel.

b. Peas can also be cross-fertilized by human manipulation of the pollen.

2. Mendel cross-fertilized true-breeding garden pea plants having clearly contrasting traits (example: white versus purple flowers).

C. Some Terms Used in Genetics

1. *Genes* carry encoded information about specific traits.

2. Each gene has a *locus* on a chromosome.

3. Diploid cells have two genes (a gene pair) for each trait–each on a *homologous chromosome.*

4. *Alleles* are various molecular forms of a gene for the same trait.

5. If *homozygous,* both alleles are the same.

6. If *heterozygous,* the alleles differ.

7. When heterozygous, one allele is *dominant* (*A*), and the other is *recessive* (*a*).

8. *Homozygous dominant* = *AA, homozygous recessive* = *aa,* and *heterozygous* = *Aa.*

9. *Genotype* is the sum of the genes, and *phenotype* is how the genes are expressed.

II. Mendel's Theory of Segregation

A. Predicting Outcomes of Monohybrid Crosses

1. Mendel's first experiments were monohybrid crosses.

a. Monohybrid crosses have two parents that are true-breeding for contrasting forms of a trait.

b. One form of the trait disappears in the first generation (*F*1), only to show up in the second generation.

c. We now know that all members of the first generation are heterozygous because one parent could produce only an *A* gamete and the other could produce only an *a* gamete.

2. Results of the *F*2 generation required mathematical analysis.

a. The numerical ratios of crosses suggested that genes do not blend.

b. For example, the *F*2 offspring showed a 3:1 phenotypic ratio.

c. Mendel assumed that each sperm has an equal probability of fertilizing an egg. This can be seen most easily by using the Punnett square.

d. Thus, each new plant has three chances in four of having at least one dominant allele.

3. The Mendelian theory of segregation states that diploid organisms inherit two genes per trait, and each gene segregates from the other during meiosis such that each gamete will receive only one gene per trait.

B. Testcrosses

1. To support his concept of segregation, Mendel crossed $F1$ plants with homozygous recessive individuals.

2. A 1:1 ratio of recessive and dominant phenotypes supports his hypothesis.

III. Independent Assortment

A. Predicting Outcomes of Dihybrid Crosses

1. Mendel also performed experiments involving two traits–a dihybrid cross.

a. Mendel correctly predicted that all $F1$ plants would show both of the dominant alleles (example: all purple flowers and all tall plants).

b. Mendel wondered if the genes for flower color and plant height would travel together when two $F1$ plants were crossed.

2. The $F2$ results showed 9/16 were tall and purple-flowered and 1/16 were dwarf and white-flowered–as were the original parents; however, there were 3/16 each of two new combinations: dwarf purple-flowered and tall white-flowered.

B. The Theory in Modern Form

1. We now know that genes located on *non*homologous chromosomes segregate independently of each other and give the same phenotypic ratio as Mendel observed: 9:3:3:1.

2. The Mendelian theory of independent assortment states that each gene of a pair tends to assort into gametes independently of other gene pairs located on nonhomologous chromosomes.

IV. Dominance Relations

A. Incomplete Dominance,

1. This is condition in which the dominant allele cannot completely mask the expression of another

2. For example: red-flowered snapdragons crossed with white ones yield pink.

B. ABO Blood Types: A Case of Codominance

1. In codominance, both alleles are expressed in heterozygotes .

2. Blood type is determined by markers produced by three genes–a multiple allele system.

a. *IA* and *IB* are each dominant to *i,* but are codominant to each other.

b. Therefore, some persons can express both genes and have AB blood.

V. Multiple Effects of Single Genes

A. Pleiotropy occurs when a single gene affects unrelated aspects of the phenotype.

B. The gene for sickle-cell anemia codes for a variant form of hemoglobin. The altered hemoglobin in turn affects the shape of the red blood cells, which clump together and block capillaries. Impaired gas flow damages tissues.

VI. Interactions Between Gene Pairs

A. Epistasis is a condition in which one gene pair masks the expression of another gene.

B. Hair Color in Mammals

1. The black, brown, or yellow fur color in Labrador retrievers is the result of variations in the amount and distribution of the pigment melanin.

2. The alleles of one gene control the production of melanin (black and brown) while another specifies its deposition (less of the pigment results in the yellow color).

C. Comb Shape in Poultry

1. In some cases of epistasis, interaction between two gene pairs results in

a phenotype the neither pair can produce alone.

2. Various allelic combinations can produce combs with names like single, rose, pea, and walnut.

VII. How Can We Explain Less Predictable Variations?

A. Regarding the Unexpected Phenotype

1. Different combinations of alleles may interact differently in some individuals than in others.

2. Campodactyly can show up in one, both, or neither hand.

B. Continuous Variation in Populations

1. Mendel's traits show discontinuous variation because they belonged to one or more clear classes.

2. Most traits are not qualitative but show continuous variation and are transmitted by quantitative inheritance; example: height in humans..

VIII. Examples of Environmental Effects on Phenotype

A. Environmental temperature affects a heat-sensitive enzyme necessary for melanin deposition in the fur of Siamese cats.

B. The acidity of the soil will influence the flower color in hydrangea plants.