

Maternal Inheritance Effect in Pigment Expression of *Brassica rapa*

Name

Partner's Name

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Abstract

Extranuclear inheritance through the independent genetic codes of some organelles leads to non-Mendelian expression of traits. In this lab, we explored the phenomenon of extranuclear inheritance in a stock of *Brassica rapa* plants with a mutant phenotype. These plants express variegated leaf color with patches of white and green appearing in the tissue of the leaves and stems. We performed crosses between the variegated and wildtype plants. The F1 generation was scored for variegation with the result that variegated females mated with wildtype males gave rise to all variegated offspring while the reciprocal cross produced wildtype plants. This indicates that variegation is passed by maternal inheritance through the chloroplasts present in the cytosol of the egg rather than through the chromosomal genes.

Introduction

Mitochondria and chloroplasts have their own genetic material. These organelles are not coded for in any organism's genome but are passed to progeny cells in the cytosol. Thus any attribute expressed by these organelles will be inherited independently of the nuclear complement of genetic material. An example in humans is the disease myoclonic epilepsy. This disease is caused by a mutation in a tRNA gene in mitochondria. The mutation causes formation of incorrect protein structures that crystallize within the mitochondria. (1) The presence of the crystals coupled with the fact that proper tRNA is crucial to translation means that the mutation affects the synthesis of any protein within the mitochondrion. The combined effect of all the affected pathways is a disease phenotype with a range of symptoms including seizures, deafness, and dementia. Because the disease is linked to a mutation present within the genes of the mitochondria it is passed on to offspring in a different way than most traits. When sperm and egg fuse to form a zygote, the sperm essentially injects its DNA into the egg. The egg, however, contains a full complement of organelles such as mitochondria. The mitochondria proliferate giving rise to more of themselves. Thus, in an adult the lineage of an individual mitochondrion can be traced to one of those present in the cytosol of the egg. So, the inheritance of myoclonic epilepsy is unilateral being determined by the genotype of the mother's mitochondria. This is called maternal inheritance.

We wanted to examine a possible maternal inheritance pattern in *Brassica rapa*. We obtained seeds of a mutant stock and grew them under conditions conducive to fast growth. The particular stock we used was selected for a mosaic patterning of the pigment in its leaves and stems. The plants expressing this mutant phenotype appear as white in some cases, and with patches of white and green in others. We also grew up a stock of wildtype plants that were consistently green. When the plants were mature we made crosses between the

populations of plants. These crosses were made in a reciprocal fashion so that we produced seeds in which the male was wildtype and the female was mutant and in which the male was mutant and the female wildtype. In a Mendelian pattern of inheritance the two crosses would result in matching phenotypic ratios. This was not the case with the variegation trait in Brassica. Instead when we grew the F1 generation and scored the phenotypes, we found that crosses in which the mother was wildtype, all the offspring developed as non-variegated. On the other hand, the seeds from the wildtype father and variegated mother produced about 60% variegated and 40% non-variegated offspring. This confirmed that the variegated phenotype was passed through maternal inheritance.

Materials and methods

The protocol for the experiment was taken directly from Non-Mendelian Genetics: Maternal Inheritance of Variegation. (2) Pollination was carried out by removing anthers from mature plants and directly transferring pollen to the stigma of plants of the opposite phenotype.

Results

The following chart displays the data from our scoring of the plants arising from the seeds produced by our reciprocal cross.

CROSSES	F1 OFFSPRING		
	variegated	non-variegated	total
Non variegated female X variegated male	0	14	14
Variegated female X non-variegated male	16	11	27

Discussion

Our data clearly demonstrated the maternal inheritance pattern. Had the trait been controlled by a recessive gene, we would have expected a 3:1 ratio of phenotypes. Had the trait been controlled by a dominant nuclear gene, we would have seen no variegated offspring because the gene would only have come from one side. In either of the two previous scenarios, we would have had the same segregation pattern regardless of the direction of the cross. Our outcome makes sense because the Brassica plant pigmentation is dictated by the chloroplasts present in its leaves. As discussed earlier, chloroplasts express a set of genetic information independent of the nuclear DNA. Because of the mechanics of fertilization, practically all the chloroplasts in a zygote will come from the egg and therefore from the mother plant. So, the way the chloroplasts are segregated

into the egg cell is what is important in producing the variegated pattern. If there are a few white chloroplasts and many green ones then, the offspring will likely be only somewhat variegated. If the chloroplast numbers are more even the variegation will be more even. If all of the chloroplasts are white, then the arising plant will have a white phenotype. These plants live long enough to be scored, but are not viable because the pigment is related to photosynthesis and the mutation prevents the plant from making food.

References:

1. Hartl D. L., Jones E. W., (1998) *Genetics: Principles and Analysis* Extranuclear Inheritance, Jones and Bartlett Publishers. pp 599 - 604
2. Non-Mendelian Genetics: Maternal Inheritance of Variegation Student Worksheet. Biology 163, UNC Chapel Hill