Cytoplasmic Inheritance

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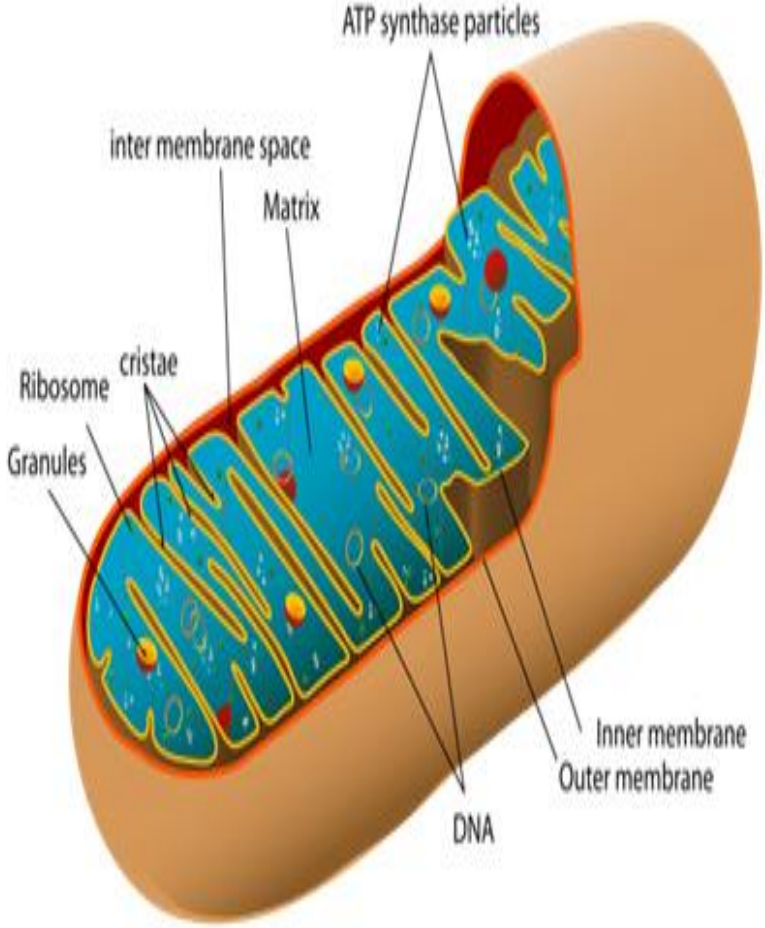
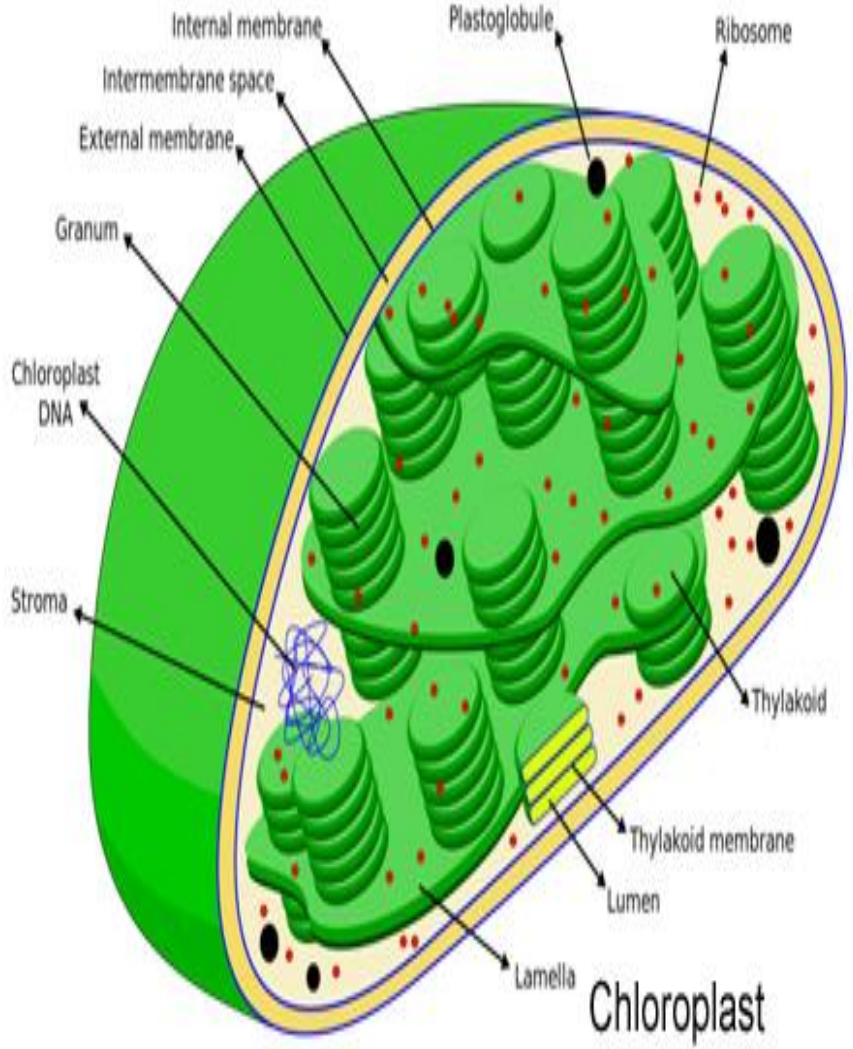
BOT – CPT 2.2 Cell Biology, Genetics and Biostatistics



Mitochondria



Chloroplast

Chloroplast inheritance

- Extra-nuclear inheritance is also associated with certain cytoplasmic organelles (mitochondria, plastids) that contain naked circular DNA and protein synthesizing apparatus.

Plastid Inheritance in Mirabilis:

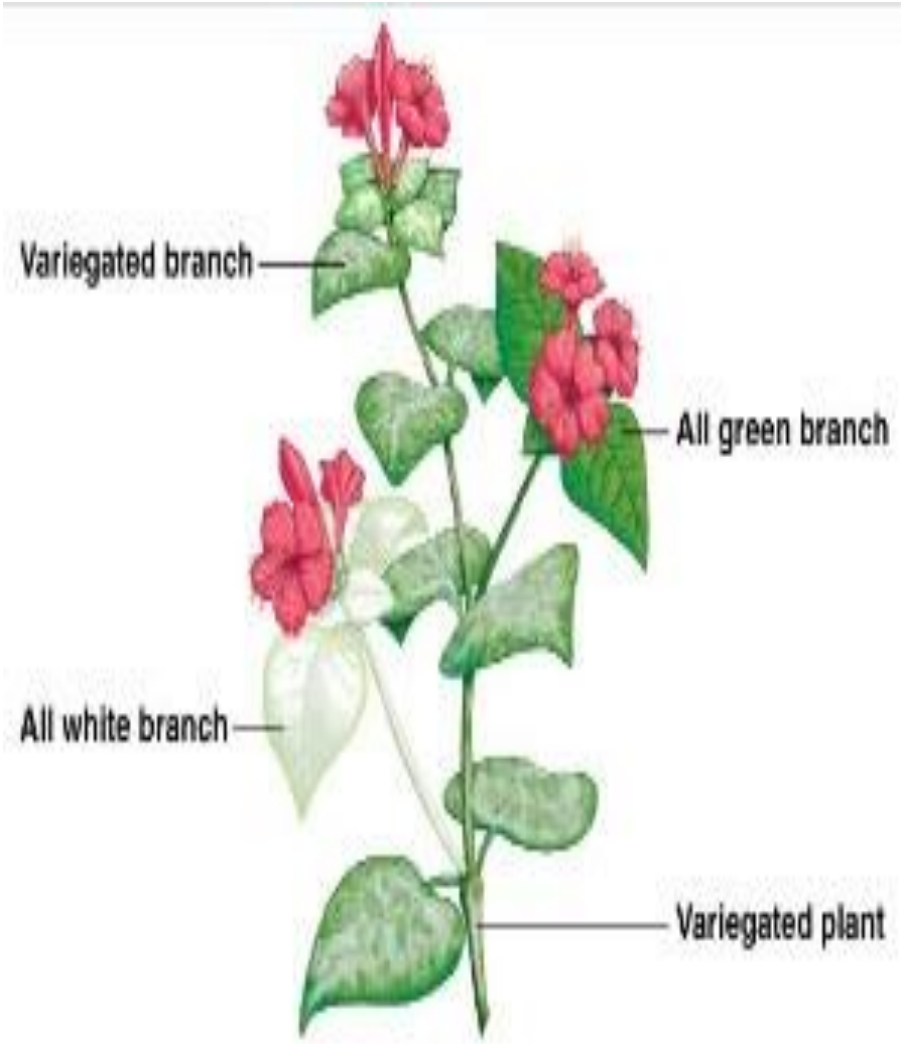
- Plastid inheritance means the inheritance of plastid characteristics due to plasma genes located in plastids.
- Plastid inheritance was first described by C. Corens (1908) in the four o'clock plant, *Mirabilis jalapa*.
- Leaves of Mirabilis jalapa may be green, white or variegated and some branches 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.

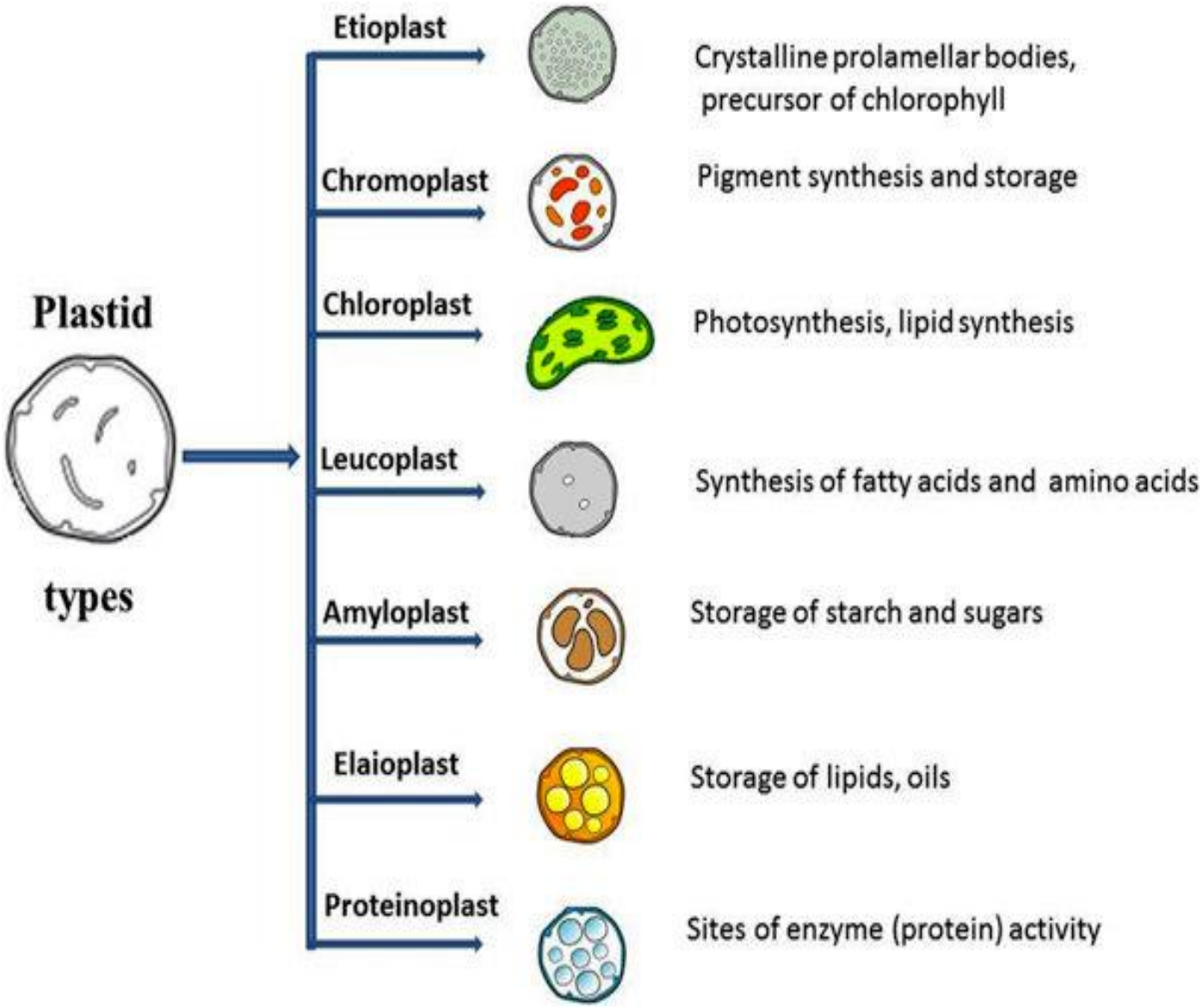
Variegation may be produced by:

(a) Some environmental factors,

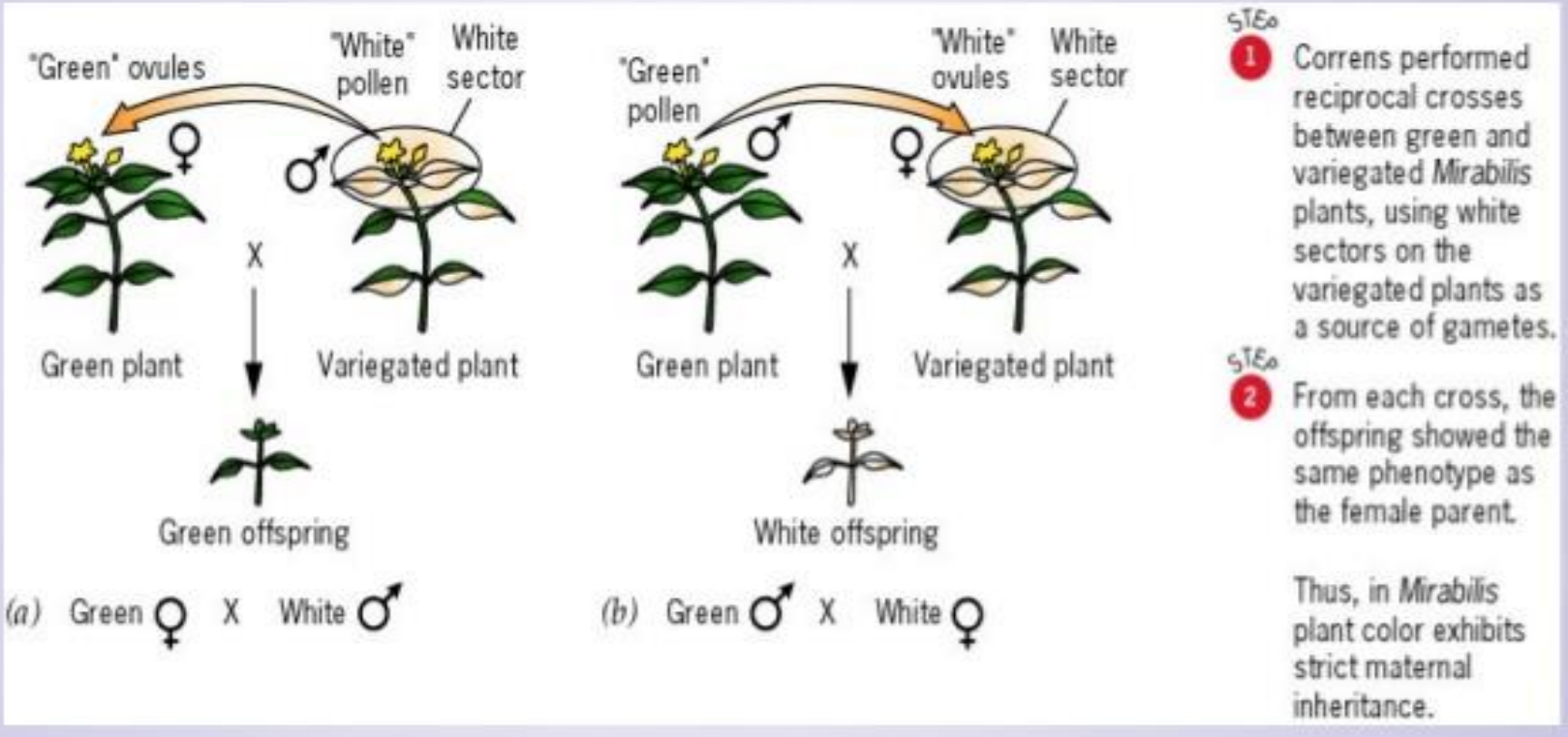
(b) Some nuclear genes,

(c) Plasma-genes in some cases.




Plastid
types
Etioplast
Crystalline prolamellar bodies, precursor of chlorophyll
Chromoplast
Pigment synthesis and storage
Chloroplast
Photosynthesis, lipid synthesis
Leucoplast
Synthesis of fatty acids and amino acids
Amyloplast
Storage of starch and sugars
Elaioplast
Storage of lipids, oils
Proteinoplast
Sites of enzyme (protein) activity

C. CORRENS experiment…



STEP 1 Correns performed reciprocal crosses between green and variegated *Mirabilis* plants, using white sectors on the variegated plants as a source of gametes.

STEP 2 From each cross, the offspring showed the same phenotype as the female parent.

Thus, in *Mirabilis* plant color exhibits strict maternal inheritance.

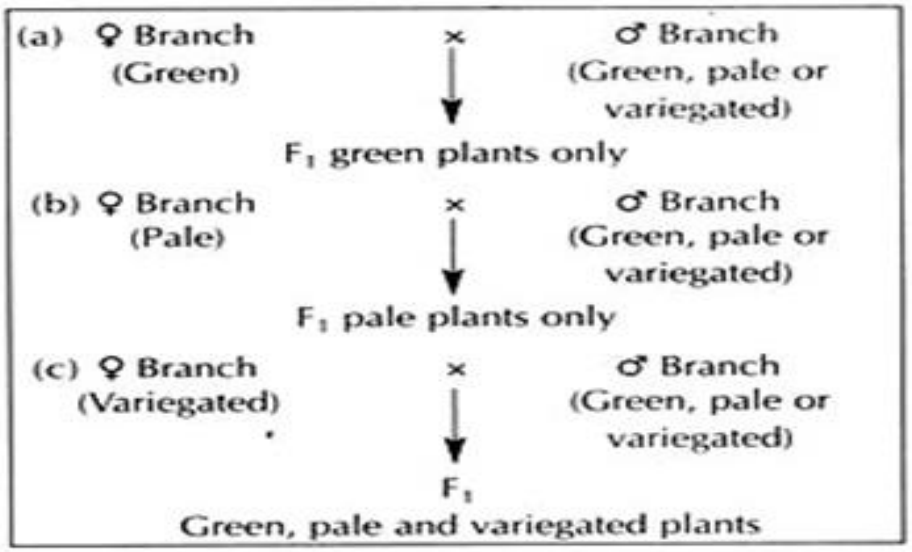


Fig. 10.2: Plastid inheritance in four o'clock showing dependence on the nature of female branch

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.

- 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.

Inheritance of Lojap Trait in Maize:

- In maize plant, iojap is a trait which produces green and white stripped leaves. This trait is controlled by a recessive chromosomal gene (ij) when present in homozygous state. The name iojap was derived from ‘Iowa’ state (USA), the source of maize strain and japonica, the name of a stripped variety.

- When a normal plant with green leaves used as a female parent is crossed with ioja parent, the offspring will be green leaved Again, when a reciprocal cross is made between a normal green plant (used as male) and iojap plant (used as female).
- In iojap plants, green and white stripped trait of leaf is inherited from the female parent due to maternal inheritance. It seems that iojap plants contain two types of plastids— normal green, and abnormal iojap plastids.

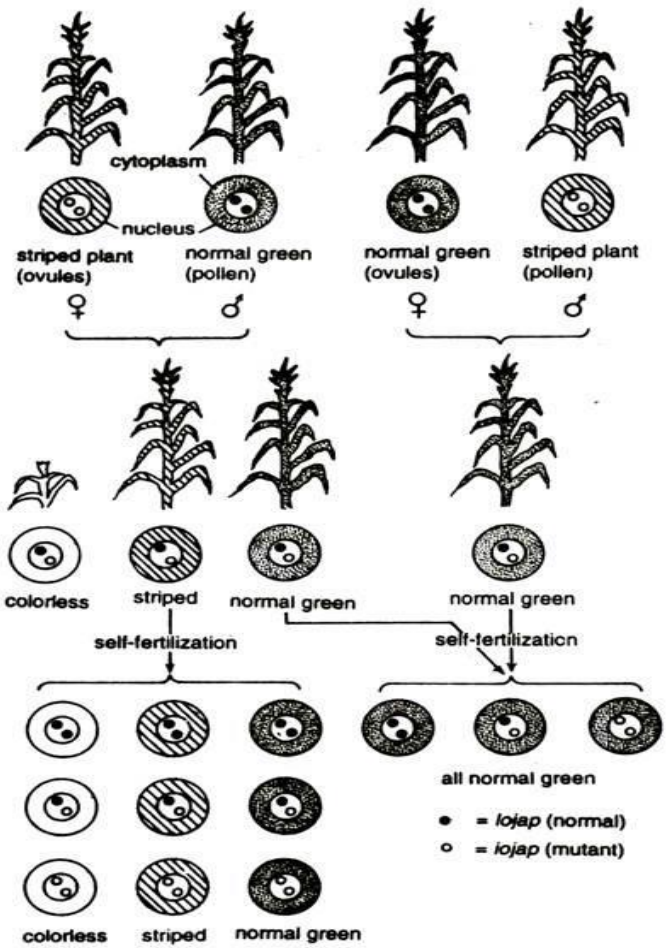


Fig. 22.4: Inheritance of lojap trait in maize.

- During the formation of egg cells plastids are randomly distributed in the egg cells. If the egg cell receives normal green plastids it will produce green leaved plants irrespective of which plant acted as pollen parent. If the egg cell receives abnormal colourless plastids, it will give rise to white leaved plants. If the egg cell receives both green and abnormal plastids it will give rise to plants with green and white stripped leaves.

- This backcross experiment shows that green males have no effect upon progeny. The appearance of iojap trait has been explained by two hypotheses. One hypothesis states that frequent mutation in the chloroplast genome produces the abnormal plastids.

- Another hypothesis suggests that certain cytoplasmic elements other than chloroplast mutation bring about the bleaching of chloroplasts. It is also suggested that a nuclear gene controls the development of abnormal plastids in the cytoplasm. So this type of inheritance is a case of inaction between nuclear and cytoplasmic inheritance.