Heterothallism and Parasexuality in Fungi

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## Heterothallism

- The term Heterothallism was first used by an American geneticist A.F. Blakeslee in 1904
- ➤This is a condition of sexual reproduction in certain species of Mucorales
- ➢It was observed that in some species of Rhizopus, only when two mycelia of different strains were allowed to come in contact with each other they developed into a Zygospore

Heterothallism may therefore be defined as the "condition in which Zygospore formation takes place only when mycelia arising from asexual spores of two genetically different mating types (+) and (-), are allowed to interact"

#### Homothallic

➤ The homothallic species are those which require mycelia of only one strain to interact for the formation of Zygospores

≻The mycelium is bisexual

#### Heterothallic

➤The heterothallic species require mycelia of two different strains to interact to enable the zygospores to be formed

The mycelium is unisexual, (+) and (-) strains represent the two different sexes





- The phenomenon of heterothallism was first reported in the order Mucorales, but now this has been established in rusts, smuts, members of Homobasidiomycetidae and other fungi
- However, one common feature of inter-mycelial contact is present in all
- This arises the phenomenon of Morphological and Physiological heterothallism
- Both are considered to have evolved independently of one another

# **Types of Heterothallism**

### **1. Morphological heterothallism:**

➢ Morphological heterothallism may be defined as the condition when morphologically different sex organs are produced in two closely associated mycelia

➤ The two sex organs or gametes are morphologically different that it is easier to term one of them as male and the other as female

Ex. Achlya ambisexualis, A. bisexualis, Blastocladiella variabilis, Dictyuchus monosporus, Phytophthora palmivora and Peronospora parasitica

- 2. Physiological heterothallism
- Sexual reproduction takes place by two morphologically similar but physiologically different hyphae
- **Physiological heterothallism may be of two types:**
- (i) Two-Allele Heterothallism:
- ≻The nuclei of both the mating types are different in genetic characters and represented by A and a located at single same locus of allele of the chromosome
- > The allele A is dominated and represented by (+) and a by (-)
- The spores bearing (+) allele will produce (+) mycelia and the spores with (-) allele will give rise to (-) mycelia.
- > The mycelia of (+) and (+), and (-) and (-) are self-sterile or self-incompatible
- Ex. Ascobolus magnificus, Puccinia graminis, Neurospora sitophila Mu mucedo, Ustilago kolleri,Puccinia Graminis, Neurospora Sitophil and Mucor Mucedo

### (ii) Multiple Allele Heterothallism:

➢In this type, more than two (multiple) alleles determine the sexual compatibility, located at one (bipolar) or two (tetrapolar) loci

#### This may be of two types:

(a) **Bipolar Multiple-allele heterothallism: This heterothallism is controlled by multiple alleles at a single locus** 

### **Ex.** Coprinus comatus

- (b) Tetrapolar multiple-allele heterothallism: This heterothallism is controlled by multiple alleles at two loci
- Ex. Ustilago maydis, Comprinus firmaterius



## **Parasexuality**

- ➤ The phenomena was first discovered in 1952 by Pontecorvo and Roper of the University of Glasgow in Aspergillus nidulans, the imperfect stage of Emericella nidulans
- Generally parasexual cycle occurs in those fungi in which true sexual cycle does not take place
- Parasexuality is defined as a cycle in which Plasmogamy, Karyogamy and Meiosis (Haploidization) take place in sequence but not at a specified time or at specified points in the life cycle of an organism
- **Parasexual cycle is also known as Somatic recombination**
- Since then parasexual phenomena have been identified in several imperfect fungi, as well as in Basidiomycetes and in Ascomycetes

## **Steps Involved in Parasexual Cycle**



**1. Formation of heterokaryotic mycelium** 

Heterokaryotic mycelium is formed most commonly by the anastomosis of somatic hyphae of different genetic combinations

- ➤The foreign nucleus or nuclei introduced into a mycelium multiplies and its progeny spreads
- Mutation in one or more nuclei of a homokaryotic mycelium also makes it heterokaryotic

- 2. Fusion between two nuclei (Karyogamy)
- >The nucelar fusion may be of two types:
- A. Fusion between like nuclei
- **B.** Fusion between unlike nuclei
- ≻The nuclear fusion results in the formation of homozygous or heterozygous diploid nucleus
- ➢If the genotype of unlike nuclei present in the heterokaryotic mycelium is A and B, then five types of nuclei can be formed by their fusion:
  - $\checkmark$  two types of haploid nuclei (A and B)
  - $\checkmark$  two types of homozygous diploid nuclei (AA and BB)
  - ✓ one type of heterozygous diploid nucleus (AB)

## **3. Multiplication of diploid nuclei**

The above mentioned five types of nuclei multiply at a proportion of one diploid heterozygous nucleus to 1000 haploid nuclei (Portecarvo, 1958)

### 4. Occasional mitotic crossing over

- Mitotic crossing over results in the formation of new gene combinations
- These recombinations are dependent on the existence of heterokaryosis

## **5. Sorting out of Diploid nuclei**

- Sorting out of the diploid nucleus occurs by their incorporation into conidia which germinate to produce diploid mycelia
- The conidia of diploid strains are somewhat larger than those of haploid strains

## 6. Occasional haploidisation of the diploid nuclei

- Some hyphae of diploid mycelium form haploid conidia through aneuploidy which form haploid mycelia on germination
- ≻The formation of haploid conidia by diploid mycelium indicates haploidisation
- 7. Sorting of new haploid strains
- ➢After haploidisation, the mycelium are sorted out by incorporation of haploid nuclei in the uninucleate conidia
- Some of these haploid strains are genotypically different from their parents because of their mitotic recombinations

## **Consequences of Parasexual cycle**

- **1. Haploid nuclei like both the parents**
- 2. Haploid nuclei with various new genetic recombinations
- **3. Several types of diploid homozygous nuclei**
- 4. Several types of diploid heterozygous nuclei





# **Significance of Parasexual Cycle**

- Parasexual cycle is important in industrial processes
- New and better strains of these fungi can be developed by mutation or through mitotic recombinations during Parasexual cycle
- Parasexuality can also be applied in the analysis of genetic and physiological processes of perfect and imperfect fungi
- Parasexual cycle has also been successfully employed in genetic control of pathogenicity and host-range in several species of pathogenic fungi

## **Comparison between Sexual and Parasexual cycle**

#### **Sexual Cycle**

- Nuclear fusion in specialized structures
- Zygote persist one nuclear generation
- Recombination by meiosis crossing over and reduction of chromosome number
- Products readily recognised and isolated

#### **Parasexual Cycle**

- No nuclear fusion in vegetative structure
- Zygote persists through many mitosis
- Recombination by rare mitosis or mitotic crossing over and random assortment of chromosomes
- Recognised only by suitable markers

## Examples

### The parasexual cycle have been reported in the following fungal groups

✓ Aspergillus niger
✓ A. Fumigatus
✓ A. Oryzae
✓ Penicilium chrysogenum
✓ P. expansum

✓ Ustilago mydis
 ✓ U. Hordei
 ✓ Piricularia oryzae
 ✓ Verticilium alboatrum
 ✓ Fusarium oxysporum

## Thank you....