12.1: Mendel's Experiments and the Laws of Probability

In 1865, Mendel presented the results of his experiments with nearly 30,000 pea plants to the local Natural History Society. He demonstrated that traits are transmitted faithfully from parents to offspring independently of other traits and in dominant and recessive patterns.

Review Questions

Mendel performed hybridizations by transferring pollen from the _______ of the male plant to the female ova.

1. anther
2. pistil
3. stigma
4. seed

Which is one of the seven characteristics that Mendel observed in pea plants?

1. flower size
2. seed texture
3. leaf shape
4. stem color
Imagine you are performing a cross involving seed color in garden pea plants. What F₁ offspring would you expect if you cross true-breeding parents with green seeds and yellow seeds? Yellow seed color is dominant over green.

1. 100 percent yellow-green seeds
2. 100 percent yellow seeds
3. 50 percent yellow, 50 percent green seeds
4. 25 percent green, 75 percent yellow seeds

Consider a cross to investigate the pea pod texture trait, involving constricted or inflated pods. Mendel found that the traits behave according to a dominant/recessive pattern in which inflated pods were dominant. If you performed this cross and obtained 650 inflated-pod plants in the F₂ generation, approximately how many constricted-pod plants would you expect to have?

1. 600
2. 165
3. 217
4. 468

**Free Response**

Describe one of the reasons why the garden pea was an excellent choice of model system for studying inheritance.

The garden pea is sessile and has flowers that close tightly during self-pollination. These features help to prevent accidental or unintentional fertilizations that could have diminished the accuracy of Mendel’s data.

How would you perform a reciprocal cross for the characteristic of stem height in the garden pea?

Two sets of P₀ parents would be used. In the first cross, pollen would be transferred from a true-breeding tall plant to the stigma of a true-breeding dwarf plant. In the second cross, pollen would be transferred from a true-breeding dwarf plant to the stigma of a true-breeding tall plant. For each cross, F₁ and F₂ offspring would be analyzed to determine if offspring traits were affected according to which parent donated each trait.

**12.2: Characteristics and Traits**

The genetic makeup of peas consists of two similar or homologous copies of each chromosome, one from each parent. Each pair of homologous chromosomes has the same linear order of genes; hence peas are diploid organisms. The same is true for many other plants and for virtually all animals. Diploid organisms utilize meiosis to produce haploid
gametes, which contain one copy of each homologous chromosome that unite at fertilization to create a diploid zygote.

**Review Questions**

The observable traits expressed by an organism are described as its ________.

1. phenotype
2. genotype
3. alleles
4. zygote

A

A recessive trait will be observed in individuals that are ________ for that trait.

1. heterozygous
2. homozygous or heterozygous
3. homozygous
4. diploid

C

If black and white true-breeding mice are mated and the result is all gray offspring, what inheritance pattern would this be indicative of?

1. dominance
2. codominance
3. multiple alleles
4. incomplete dominance

D

The ABO blood groups in humans are expressed as the $I^A$, $I^B$, and $i$ alleles. The $I^A$ allele encodes the A blood group antigen, $I^B$ encodes B, and $i$ encodes O. Both A and B are dominant to O. If a heterozygous blood type A parent ($I^Ai$) and a heterozygous blood type B parent ($I^Bi$) mate, one quarter of their offspring will have AB blood type ($I^AI^B$) in which both antigens are expressed equally. Therefore, ABO blood groups are an example of:

1. multiple alleles and incomplete dominance
2. codominance and incomplete dominance
3. incomplete dominance only
4. multiple alleles and codominance

D

In a mating between two individuals that are heterozygous for a recessive lethal allele that is expressed in utero, what
genotypic ratio (homozygous dominant:heterozygous:homozygous recessive) would you expect to observe in the offspring?

1. 1:2:1
2. 3:1:1
3. 1:2:0
4. 0:2:1

C

Free Response

The gene for flower position in pea plants exists as axial or terminal alleles. Given that axial is dominant to terminal, list all of the possible F1 and F2 genotypes and phenotypes from a cross involving parents that are homozygous for each trait. Express genotypes with conventional genetic abbreviations.

Because axial is dominant, the gene would be designated as A. F1 would be all heterozygous Aa with axial phenotype. F2 would have possible genotypes of AA, Aa, and aa; these would correspond to axial, axial, and terminal phenotypes, respectively.

Use a Punnett square to predict the offspring in a cross between a dwarf pea plant (homozygous recessive) and a tall pea plant (heterozygous). What is the phenotypic ratio of the offspring?

The Punnett square would be 2 × 2 and will have T and T along the top, and T and t along the left side. Clockwise from the top left, the genotypes listed within the boxes will be Tt, Tt, tt, and tt. The phenotypic ratio will be 1 tall:1 dwarf.

Can a human male be a carrier of red-green color blindness?

No, males can only express color blindness. They cannot carry it because an individual needs two X chromosomes to be a carrier.

12.3: Laws of Inheritance

Mendel generalized the results of his pea-plant experiments into four postulates, some of which are sometimes called “laws,” that describe the basis of dominant and recessive inheritance in diploid organisms. As you have learned, more complex extensions of Mendelism exist that do not exhibit the same F2 phenotypic ratios (3:1). Nevertheless, these laws summarize the basics of classical genetics.

Multiple Choice

Assuming no gene linkage, in a dihybrid cross of AABB x aabb with AaBb F1 heterozygotes, what is the ratio of the F1 gametes (AB, aB, Ab, ab) that will give rise to the F2 offspring?

1. 1:1:1:1
2. 1:3:3:1
3. 1:2:2:1
4. 4:3:2:1

A

The forked line and probability methods make use of what probability rule?

1. test cross
2. product rule
3. monohybrid rule
4. sum rule

B

How many different offspring genotypes are expected in a trihybrid cross between parents heterozygous for all three traits when the traits behave in a dominant and recessive pattern? How many phenotypes?

1. 64 genotypes; 16 phenotypes
2. 16 genotypes; 64 phenotypes
3. 8 genotypes; 27 phenotypes
4. 27 genotypes; 8 phenotypes

D

Free Response

Use the probability method to calculate the genotypes and genotypic proportions of a cross between AABBCc and Aabbcc parents.

Considering each gene separately, the cross at A will produce offspring of which half are AA and half are Aa; B will produce all Bb; C will produce halfCc and half cc. Proportions then are (1/2) × (1) × (1/2), or 1/4 AABbcc; continuing for the other possibilities yields 1/4 AABbCc, 1/4 AaBbCc, and 1/4 AaBbcc. The proportions therefore are 1:1:1:1.

Explain epistasis in terms of its Greek-language roots “standing upon.”

Epistasis describes an antagonistic interaction between genes wherein one gene masks or interferes with the expression of another. The gene that is interfering is referred to as epistatic, as if it is “standing upon” the other (hypostatic) gene to block its expression.

In Section 12.3, “Laws of Inheritance,” an example of epistasis was given for the summer squash. Cross white WwYy heterozygotes to prove the phenotypic ratio of 12 white:3 yellow:1 green that was given in the text.

The cross can be represented as a 4 × 4 Punnett square, with the following gametes for each parent: WY, Wy, wY, and wy. For all 12 of the offspring that express a dominant W gene, the offspring will be white. The three offspring that are
homozygous recessive for \( w \) but express a dominant \( Y \) gene will be yellow. The remaining \( wyy \) offspring will be green.