Quadrant II – Transcript and Related Materials

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Module Name: Characteristics of extra-chromosomal inheritance and Cytoplasmic inheritance in *Mirabilis jalapa*

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Notes:

Introduction

Outside the nucleus, DNA is found in the mitochondrion and the chloroplast. Cytoplamic inheritance is the transmission of genes that occur outside the nucleus. It is found in most eukaryotes and is commonly known to occur in cytoplasmic organelles such as mitochondria and chloroplasts.These two autonomous cell organells have their own genetic material. The genes in these mitochondrial and chloroplast genomes are known as extranuclear genes, extrachromosomal genes, cytoplasmic genes, non-Mendelian genes, or organellar genes. These non-Mendelian, extranuclear genes do not follow the rules of Mendelian inheritance, as do nuclear genes. Cytoplasm is inherited

from the mother in many organisms, so the inheritance of extranuclear genes in these organisms is strictly maternal.

Characteristics of cytoplasmic inheritance:

1. **Reciprocal differences:** Reciprocal crosses show marked differences for the characters governed by plasmagenes. In most cases, plasmagenes from only one parent, generally the female parent are transmitted, this phenomenon is known as uniparental inheritance.

2. **Lack of segregation**: In general, F2 F3 and the subsequent generations do not show segregation for a cytoplasmically inherited trait. This is because the f1 individuals generally receive plasma genes from one parent only.

3. **Irregular segregation in biparental inheritance:** In some cases, plasma genes from both the parents are transmitted to the progeny, this is known as biparental inheritance.

4. **Somatic segregation**: Plasma genes generally show somatic segregation during mitosis, a feature of rare occurrence in the case of nuclear genes.

5. **Association with organelle DNA:** Several plasma genes have been shown to be associated with cp-DNA or mt-DNA.

6. **Nuclear transplantation:** If nuclear transplantation revealas a trait to be governed by the genotype of cytoplasm and not by that of nucleus, cytoplasmic inheritance of the trait is strongly indicated. In nuclear transplantation, nucleus of a cell is removed and replaced by a nucleus of another genotype from a different cell. Generally nuclei of somatic cells are transplanted into zygotes before the first mitotic division is initiated.

7. **Transfer of nuclear genome through back crosses:** The nucleus of a variety or species may be transferred into the cytoplasm of another species or variety through repeated back crossing with the former, which is used as the recurrent male parent. Lines produced in this way are known as alloplasmic lines since they have nuclei and cytoplasms from two different species. A comparison of the various characters of alloplasmic lines with those of the corresponding euplasmic line (lines having nuclei and cytoplasms from the same species) demonstrates cytopalsmic effects, if any on these traits. This technique is time consuming, but extremely powerful; it has been extensively used to study the cytopalsmic differentiation during evolution.

8. **Mutagenesis:** Some mutagens eg: Ethidium bromide are highly specific mutagens for plasma genes while nuclear genes are not affected by them.Induction of mutation by such agenets in a gene indicates it to be a plasma gene.

9**. Lack of chromosomal location**: In many organism, extensive linkage maps of nuclear genes are available. If a gene is shown to be located in one of these linkage groups, it cannot be a plasma gene. Failure to demonstrate the location of a gene in one of the linkage groups of an organism is indicative of its cytoplasmic location, but this is highly tentative.

10. **Lack of association with a parasite, symbiont or virus:** In many cases, a cytoplasmically inherited character is associated with a parasite, symbiont or virus present in the cytoplasm of the organism. Such cases cannot be regarded as cases of cytoplamic inheritance. Only those cytoplasmically inherited characters which are not associated with parasites, symbionts or viruses can be regarded as governed by plasma genes.

11. Plastid inheritance: The inheritance pattern of plastid characters due to plasma genes located in plastid is known as plastid inheritance. Plastid inheritance was first case of cytoplasmic inheritance to be discovered independently by Correns and Baur in 1908.

Inheritance of plastids in *Mirabilis jalapa*:

Plastid inheritance means the inheritance of plastid characteristics due to plasma genes located in plastids. Plastid inheritance was first described by C. Corens (1908) in the four o'clock plant, *Mirabilis jalapa*.

Leaves of *Mirabilis jalapa* may be green, white or variegated and some branches may have only green, only white or only variegated leaves. Variegation means the presence of white or yellow spots of variable size on the green background of leaves.

Thus it forms the mosaic pattern of coloration on a leaf. Due to certain inheritable defects chloroplast of all cells or some cells of leaf often are unable to synthesize the chlorophyll pigments. Such cells remain non- green and form white or yellow coloured leaf, or white or yellow patches, interspersed with areas containing normal green cells with healthy chloroplasts.

In M. jalapa, leaves may be green, white or variegated. Some branches may have only green, only white or only variegated leaves. Correns made crosses in all possible combinations among the flowers produced on these three types of branches.

The results obtained from various crosses of leaf phenotypes of *Mirabilis jalapa*, clearly indicates that leaf phenotype of the progeny is the same as that of the female parent The phenotype of male parent did not contribute anything to the progeny. When green was used as female and either green,

white or variegated as male, all individuals in F_1 were green. When white was used as female and either green, white or variegated as male, all individuals in F_1 were white. When variegated was used as female and either green, white or variegated as male, various proportions of green, white and variegated individuals were obtained in F_1

This phenomenon is referred to as uniparental transmission. Again, the results of the crosses of *Mirabilis jalapa* cannot be explained by sex-linkage.

The inheritance of different leaf colours in *Mirabilis jalapa* might be explained if the plastids are somehow autonomous and are never transmitted through male parent. For an organelle to be genetically autonomous, it must be provided with its own genetic determinants that are responsible for its phenotype.

Since the bulk amount of cytoplasm containing many plastids is contributed by the egg and the male gametes contribute negligible amount of cytoplasm, therefore plastids present in the cytoplasm of egg is responsible for the appearance of maternal colour in the offspring and the failure of male plant to transmit its colour to offspring is reasonable.

In the offspring from variegated female parents, green, white and variegated progeny are recovered in variable proportions. The variegated parent produces three kinds of egg- some with colourless plastids, some contains only green plastids, and some are with both chloroplasts and leucoplasts.

As a result, zygotes derived from these three types of egg cells will develop into green, white and variegated offspring's, respectively.