

Teacher Preparation Notes for Dragon Genetics -- Independent Assortment and Genetic Linkage

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This activity is designed for students who already understand mitosis, meiosis, fertilization, and basic genetics. Useful activities for introducing these topics are "Mitosis, Meiosis and Fertilization" and "Genetics", both available on this web site.

Preparations of Popsicle Stick Chromosomes

Each popsicle stick represents a pair of homologous chromosomes, with the alleles of one of the homologous chromosomes on one side of the popsicle stick and the alleles of the other homologous chromosome on the other side of the popsicle stick. The appropriate alleles can be written directly on each side of the popsicle stick. Alternatively, a strip of paper with the alleles of one of the chromosomes can be pasted on one side of the popsicle stick, and a strip with the alleles of the other homologous chromosome can be pasted on the other side of the popsicle stick.

For the Law of Independent Assortment activity, each student will need two popsicle sticks, representing the two pairs of homologous chromosomes for the mother. One popsicle stick will have a W on one side of the popsicle stick and a w on the other side, representing the heterozygous wing genes. The other popsicle stick will have a H on one side of the popsicle stick and an h on the other side of the popsicle stick, representing the heterozygous horn genes.

For the Genetic Linkage activity (especially 3 on page 8 of the student handout), students may find it useful to have a set of four popsicle sticks, two representing the two pairs of homologous chromosomes in the heterozygous father and two representing the two pairs of homologous chromosomes in the homozygous mother. For the father, the first popsicle stick will have WFN on one side and wfn on the other side (see page 7 of the student handout). The second popsicle stick will be the same as for the previous activity, with H on one side and h on the other. For the mother, the first popsicle stick will have wfn on both sides, and the second popsicle stick will have h on both sides.

The last two pages of these teacher preparation notes provide templates which can be photocopied to prepare strips of paper for gluing onto the popsicle sticks. In each case, adjacent columns of letters represent pairs of homologous chromosomes to be glued on opposite sides of a popsicle stick. To prevent the strips from coming loose from the popsicle sticks during the activity, apply a good glue carefully and thoroughly. One copy of page 3 will provide enough strips to make 12 pairs of popsicle sticks for the Law of Independent Assortment activity. One copy of the last page will provide enough strips to make six sets of three chromosomes, which together with the Hh chromosomes from the previous activity will provide six sets of the four chromosomes to help students understand the mating analyzed in the Genetic Linkage activity.

¹ These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron.

Discussion

The Law of Independent Assortment activities help students to understand that genes located on two separate chromosomes are inherited independently. First, the basis for understanding the Law of Independent Assortment is developed by analyzing expected outcomes of meiosis and fertilization. Then, a simulation of the Law of Independent Assortment is provided by a hands-on activity which uses popsicle sticks to simulate the behavior of two pairs of homologous chromosomes during meiosis 1, with modified Punnett squares to tabulate the genotypes and phenotypes of the resultant fertilizations. Then, question 4 (on page 6 of the student handout) illustrates one application of the Law of Independent Assortment to human genetics, namely, that both sexes are equally likely to inherit an autosomal genetic condition such as sickle cell anemia.

The second activity illustrates genetic linkage (without crossing over) and contrasts patterns of inheritance for closely linked genes (e.g. no new combinations of alleles) vs. independent assortment.

In both activities, one of the parents is homozygous recessive so that the genotypes of the gametes of the other parent have a clear effect on phenotypic characteristics (similar to the use of a homozygous recessive individual in making a test cross). Thus, these activities can be used to reinforce the test cross concept.

Teaching Points

- The inheritance of multiple genes can be predicted by understanding the behavior of chromosomes during meiosis and fertilization.
- The Law of Independent Assortment states that, if two genes are on different chromosomes, then the alleles for these genes separate independently of each other during the formation of eggs or sperm. Therefore, the traits determined by these two genes are inherited independently.
- Genetic linkage occurs because genes that are located near each other on the same chromosome move together during meiosis and fertilization.
- Inheritance in real animals and plants is much more complex than the examples in this hands-on activity.

Chromosomes for Law of Independent Assortment Activity

W w W w W w W w W w W w

W w W w W w W w W w W w

H h H h H h H h H h H h

H h H h H h H h H h H h

Chromosomes for Gene Linkage Activity

W w W w W w W w W w W w
F f F f F f F f F f F f F f
N n N n N n N n N n N n

w w w w w w w w w w w w
f f f f f f f f f f f f
n n n n n n n n n n n n

h h h h h h h h h h h h
