Streptomycin Resistance in Chlamydomonas

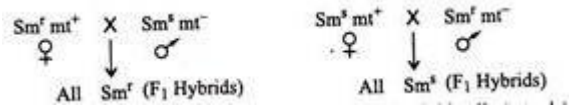
Ruthsagar (1965) has reported some cases of extrachromosomal inheritance in green alga chlamydomonas reinhardi. The alga reproduces by asexual as well as sexual means. It does not have different sexes but has positive and negative strains or mating types (mt^+ and mt).

The sexual reproduction involves fusion between two morphologically similar but physiologically dissimilar gametes of two different mating types (+ strain or mt^+ and – strain or mt^-) and the gametic fusion results in zygote.

The sex is determined by a single chromosomal gene. When meiosis occurs in zygote, four haploid daughter protoplasts are formed which give rise to new plants. Out of 4 new plants resulted from a zygote two are of + strain and the other two are of negative (-) strain. Although both the sexes contribute equally to the zygote, there is maternal transmission of certain cytoplasmic traits.

Ruthsagar (1965) isolated two strains of chlamydomonas: one strain was resistant (Sm^r) to 500 jig of streptomycin per ml. of culture solution and the other was sensitive (Sm^s).

When the reciprocal crosses were made between the streptomycin resistant (Sm^r) and streptomycin sensitive (Sm^s) strains, the following results were obtained:



The diploid cells undergo meiosis and give rise to four haploid cells (tetrads) as shown in Fig. 18.3

From these crosses the following two inferences with respect to Sm resistance can be drawn:

1. The F_1, reciprocal crosses differ from each other.

2. The phenotype of F_1, is governed by mt^+ strain i.e., it is maternal inheritance.

Using the analogy of higher organisms, mt^+ is referred to as female and mt^- as male. The mating type genes mt^+ and mt^- segregate in 1: 1 ratio as expected for the Mendelian inheritance. In the higher organism's formation of zygote involves fusion between an egg and a sperm and the contribution of cytoplasm to the zygote by sperm is negligible.

Under such condition it is easy to comprehend the mechanism of maternal inheritance.

But in Chlamydomonas, male (mt^-) and female (mt^+) gametes being indentical in size contribute equal amount of cytoplasm to the zygote, even then the cytoplasmic features of only mt^+ strain is expressed in F_1, i.e., it is uniparental inheritance. Now the question arises, what happens to the cytoplasmic determinants of mt^- gametes.

This problem was solved by ruthsagar who discovered that the chloroplast DNA of mt^- strain becomes degraded in zygote and the mt^+ gene or a gene closely associated to it specifies a restriction-modification system. Here restriction implies degradation and the modification means protection.

The system encoding the DNA modifying enzyme, modifies its own DNA which cannot be degraded by the restriction system. The mt^+ chloroplast DNA which is not modified or protected is degraded by restriction system of mt^+ gamete.

It is suggested that mt^+ linked gene encodes an endonuclease enzyme (enzyme which degrades DNA) which differentiates plastid DNA of its own cell from that of mt^- cell or digested due to modification.

Since plastid DNA of mt^- strain is degraded after sexual union, no expression of mt^- chloroplast DNA is possible and hence uniparental pattern of inheritance is observed.

In rare cases (one in a thousand), however, the plastid DNA of mt^- cell escapes degradation by restriction system of mt^+ cell and the zygote contains the plastid DNAs from both the cells. Such a zygote is referred to as cytohet or cytoplasmic heterozygote.

Cytohets are important from the view point of studying the recombination of cytoplasmic genes. Ruthsagar has constructed the genetic map of chlamydomonas chloroplast DNA using the genie analysis of cytohets.

This suggests that the inheritance of streptomycin resistance is uniparental and the factor for streptomycin resistance resides in the cytoplasm of + strain or mt^+ (Fig 18.3).

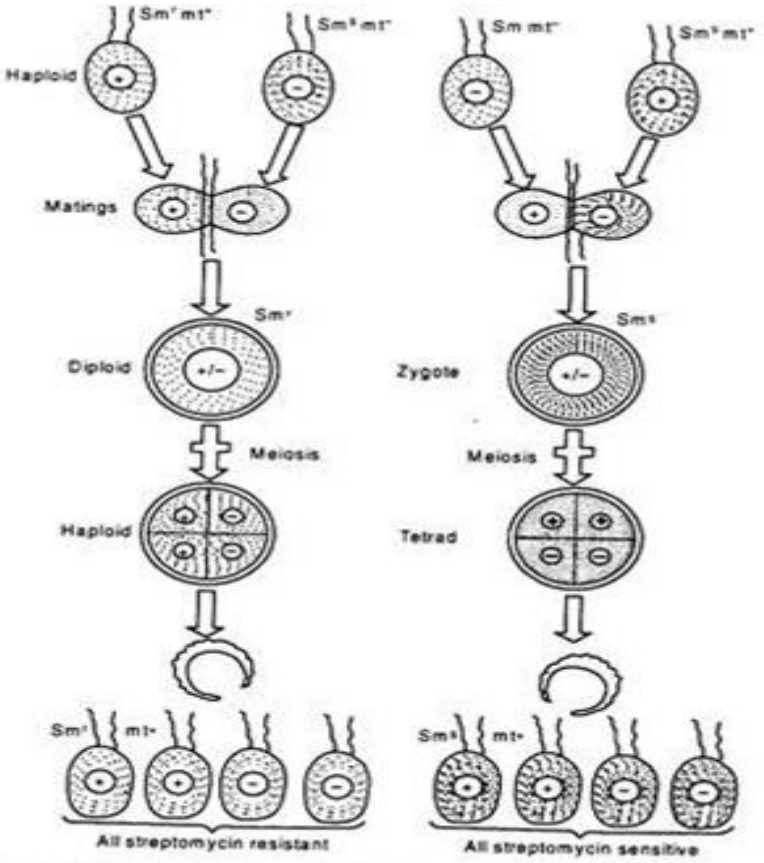


Fig. 18.3 Inheritance of resistance to streptomycin. The plus and minus signs refer to mating types (mt) which is inherited as a single gene difference. The progeny is with rare exceptions always like the plus parent in its reaction to streptomycin, but in these crosses the mating type difference segregates in every tetrad.

Source: https://www.biologydiscussion.com/genetics/cytoplasmic-inheritance/streptomycin-resistance-in-chlamydomonas-with-diagram/37163