Sex Hormones in Fungi

Fungal sex hormones

- Chemical communication is essential for coordination of activities in a multicellular organism
- Hormones play an essential role in this communication as chemical signaling molecules
- A hormone is a chemical substance that is produced in one portion of an organism and moves by diffusion or transport to another portion of same individual or to other individual of same species where it induce specific response
- Fungal sex hormones produced in small quantity and play specific role in sexual reproduction process

- **The involvement of hormones controlling sexual reproduction in the Mucorales was first demonstrated by Burgeff (1924)**
- **In this group of fungi sexual reproduction occurs between morphologically indistinguishable mating types, (+) and (-)**
- **Burgeff (1924) showed that diffusible substances are responsible for the formation of sexual hyphae when two mating types meet**
- **Plempel (1963) obtained evidence for diffusible factors, 'progamones', released by each mating type and causing the opposite mating type to produce the sex hormones**

Machlis (1972) has classified the fungal sex hormones into the following three types:

(1) Erotactins: attracts motile cells (“sperm attractant”)

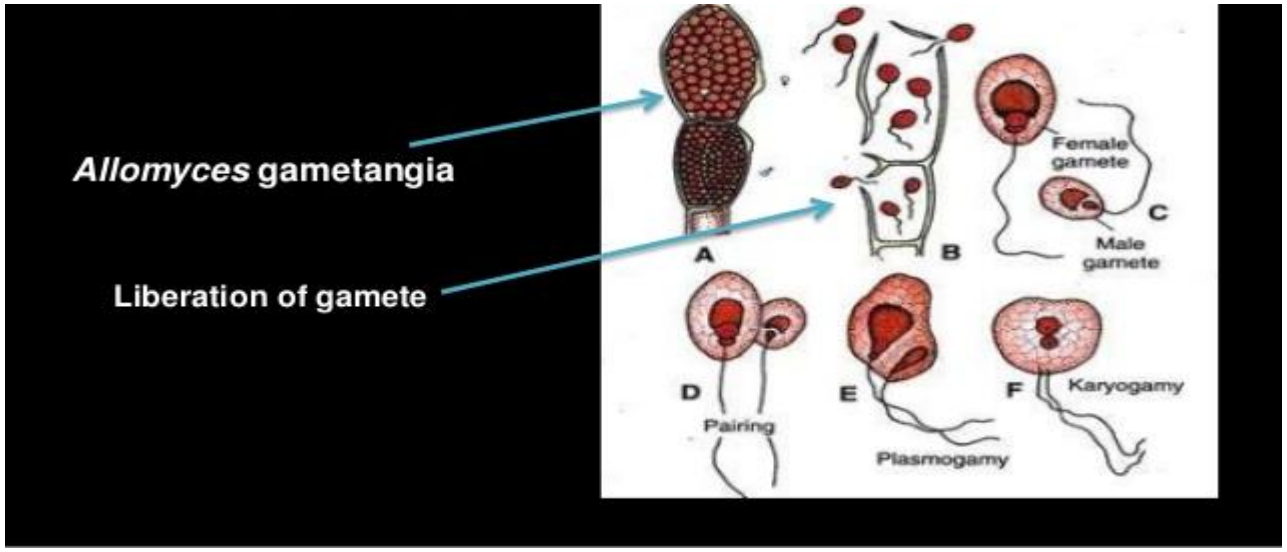
(2) Erotropins: includes chemotropic growth of sex organs

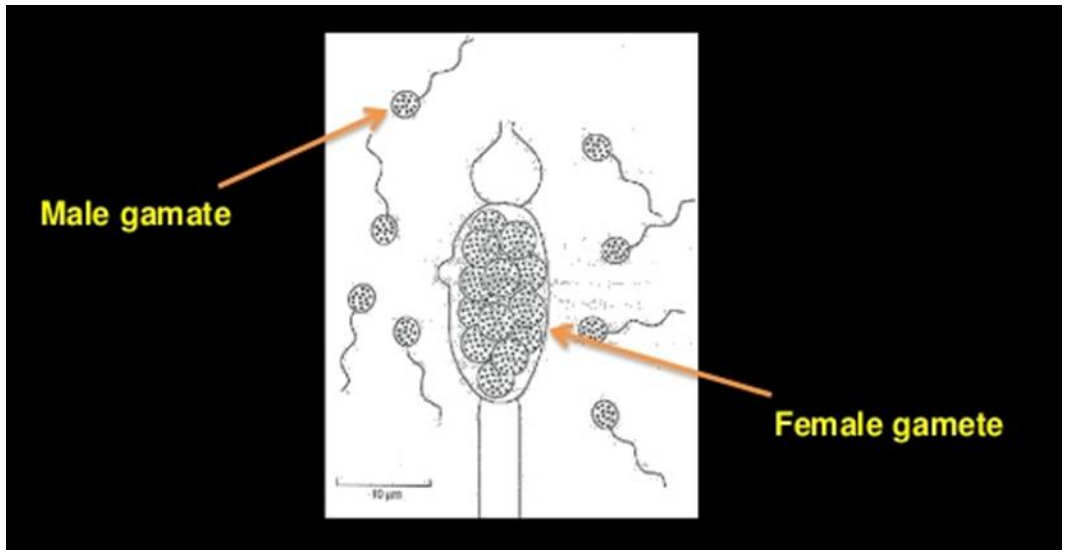
(3) Erogens: controls the induction and differentiation of sex organs

- **There is evidence of existence of number of sex hormones in fungi, but few are identified and chemically characterized such as Sirenin, Antheridiol, Oogonial and Trisporic acid**

Sirenin

- Sirenin was the first fungal sex hormone to have its structure determined. It is produced by female gametangia and gametes of the chytridiomycete genus *Allomyces* and attracts male gametes of the genus
- It was discovered in 1958 by Leonard Machlis and, with the help of organic chemists, was purified and had its structure determined by 1968
- Allomyces (Chytridiomycetes), in this water mould large motile and colorless female gamete produce a potent attractant for smaller bright orange male gametes



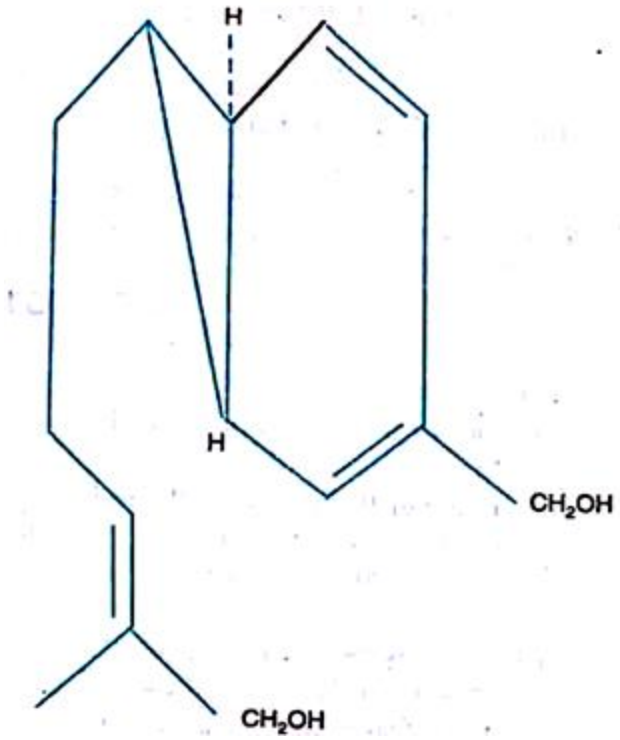


- **Machlis (1958) named that attractant as sirenin**
- **Demonstrated that male gametes are sensitive sirenin over a wide range of concentration 10-7 to 10-5 M**
- **Among five types of swimming cells produced by Allomyces only male gametes shows response to sirenin**
- **The receptor are located on plasmalemma and hormone affect the action of flagellum in some way so as to orient the gamete so that all receptor at a given level around the circumference receive the same stimulus**
- **Male gametes have been discharged from a terminal male gametangium**
- **They are swimming around sub terminal female gametangium, being attracted by Sirenin emitted by nearly mature female gametes within the gametangium**

Structure of Sirenin

- **Sirenin is a bicyclic sesquiterpenediol and found as d and l Sirenin**
- **l- Sirenin attract male gamete**

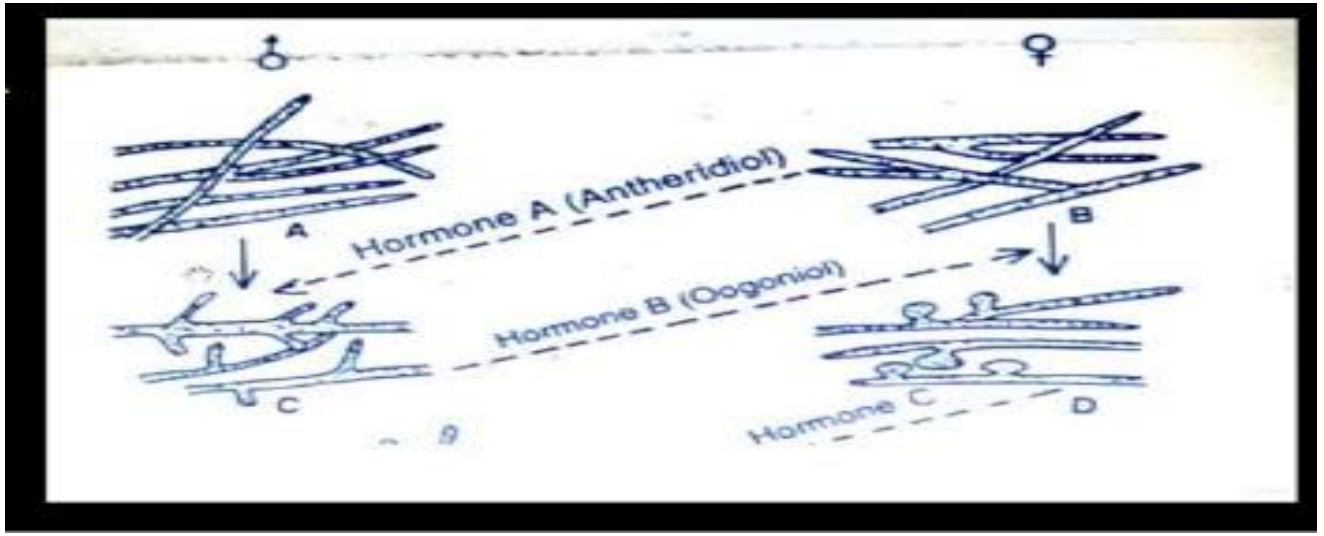
(C15H2402)



Antheridiol

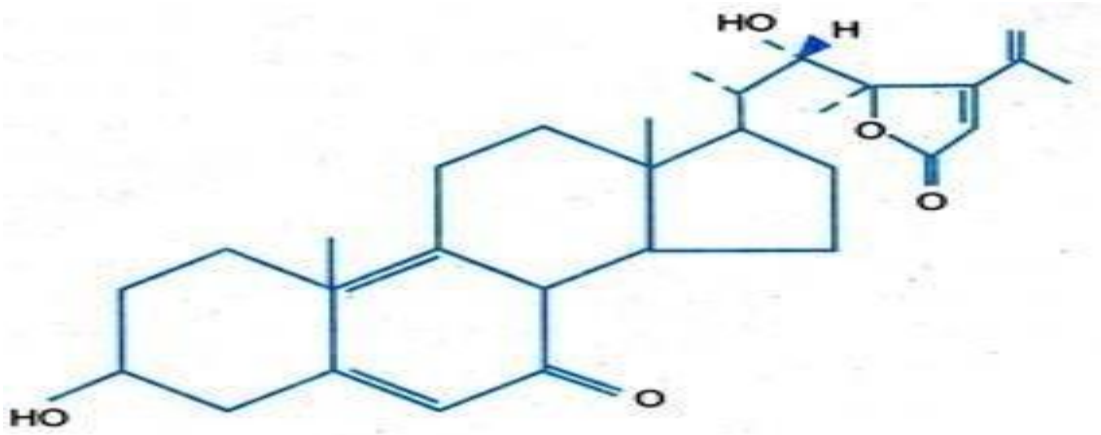
- Harmonal system in the water mold Achlya (Oomcetes) is more complex in a series of experiment with heterothallic species
- Raper (1951) demonstrated that sexual differentiation in species of this genus is regulated by complimentary hormones which diffuse from same hyphea to others
- Raper and Haagen-Smit extracted and purified the hormone that is produced by the female cells and that initiates the sequence of events leading to sexual fusion

- **Female cells produce hormone A that switches the male cells from vegetative growth to the production of many short antheridial branches**
- **In response the male cells release hormone B which diffuse back to the female cells, switching them from the vegetative phase to production of oogonial initials**
- **The female hormone A is identified as Antheridiol and complimentary hormone B is identified as Oogoniol**



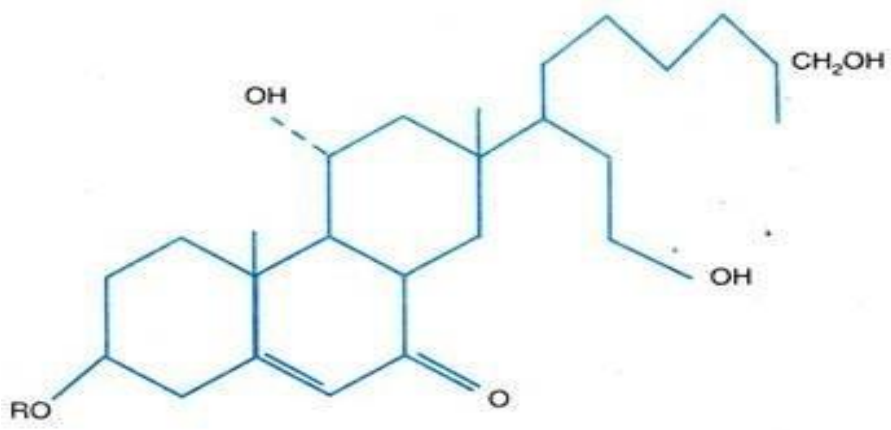
Structure of Antheridiol

- **Antheridiol (C29H42O5) is a steroid sex hormone produced by female strains of Achlya which induces antheridial initials in male strains, causes them to grow towards oogonia and bring about the delimitation of antheridia**



Oogoniol

- The hormone is synthesized by male hyphae of Achlya ambisexualis only in the presence of antheridiol
- The hormone stimulates the development of oogonium on female hyphae
- Barksdali et al. (1974) reported that oogoniol is synthesised by some hermaphrodite strains without the stimulus of antheridiol
- Two crystalline compounds, possessing hormone B activity have been isolated from culture filtrates of Achlya heterosexualis and named oogoniol-1 and oogoniol-2

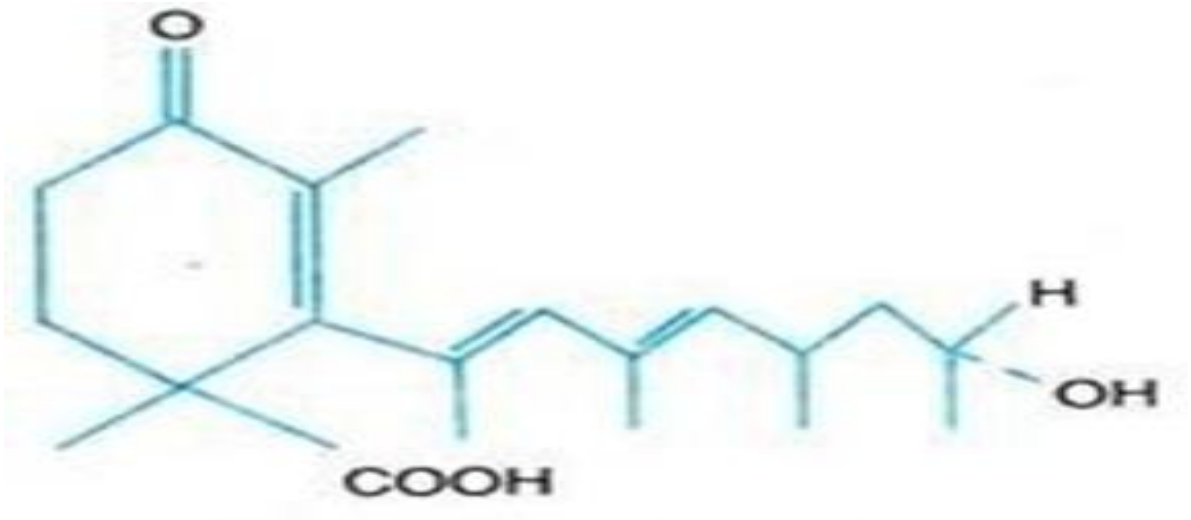


Trisporic acid

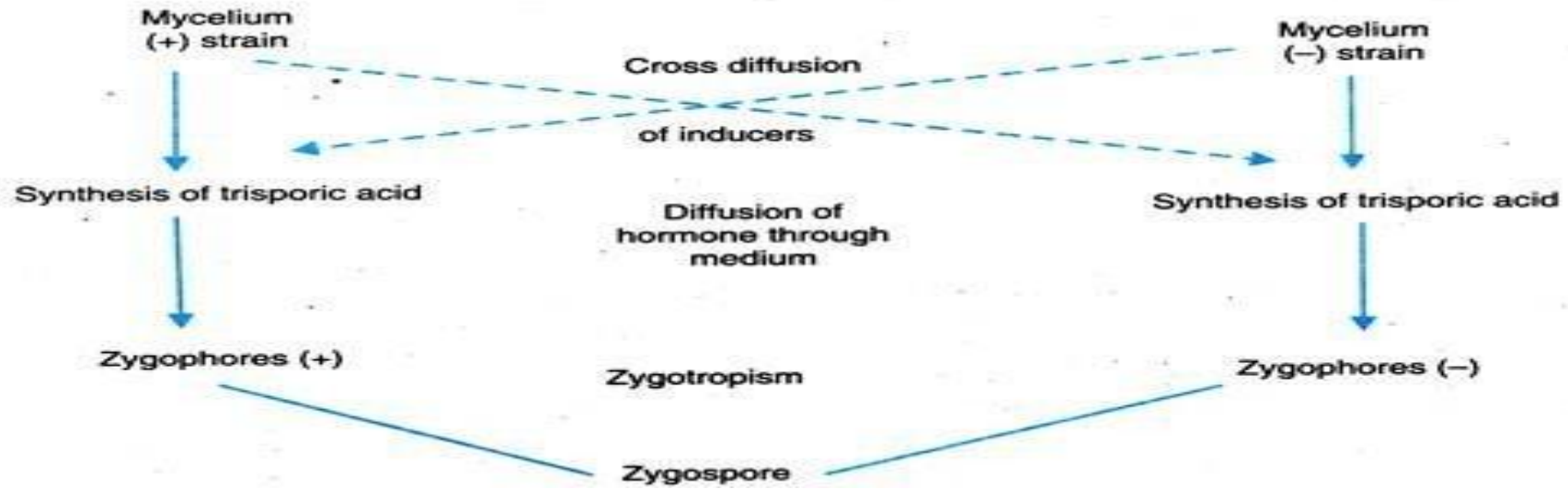
- Hans Burgeff (1924) of the university of Gottingen found that (+) and (-) strains of M. mucedo could communicate through a collodion membrane, inducing the formation of charecteristic aerial hyphae zygophores in the strains of opposite mating type
- He concluded that interaction is due to the exchange of low molecular weight substances that diffused through the substratum and atmosphere
- Banbury (1954) and Plempel and Braunitzer (1958) showed that + and – myceliya of M. mucedo when grown together in a liquid culture accumulates substances in the medium induced zygophores in both mating type of same fungus
- It is now know that each + and – strains produce precursor molecules, such as beta and gamma carotene that the compatible strain converted to trisporic acid

Structure of Trisporic acid

- It is an unsaturated and oxygenated form of trimethyl cyclo-hexane
- Three kinds of trisporic acid have been identified, trisporic acid A, B and C
- Trisporic acid C plays the major role (80%) as a sexhormone, followed with trisporic acid B with 15% activity and trisporic acid A is least active with 1-2% activity
- It appears that trisporic acid A does not have the functional group in the acid chain
- Empirical formula: $C_{18}\ H_{26}\ O_4$



Collaborative bio synthesis of Trisporic acid



(I)beta carotene is produced by both + and – strains and metabolized by both via retinal

(II) to 4-dihydrotrisporol

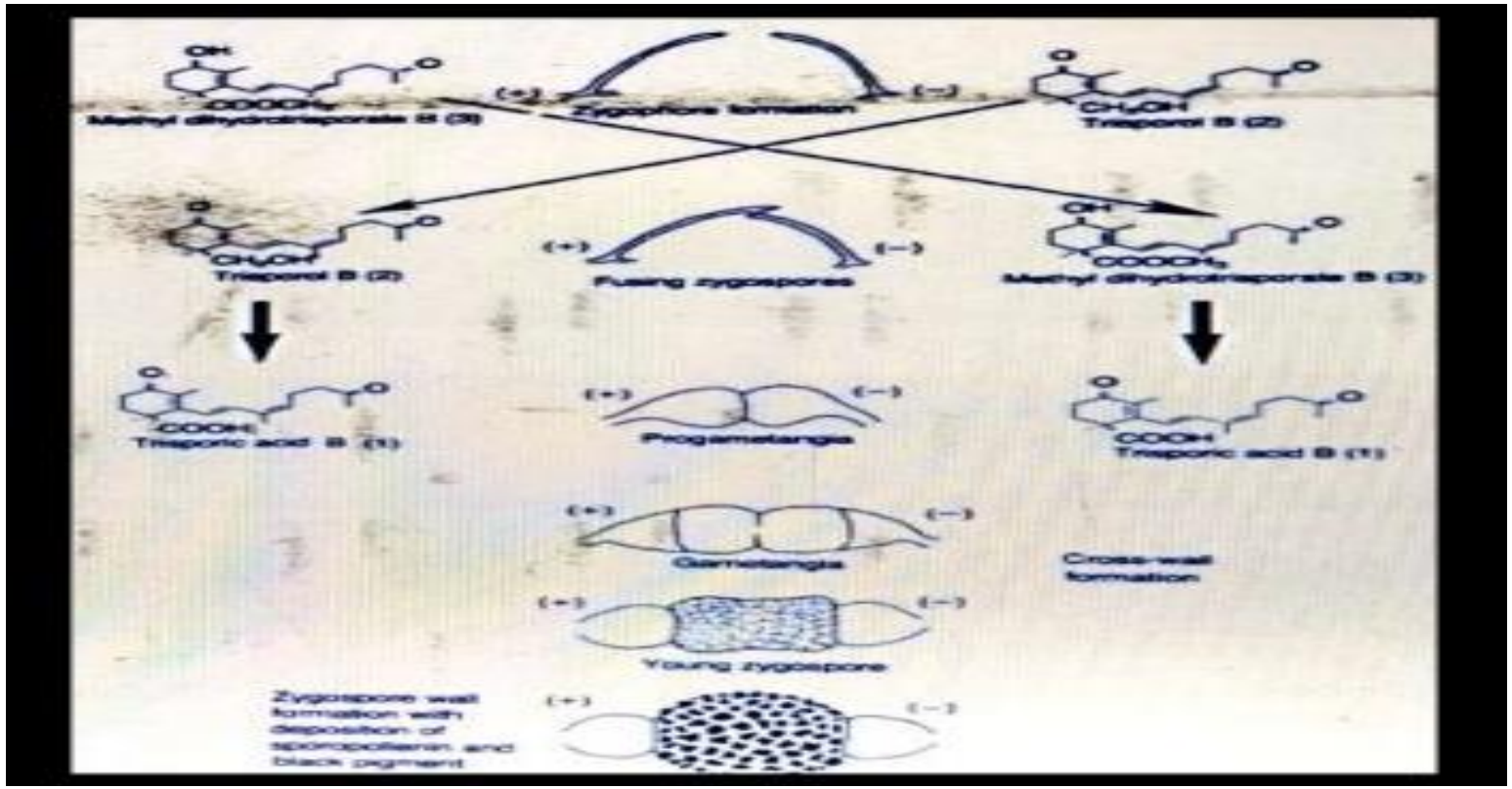
(III) this is metabolized by + stains to 4-dihydrotrisporic acid and its methyl ester

(IV) and by – strains to trisporol

(V)These are metabolized to trisporic acid

(VI) only after diffusing to the – and + strains

Zygosporogensis in Mucor mucedo



- **The progamone precursors Trisporal B formed in (-) and metabolized by (+) and methyle dyhydrotrisporate B formed in (+) and metabolized by (-) and the mating hormone trisporic acid B to which they are converted are illustrated**

Yeast α Factor

- The presence and the involvement of some hormone in the sexual reproduction of *Saccharomyces cerevisiae* was suggested by Levi in 1950
- In this fungus, the haploid cells are of two mating types ‘a’ and ‘α’ conjugate to form diploid cells
- In 1956, Levi showed that the α haploid cells produce a diffusible chemical which induces the formation of copulatory process by compatible a cells
- These ‘a’ cells, due to influence of the chemical substance produced by ‘α’ cells, stop their growth and reproduction by budding
- Instead, these ‘a’ cells swell in size and form giant cells of various shapes
- These giant cells are 30 or more times heavy in dry weight in comparison to normal haploid cells
- The α factor acts only on ‘a’ cells and has no effect on ‘α’ cells
- The α factor is reported to inhibit DNA replication in the ‘a’ cells
- It is peptide complexed with copper ion and has molecular weight of 1400

Comparative studies

Hormones	Molecular structure	Precursors	Site of synthesis	Optimal yield
Sirenin	**Sesquiterpinol** ($C_{15}H_{24}O_2$)	Farnestyl pyrophosphate	Female gamete (*Allomyces*)	10^{-6} M
Antheridiol	Sterol ($C_{29}H_{24}O_5$)	Fucosterol	Female cells *Achlya sps*	10^{-8} M
Oogoniol	Sterol ester ($C_{25}H_{54}O_6$)	Fucosterol	Male cells *Achlya sps*	-
Trisporic acid	Apocarotenoid ($C_{18}H_{28}O_4$)	Retinal	+ or – cells of *Mucorales*	10^{-6} M