Fungal flagellum, heterothallism, parasexuality

2nd Semester

Mycology and plant pathology

(BSCHBOTC201)

Unit I

By

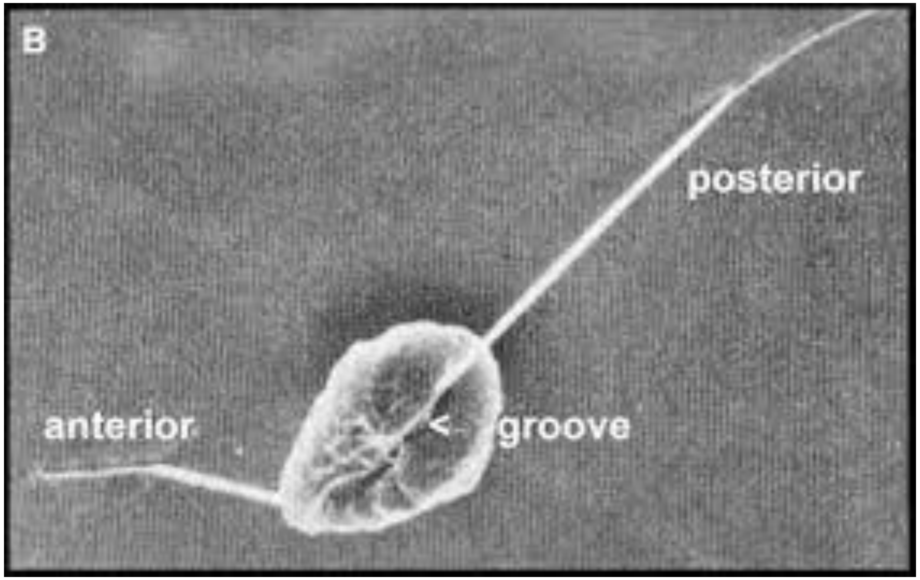
Dr. Sandipan Ray

Assistant Professor in Botany

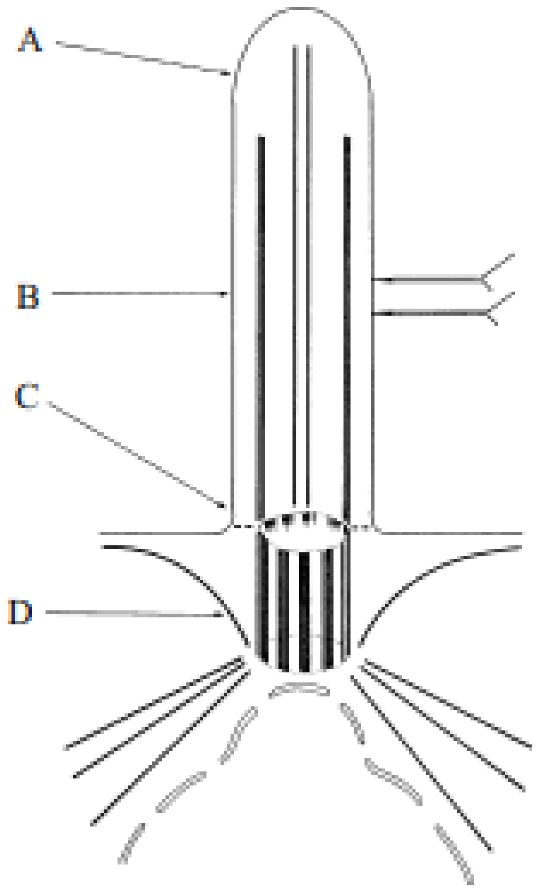
Durgapur Government College

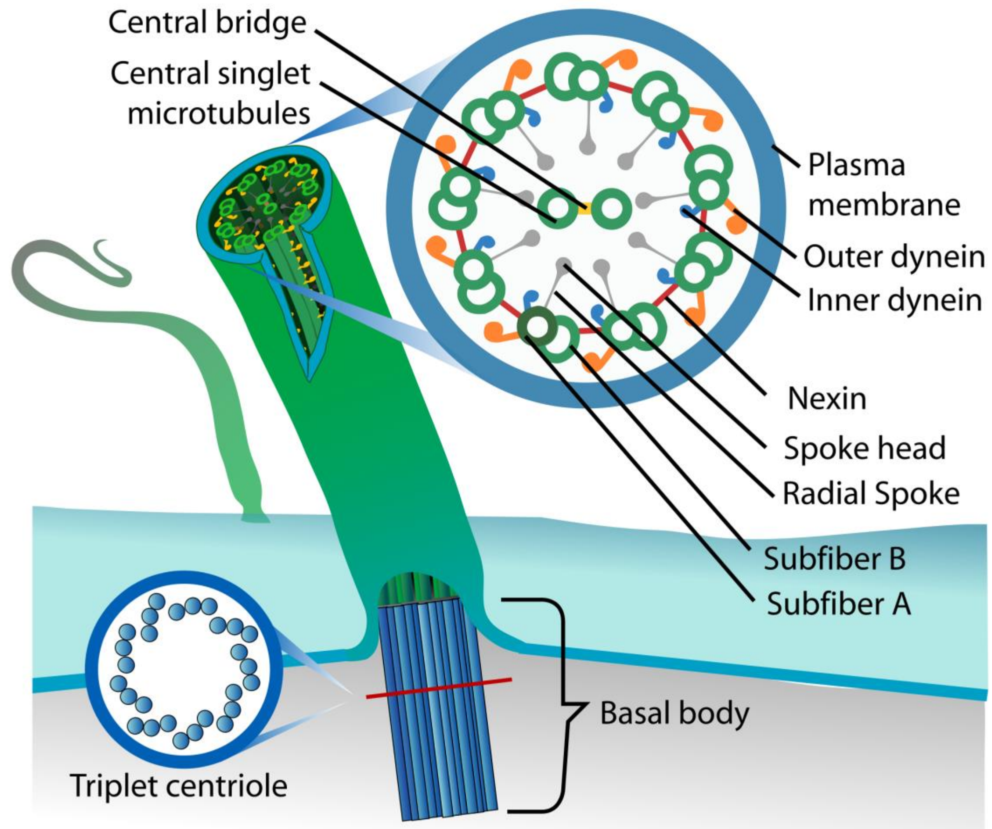
What is flagella

- Certain cells protrudes lash-like appendage called flagellum ad the cells termed as flagellates
- A flagellate can have one or several flagella
- Locomotion is primary function of a flagellum is that of , but it also often functions as a sensory organelle, being sensitive to chemicals and temperatures outside the cell

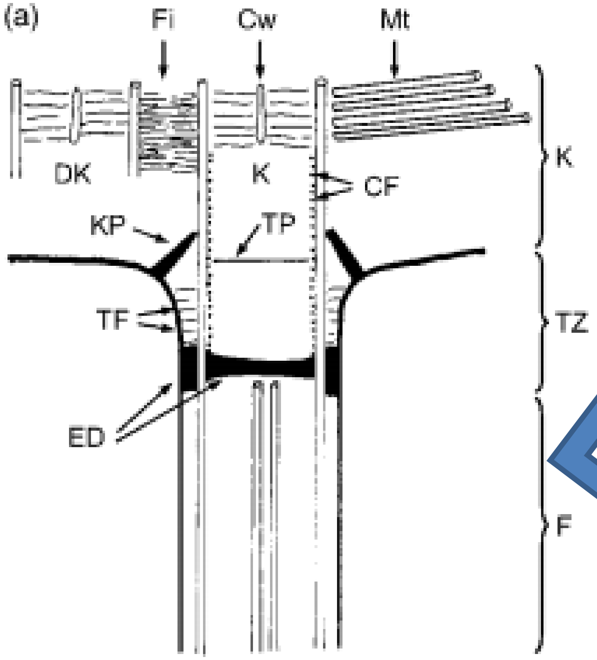


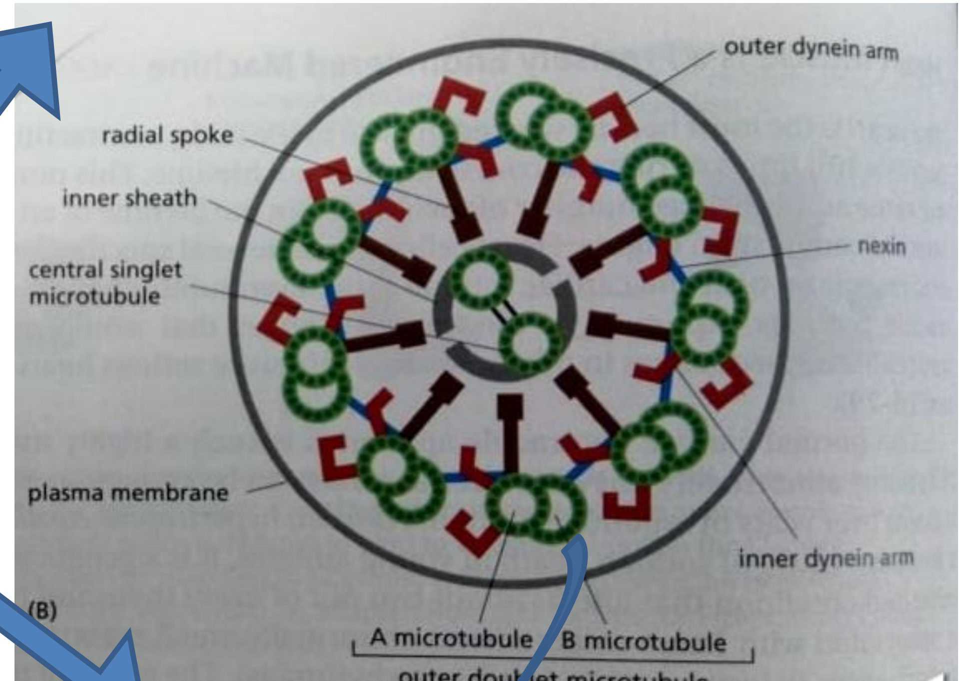
Flagellal structure of fungi:

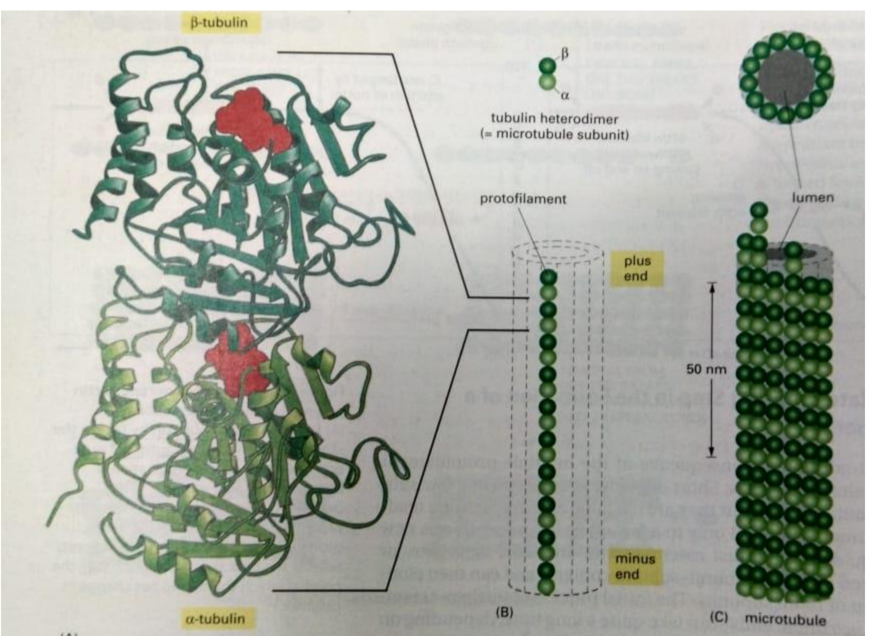


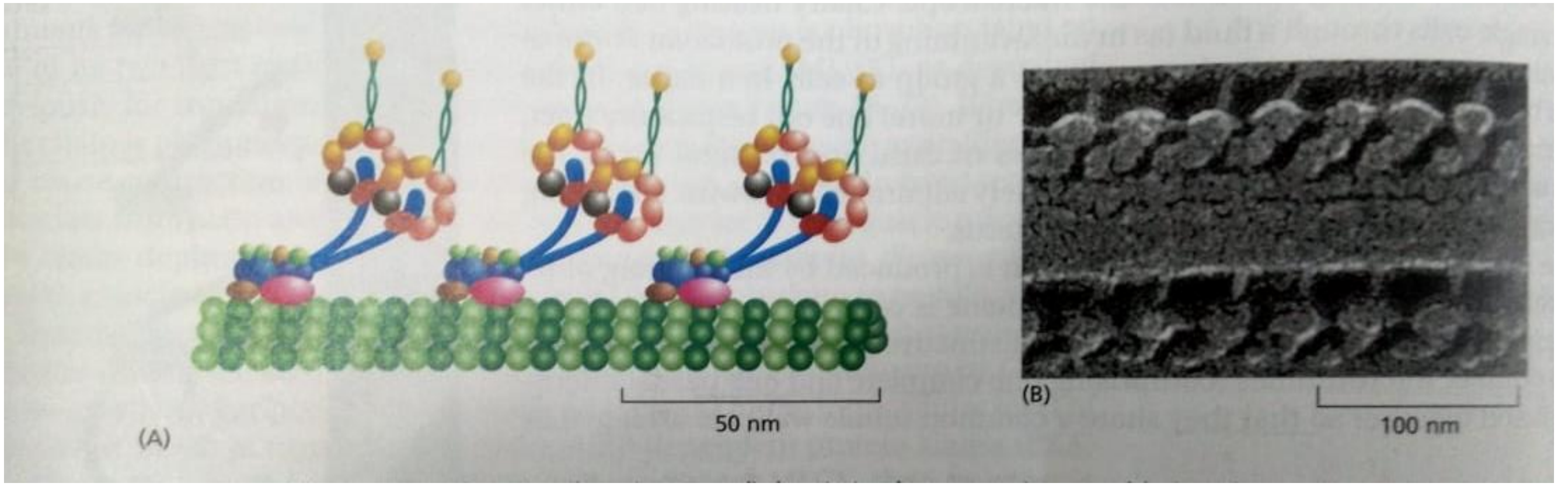


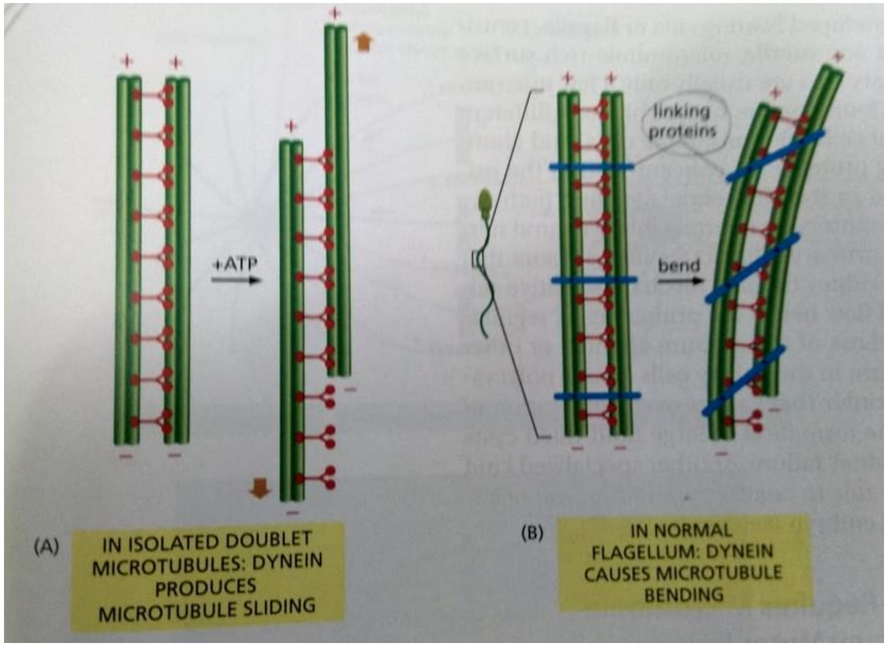
(A) the flagellar tip ; (B) the flagellar shaft ornamentation ; (C) the transitional zone ; (D) the kinetosome and the flagellar microtubular roots

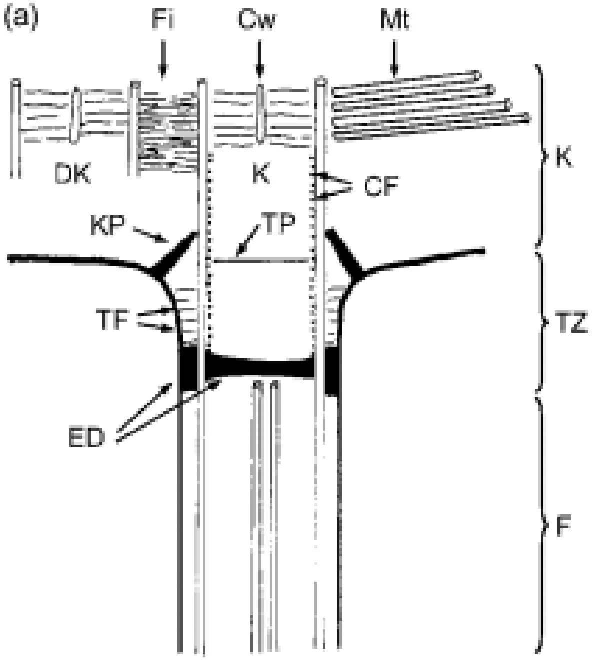

(a)
Fi
Cw
Mt
DK
K
CF
K
KP
TP
TF
TZ
ED
F

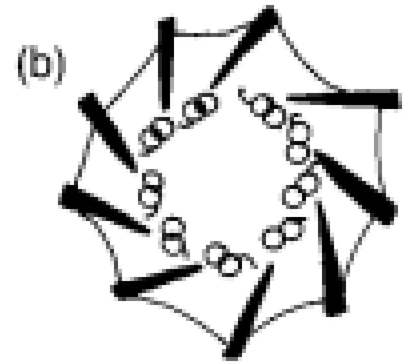

outer dynein arm
radial spoke
inner sheath
nexin
central singlet
microtubule
plasma membrane
inner dynein arm
(B)
A microtubule
B microtubule
outer doublet microtubule

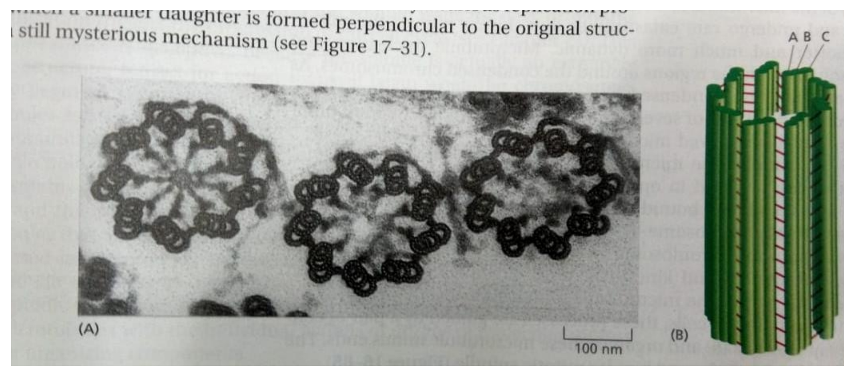

β-tubulin
β
α
tubulin heterodimer
(= microtubule subunit)
protofilament
lumen
plus
end
50 nm
minus
end
α-tubulin
(A)
(B)
(C) microtubule


50 nm
(A)
(B)
100 nm

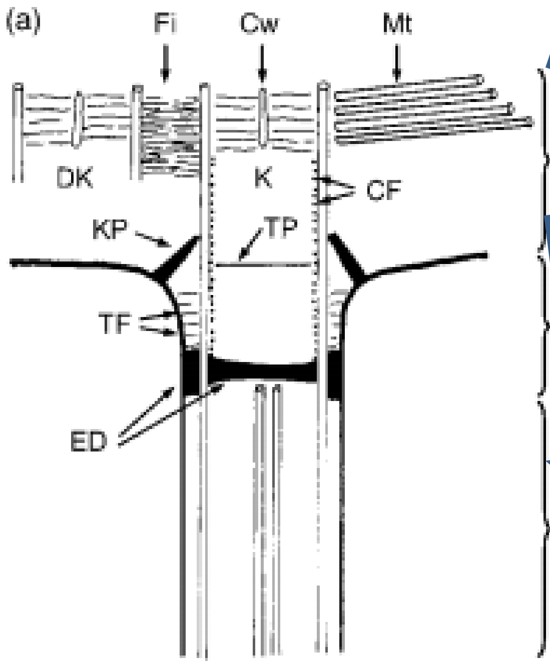

+ATP
linking proteins
bend
(A)
IN ISOLATED DOUBLET MICROTUBULES: DYNEIN PRODUCES MICROTUBULE SLIDING
(B)
IN NORMAL FLAGELLUM: DYNEIN CAUSES MICROTUBULE BENDING

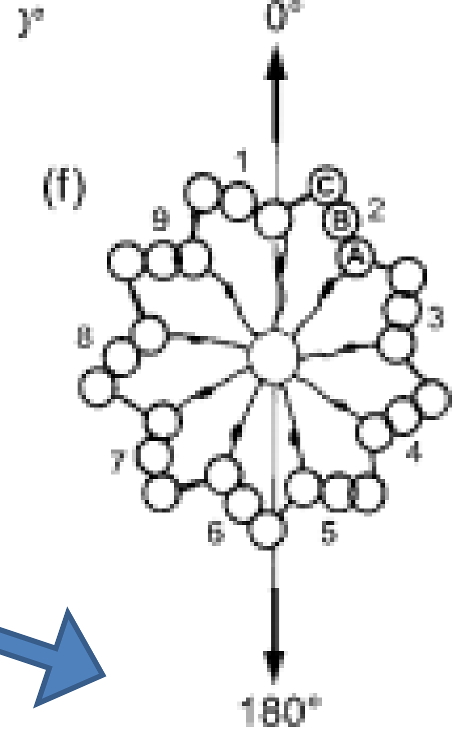


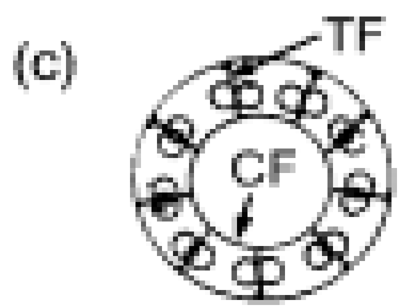




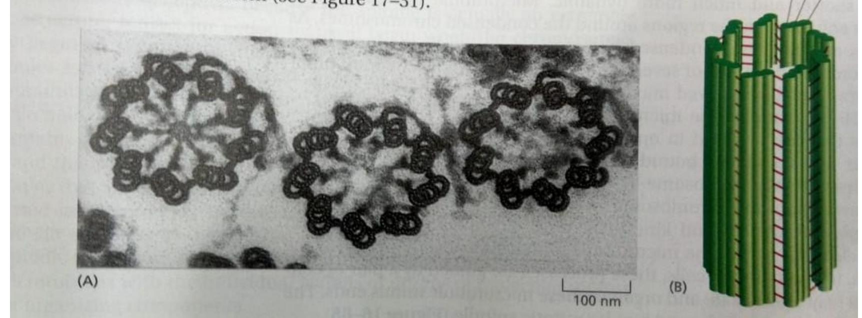
flagellum proper (F), transitional zone (TZ), kinetosome (K), electron-dense region (ED), concentric fibres (CF), transitional fibres (TF), kinetosome props (KP), terminal plate (TP), kinetosome (K) showing a cartwheel-like organization (Cw), dormant kinetosome (DK), fibrillar material (Fi) foundin some taxa, and microtubular roots (Mt) extending from the side or end of the kinetosome into the body of the zoospore





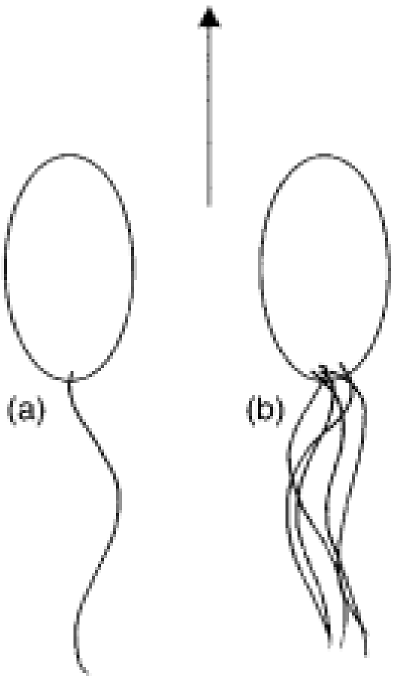


daughter is formed perpendicular to the original struc-
still mysterious mechanism (see Figure 17–31).

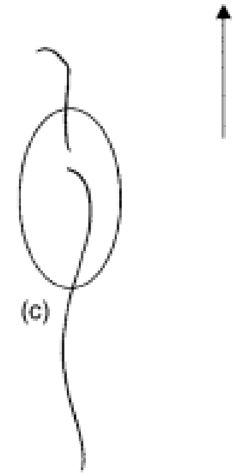


1. Posteriorly flagellate zoospores

- Chytridiomycetes have whiplash type flagella
- Each whiplash flagellum has 11 microtubules arranged in the 9 + 2 pattern typical of eukaryotes
- smooth, membranous axoneme sheath encloses microtubules are enclosed in a continuous with the plasma membrane
- single posterior flagella is present in most members of the Chytridiomycota but in the rumen-inhabiting Neocallimastigales there may be up to 16 flagella
- Such spores are driven forward by sinusoidal rhythmic beating of the flagellum
- This type of zoospore flagellation is termed opisthokont (Gr. opisthen = behind, at the back; kontos = a pole)

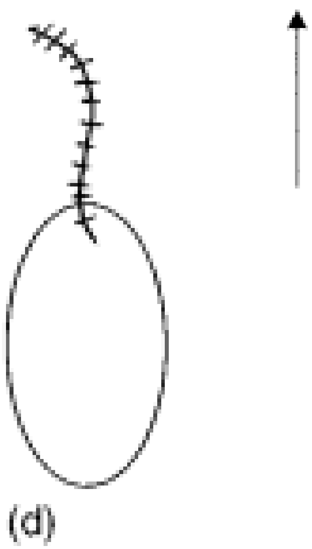


2. Biflagellate zoospores with two whiplash flagella of unequal length are called anisokont and are found in some Myxomycota and the Plasmodiophoromycota



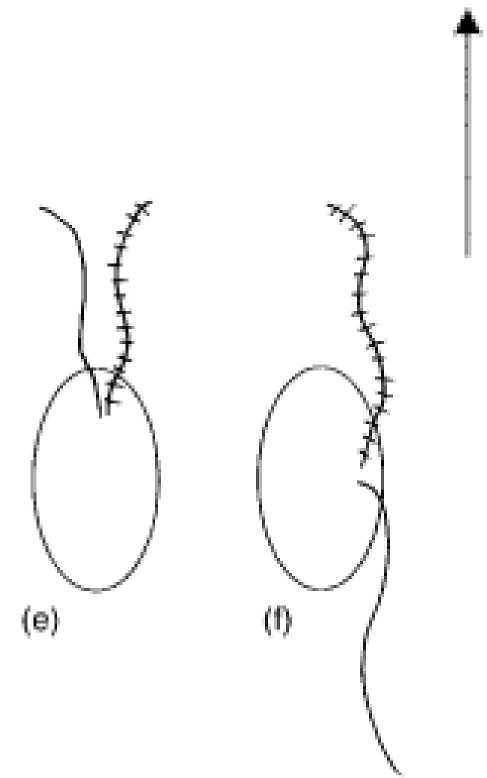
3. Anteriorly uniflagellate zoospores

- Hyphochytriomycota is characterized by flagellum of the tinsel type
- The axoneme sheath of the tinsel or straminipilous flagellum (Lat. stramen = straw; pilus = hair) is adorned by two rows of fine hairs
- These are called tripartite tubular hairs or mastigonemes (Gr. mastigion = a small whip; nema = a thread)
- Rhythmic sinusoidal beating of the tinsel type flagellum pulls the zoospore along, in contrast to the pushing action of whiplash flagellum



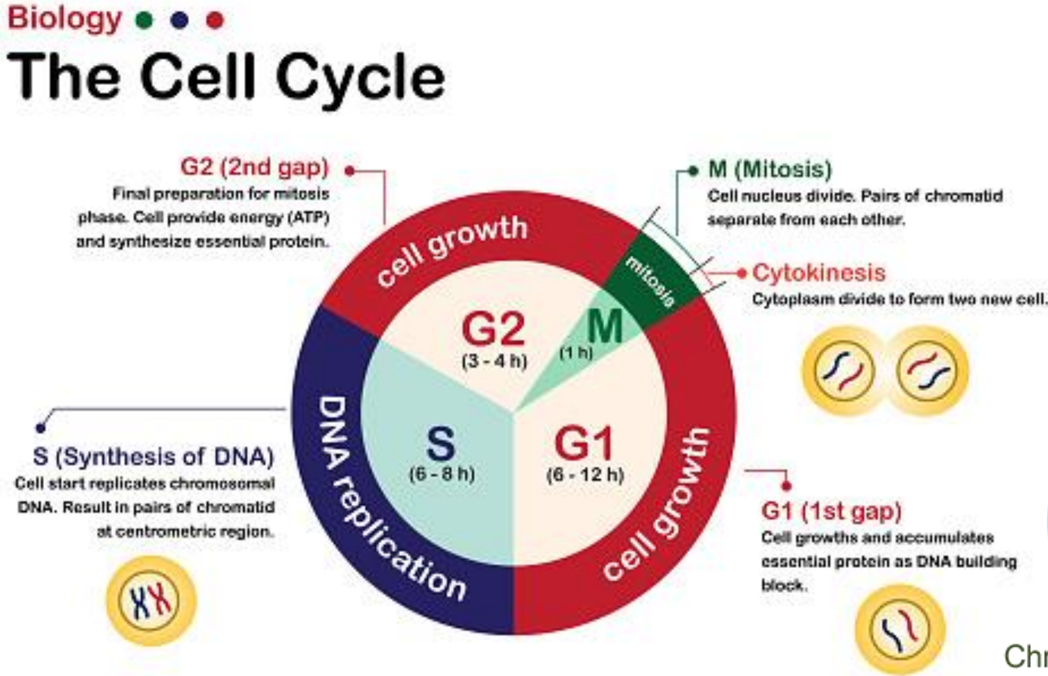
4. Biflagellate zoospores

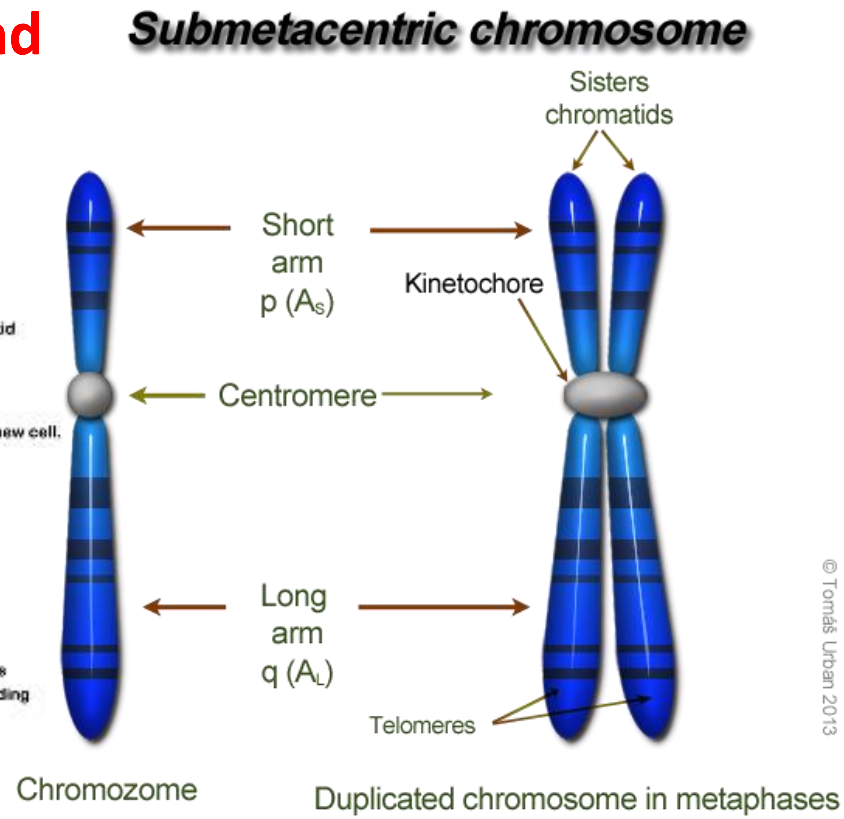
- Oomycota is characterized by anteriorly or laterally attached flagella, one of which is of the whiplash type and the other of the tinsel type
- Zoospores with the two different kinds of flagellum are heterokont
- in the first-released zoospores of *Saprolegnia* sp., the two types of flagellum are attached anteriorly, but their propulsive actions tend to work against each other and the zoospore is a very poor swimmer
- However, laterally attached flagella in secondary zoospore (termed the principal zoospore) in *Saprolegnia* sp. and in many other Oomycota with the tinsel-type (pulling action) flagellum pointing forwards and the whiplash-type (pushing action) flagellum directed backwards and possibly acting as a rudder, jointly providing much more effective propulsion

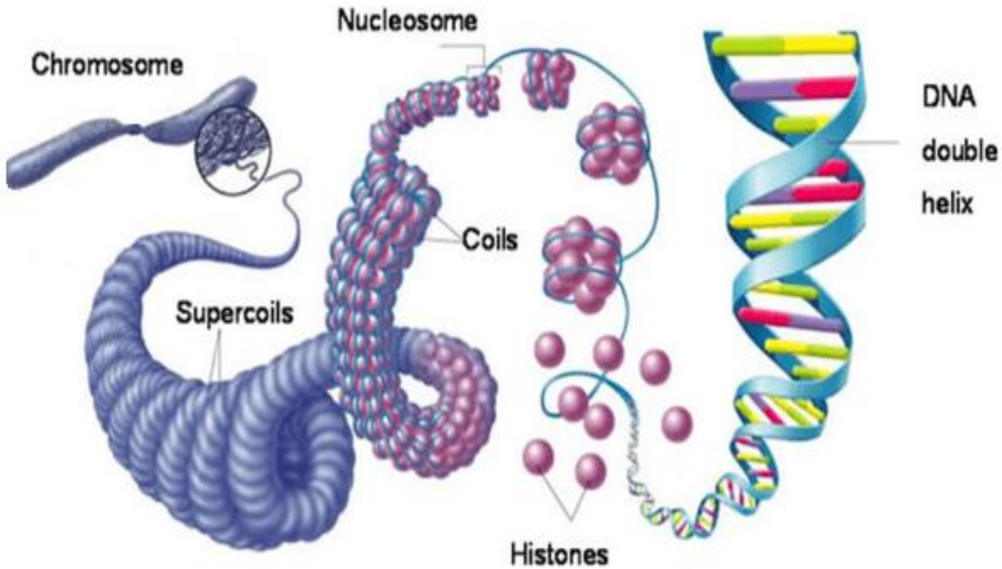


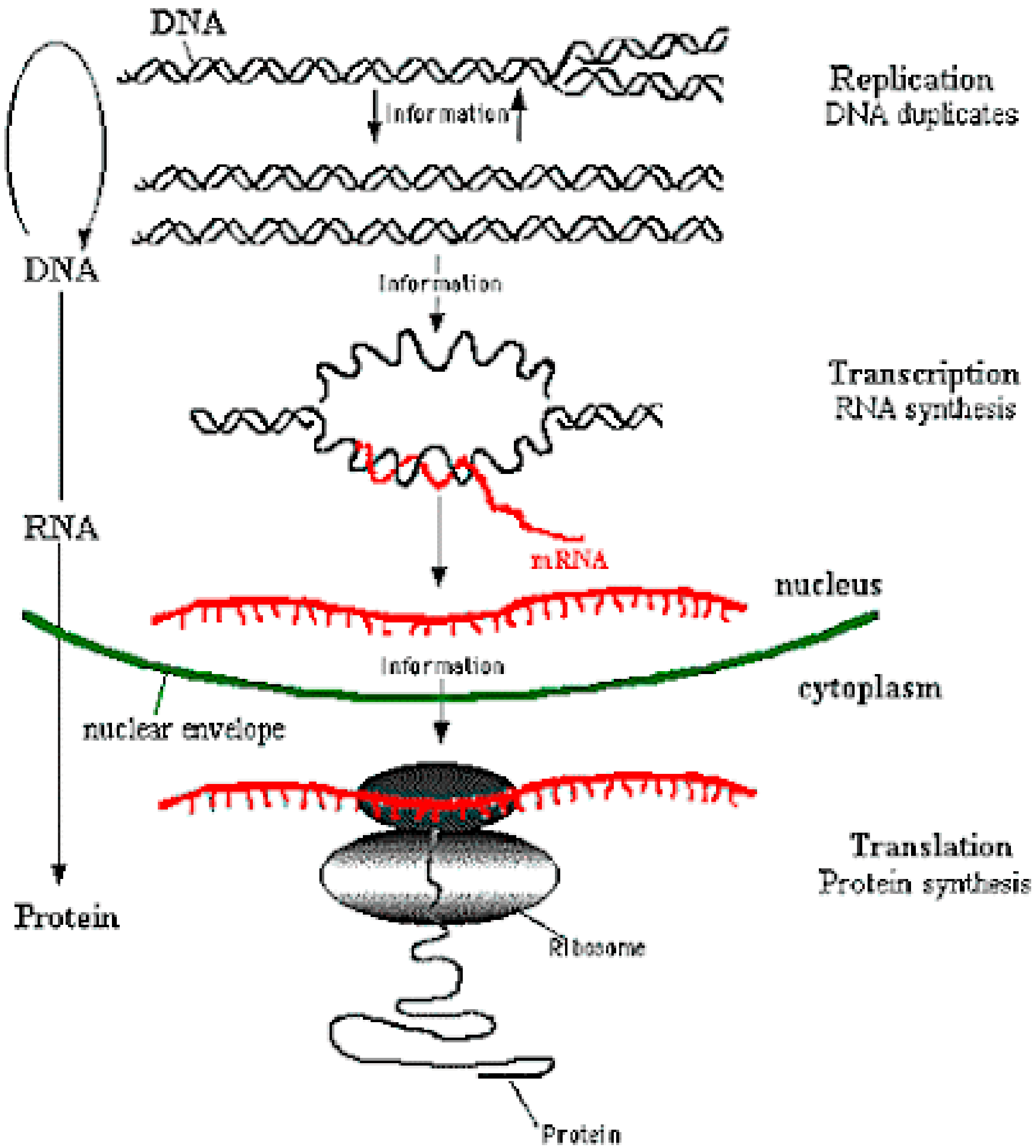
Parasexual reproduction

Overview of normal cell cycle and chromosome





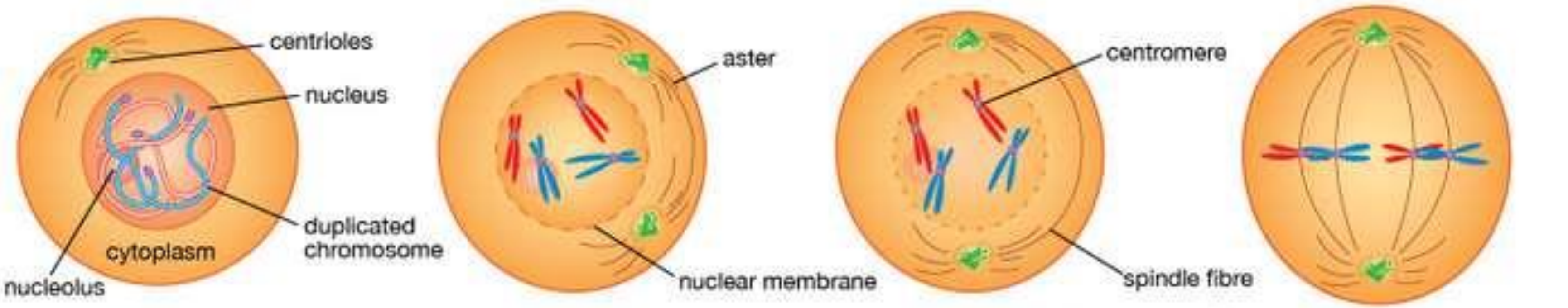




The Central Dogma of Molecular Biology

Normal mitosis

Mitosis, or somatic cell division

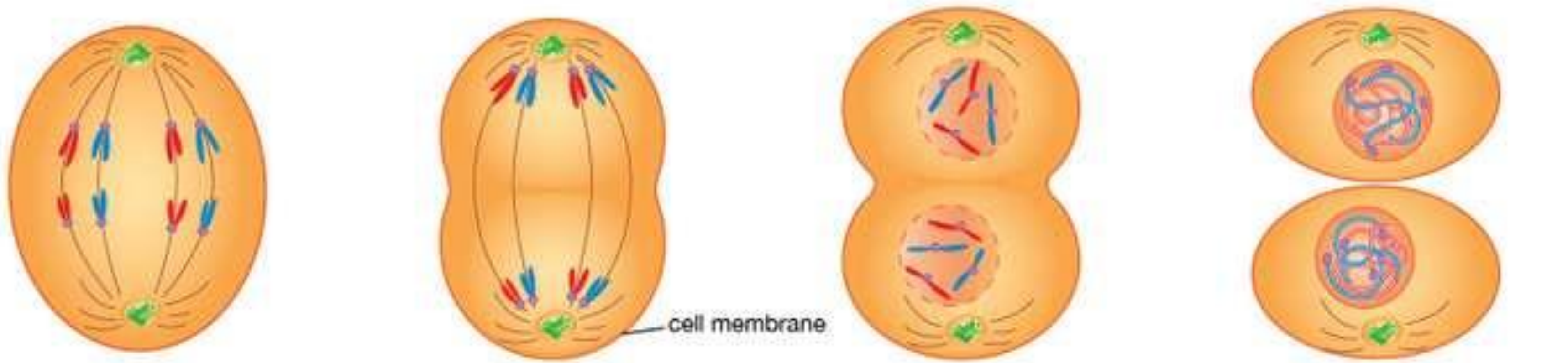


Prior to mitosis, each chromosome makes an exact duplicate of itself. The chromosomes then thicken and coil.

In early prophase the centrioles, which have divided, form asters and move apart. The nuclear membrane begins to disintegrate.

In late prophase the centrioles and asters are at opposite poles. The nucleolus and nuclear membrane have almost completely disappeared.

The doubled chromosomes—their centromeres attached to the spindle fibres—line up at mid-cell in metaphase.



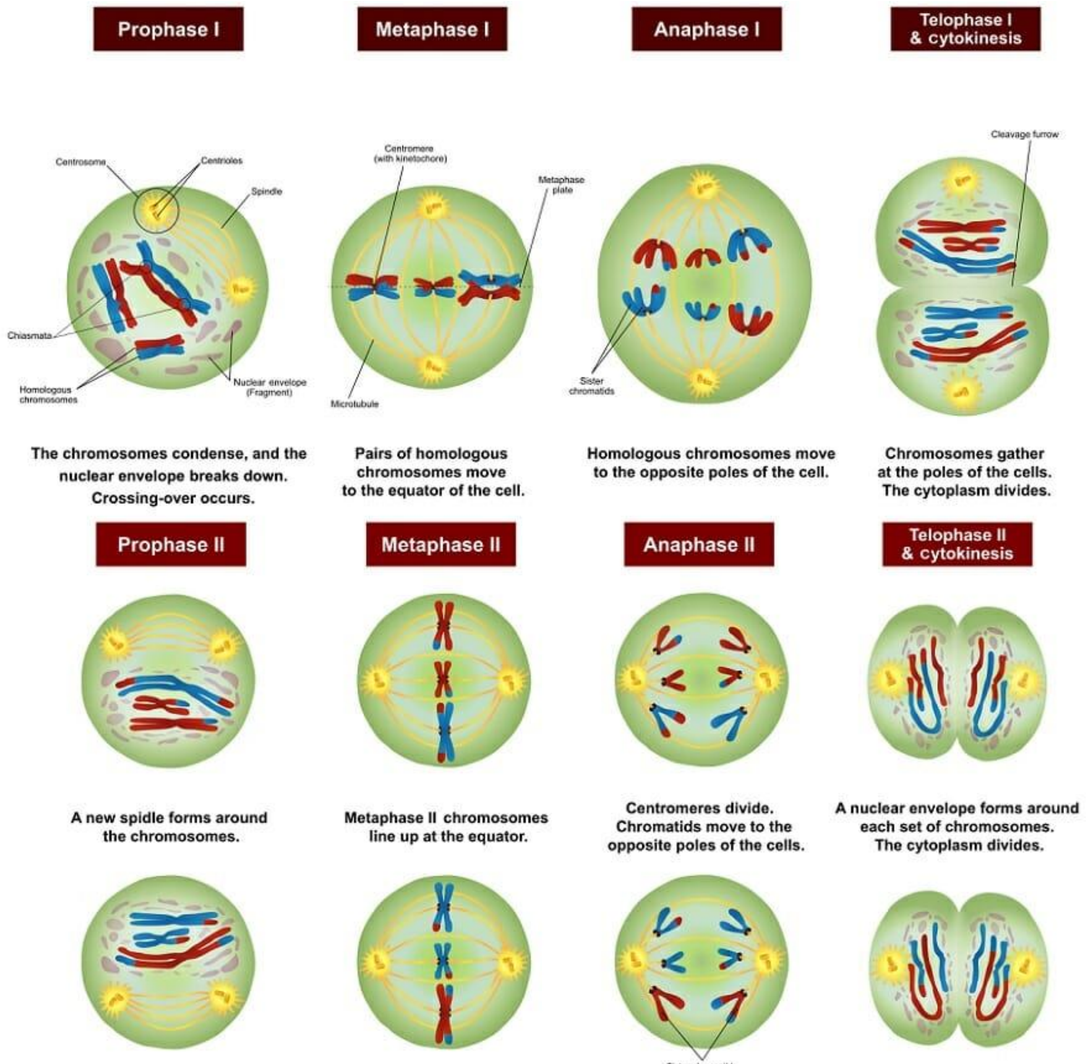
In early anaphase the centromeres split. Half the chromosomes move to one pole, half to the other pole.

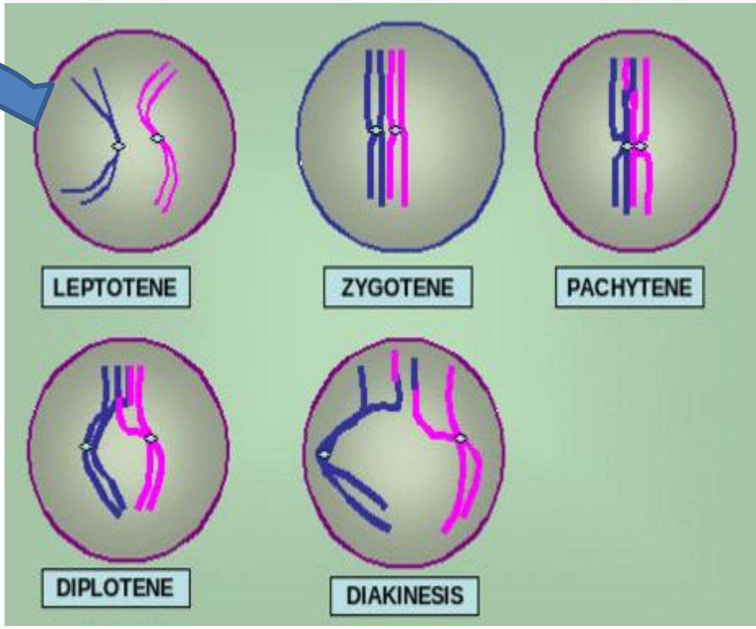
In late anaphase the chromosomes have almost reached their respective poles. The cell membrane begins to pinch at the centre.

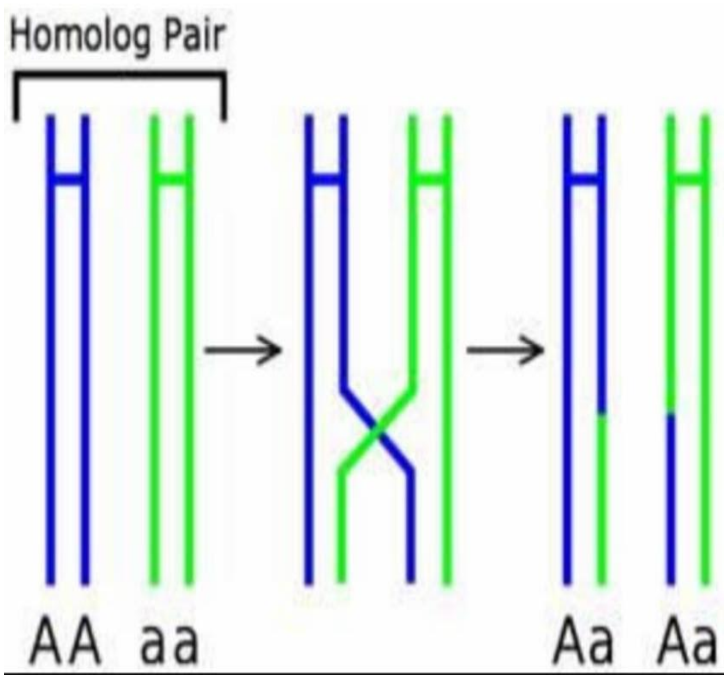
The cell membrane completes constriction in telophase. Nuclear membranes form around the separated chromosomes.

At mitosis completion, there are two cells with the same structures and number of chromosomes as the parent cell.

Normal meiosis





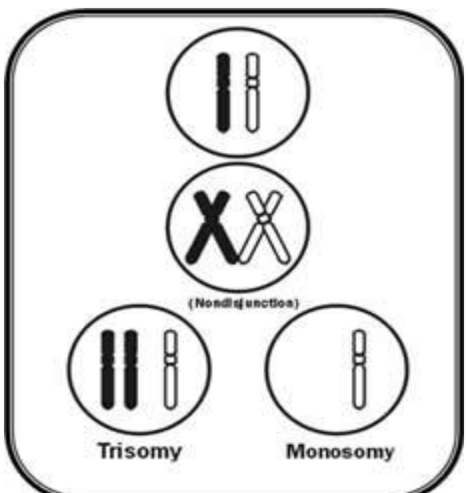


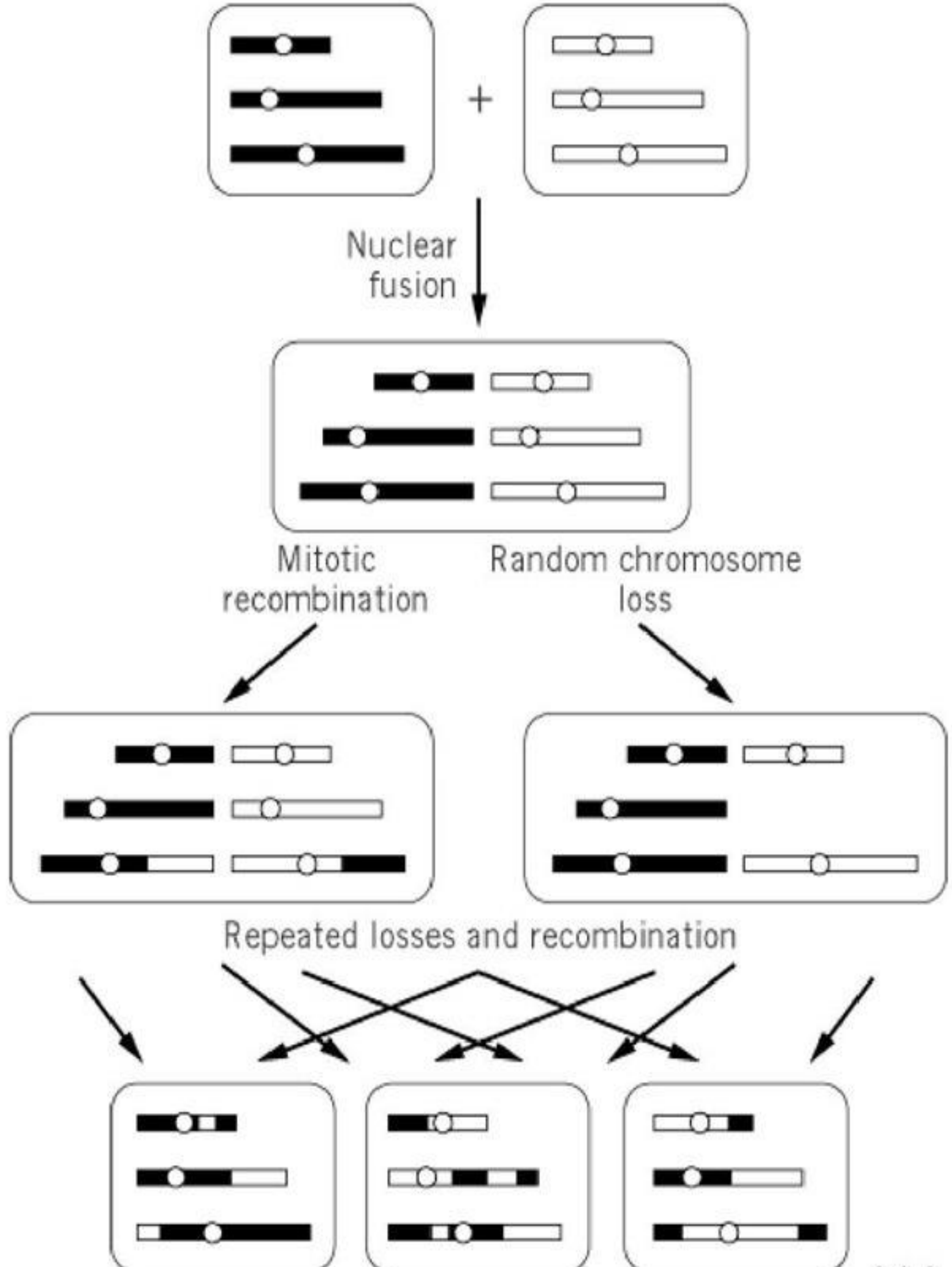
Parasexual reproduction

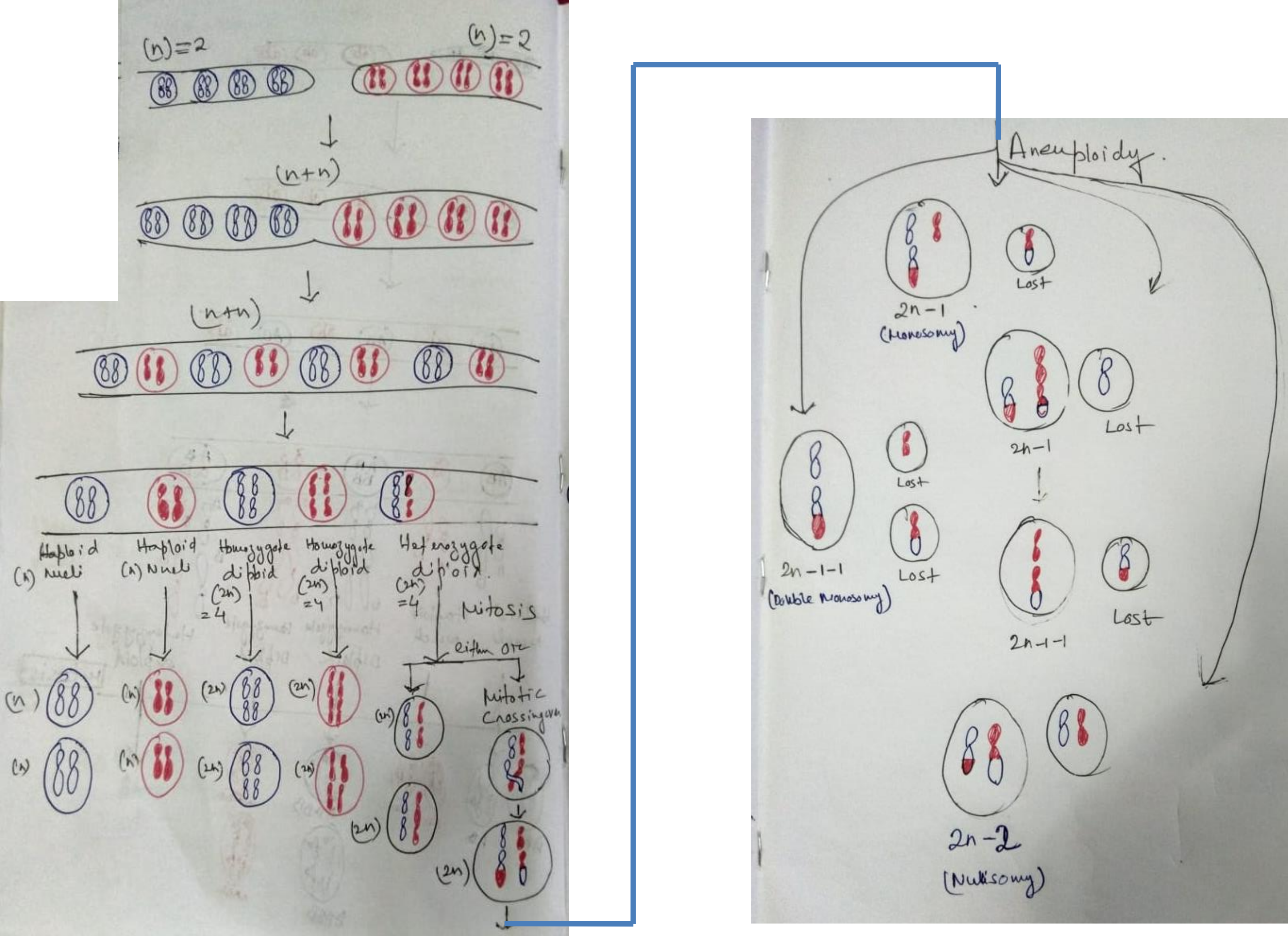
This is a process in which genetic recombination can occur through nuclear fusion and **crossingover of chromosomes during mitosis**. **Meiosis does not occur**, and instead **haploidization takes place by the successive loss of chromosomes** during mitotic divisions

It is believed that the necessary cytological steps take place in a regular sequence which Pontecorvo (1956) has termed the parasexual cycle

(i) nuclear fusion between genetically distinct haploid nuclei in a heterokaryon to form diploid nuclei
(ii) multiplication of the diploid nuclei along with the original haploid nuclei
(iii) the development of a diploid homokaryon
(iv) genetic recombination by crossing-over during mitosis in some of the diploid nuclei
(v) haploidization of some of the diploid nuclei by progressive loss of chromosomes (aneuploidy) during mitosis






(n)=2
(n)=2
(n+n)
(n+n)
Haploid (n) Nuceli
Haploid (n) Nuceli
Homozygote diploid (2n) =4
Homozygote diploid (2n) =4
Heterozygote diploid (2n) =4
Mitosis
either one
Mitotic Crossingover
(n)
(2n)
Aneuploidy.
2n-1 (Monosomy)
Lost
2n-1
Lost
2n-1-1 (Double Monosomy)
Lost
Lost
2n-1-1
Lost
2n-2 (Nullisomy)

Homo & heterothallism

Homothallism:

- Each thallus is sexually self fertile
- Such species have only one strain and thus self compatable
- Sexual reproduction occur in a colony derived from a single spore
- All individual are alike morphologically and physiologically

Three types of homothallic behaviour may be distinguished, namely primary, secondary and unclassified homothallism

Primary homothallism

- A single basidiospore germinates to form a mycelium, which soon becomes organized into binucleate segments bearing clamp connections at the septa
- There is no genetic distinction between the two nuclei in each cell, and this mycelium is capable of forming fruit bodies

Secondary homothallism (pseudohomothallism)

- the basidia bear only two spores, but the spores are heterokaryotic
- After meiosis **two nuclei enter each spore** and a mitotic division may follow
- On germination, a single spore forms a dikaryotic mycelium with clamp connections, capable of fruiting
- Occasional spores, on germination, give rise to non-clamped mycelia, and fruiting occurs only if these are paired in certain combinations, showing that the fungus is basically heterothallic
- Fungi showing both secondary homothallism and heterothallic behaviour are said to be amphithallic

Unclassified homothallism

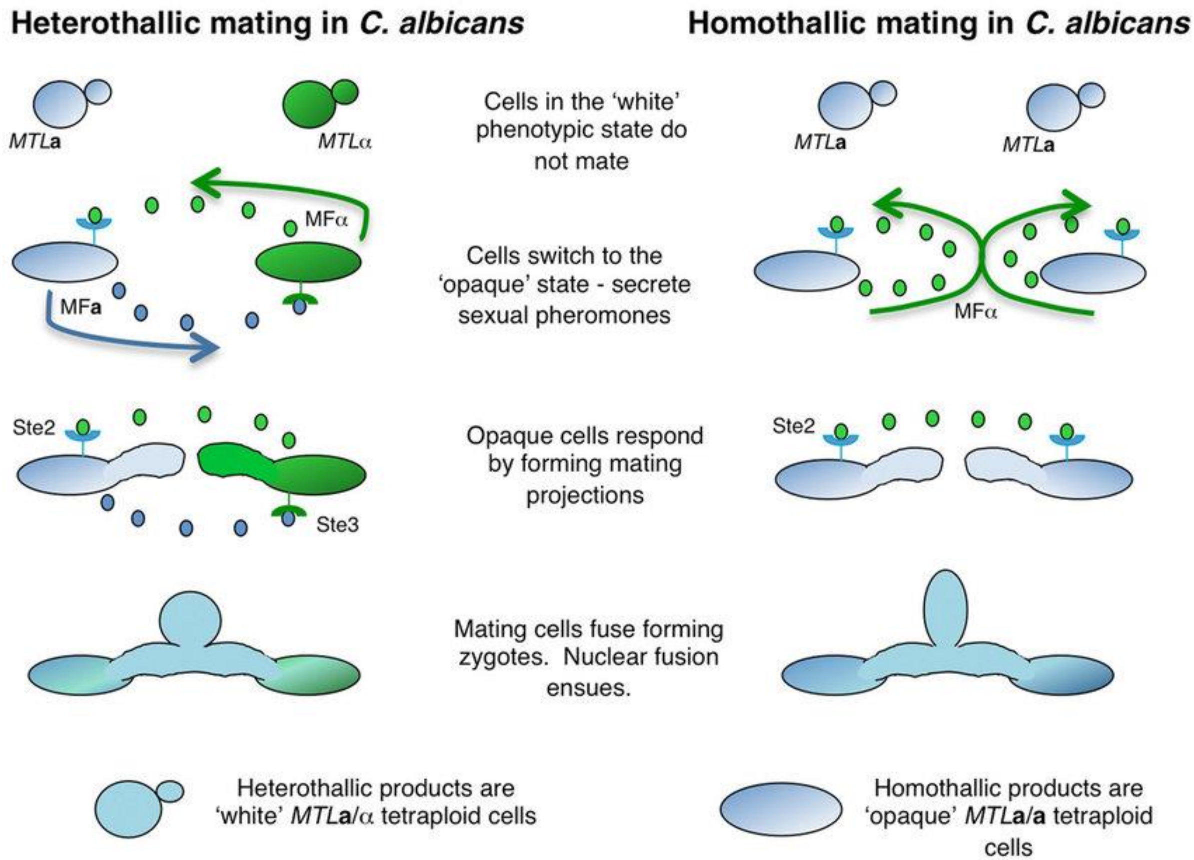
•The four-spored wild mushroom*, Agaricus campestris*, is homothallic in the sense that a mycelium derived from a single spore is capable of fruiting. There is nuclear fusion in the basidium, followed by two nuclear divisions, presumably meiotic. However, paired nuclei, conjugate nuclear divisions and clamp connections have not been observed

Heterothallism:

•In this kind of species there are more than one strain of thalli

•Single thalli are sexually self sterile

•Require aid of another compatible thalli of different mating type for sexual reproduction



Blakeslee (1904) first reported this phenomenon in some species of *Rhizopus.* He designated them as ‘+’ and ‘-’ as their gametangia are morphologically similar

According to Whitehouse (1949) the fungi may be morphologically or physiologically heterothallic

Morphological:
The sex organ produced by different thali are morphologically different

Eg. *Achlya ambisexualis*

Physiological:
In this type the two sex organ of two thalli are morphologically same but differ in genetic factor. Can be of two type.

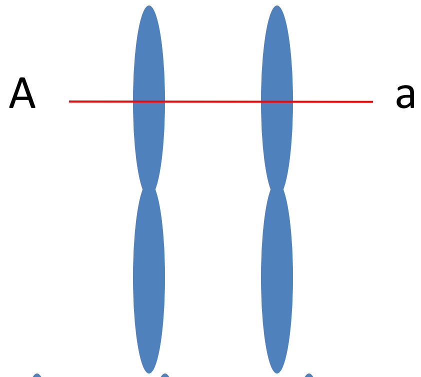
Two allelomorph: determined by two allelomorph at a single locus
eg. *Ascobolus mangifera*

Multiple allelomorph: determined by multiple allel either at one, two or three loci

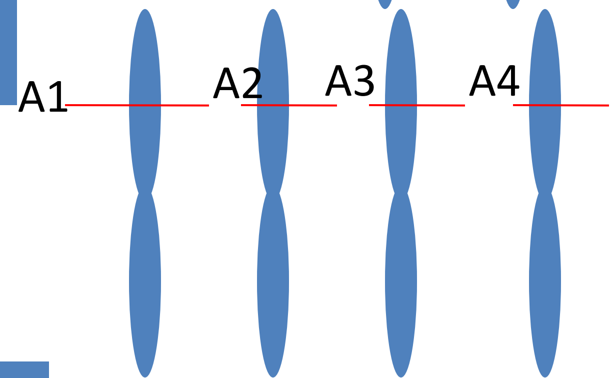
Heterothallic fungi may also be grouped under following type

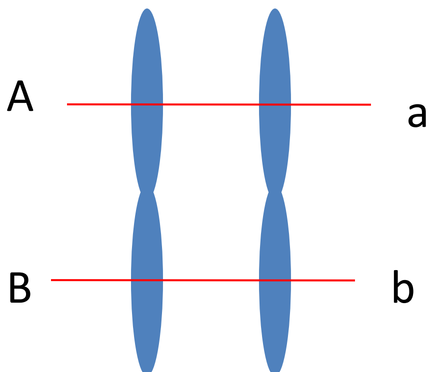
Bipolar heterothallism

Bipolar two allele heterothallism

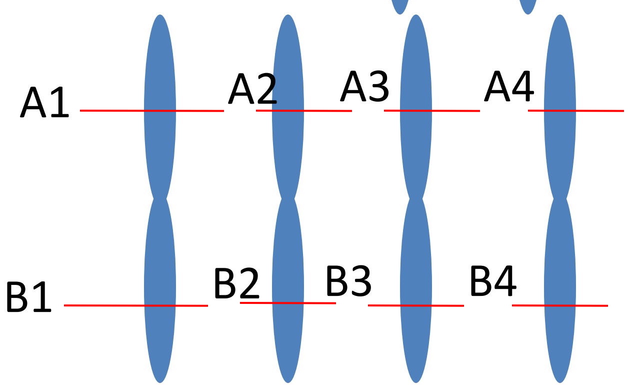


Bipolar multiple allele heterothallism





Tetrapolar two allele heterothallism



Tetrapolar heterothallism

Tetrapolar multiple allele heterothallism

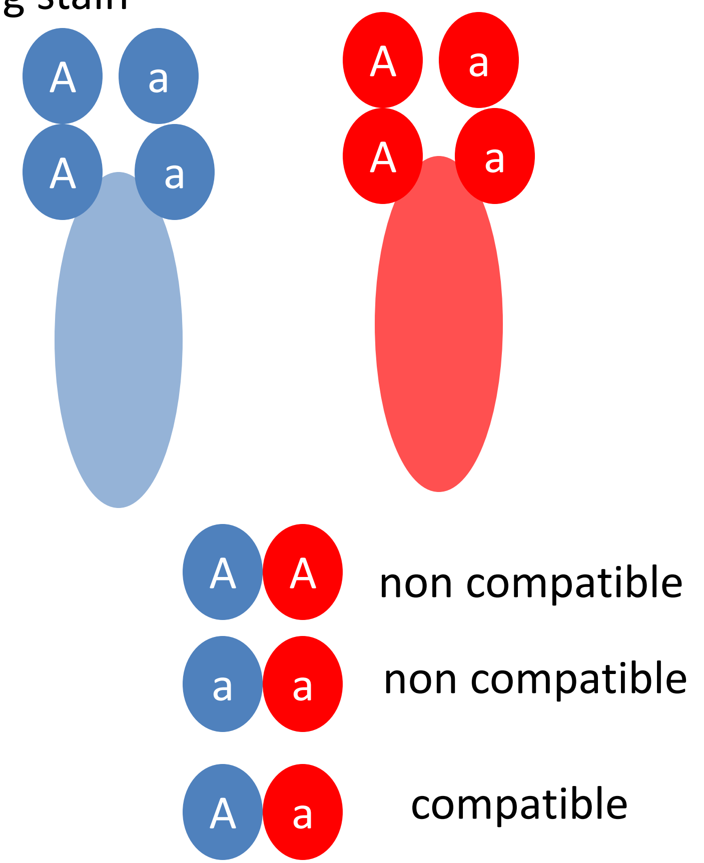
Octapolar heterothallism

Bipolar heterothallism:
Heterothallism is controlled by a single locus having two allele or multiple allele

Bipolar two allele heterothallism:

- Compatibility of two matting type is governed by one pair of allele in as single locus
- One stain carries ‘A’ and other stain carries allele ‘a’
- Only thalli carrying complementary allele is compatable and give ‘Aa’ zygote
- 50% chance of interfertility between opposite mating stain

	A	**a**
A	AA (non compatible)	Aa (compatible)
a	Aa (compatible)	aa (non compatible)



Bipolar multiple allele heterothallism

- Compatibility of two matting type is governed by multiple pair of allele in as single locus
- Multiple allele can be designated as A1, A2, A3, A4…………..A(n)
- Only thalli carrying complementary allele is compatable and give heterozygote

	A1	A2	A3	A4
A1	-	+	+	+
A2	+	-	+	+
A3	+	+	-	+
A4	+	+	+	-

-= non compatible
+ = compatible

Tetrapolar heterothallism

Heterothallism is controlled by a two locus having two allele or multiple allele

Tetrapolar two allele heterothallism

- Compatibility of two matting type is governed by two pair of allele in two locus
- Thus we can denote the two genes as A and B and their two alleles as A1, A2 and B1, B2, respectively
- Consider the cross of a monokaryon bearing A1B1 with another bearing A2B2
- This would result in a fertile dikaryon (A1B1 + A2B2)
- Such a dikaryon would form spores following meiosis and the spores would be of four kinds: A1B1, A2B2 (parentals), A2B1 and A1B2 (recombinants)
- There is 25% chance od interfertility
- In most cases studied, the proportions of the four kinds of spore are equal, showing that the A and B loci are unlinked, i.e. borne on different chromosomes

Tetrapolar multiple allele heterothallism

- Compatibility of two matting type is governed by multiple pair of allele in two locus
- Multiple allele can be designated as A1, A2, A3, A4…………..A(n) and B1, B2, B3, B4……B(n)
- Only thalli carrying complementary allele is compatable and give heterozygote

Thank you