Heterokaryosis - co-existence in the same cytoplasm of 2 or more genetically different nuclei*

* a dikaryon is a specialized heterokaryon, which has different mating-type genes (idiomorphs).

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How do heterokaryons come into existence?

1. Mutation
2. Anastomosis
3. Spore formation*
4. Diploidization of homozygous or heterozygous nuclei

* really an extension of 1 or 2 which may be more significant because can yield more obvious variant strain.(changes nuclear ratios)

Note: Hyphal fungi are products of all their nuclei (genetics of hyphal fungi can sometimes be thought of in terms of population genetics)

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Parasexuality

Operational definition -

1. Heterokaryon formation
2. Fusion in the heterokaryon of unlike somatic (non-dikaryotic) nuclei
3. Mitotic crossing over (recombination)
4. Haploidization*

*Expression or discovery only apparent after spores --> colony. (see pg. 229 of M-L for mechanisms that might produce new phenotypes)

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Sexual
Mating-type Regulation

1. Homothallism = self fertility
   Homothallic = Homomictic

   a. Self-fertile species found among all divisions of fungi and fungal-like protists.

   b. Homothallic species co-exist with heterothallic species among many genera.
   Achlya, Saprolegnia, Zygorhynchus, etc.

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2. Heterothallism = self-sterility
Heterothallic = Heteromictic

a. Dimictic = controlled by a single pair of nonhomologous mating-type gene sequences (idiomorphs) that reside at a single chromosomal locus:

a/α, A_1/A_2, A/a, +/-

b. Diphoromictic = controlled by multiple pairs of nonhomologous mating-type gene sequences (idiomorphs) that reside at either one or two chromosomal loci:

$A_1/A_2/A_3/A_4$/etc....

(Only in some (many) Basidiomycota

Models:

S. cerevisiae }
N. crassa } heterothallic
S. commune }

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***Diaphoromictic Systems**

a. Bipolarity = multiple nonhomologous pairs of mating-type gene sequences (idiomorphs) at one chromosomal locus

tetrad analysis = $2A_1 2A_2$*
2a, 2α, etc.**

b. Tetrapolarity = multiple nonhomologous pairs of mating-type gene sequences (idiomorphs) at 2 independently assorting loci

A_1 A_2 A_3 A_4 A_5 A_6 ....***
B_1 B_2 B_3 B_4 B_5 B_6....

* "most" basidiomycetes?
** a & α = $a_{1,2,3}$, $\alpha_{1,2,3}$, in some Ustilaginales
*** as per *S. commune*

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Tetrad Analysis of Tetrapolar Species*

$2A_1B_1$ or $2A_1B_2$
$2A_2B_2$ $2A_2B_1$

or $1A_1B_1$, $1A_1B_2$, $1A_2B_1$, $1A_2B_2$*

*involves a single reciprocal crossover of 1 chromatid (double crossover --> 2 types again)

Analysis of 4 basidiospores from one basidium

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Homodimixis & Homodiphoromixis

Homodimictic systems = dimictic species that, as a consequence of spore formation, appears homothallic*

Homodiphoromictic systems = diphoromictic systems that, as a consequence of spore formation, appear homothallic

* Strains derived from uninucleate cells (e.g. often conidia) will exhibit heterothallic condition.

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REVIEW

1. Homothallic/Homomictic = self-fertility

2. Heterothallic/Heteromictic = self-sterility

   a. Dimictic = self-sterility controlled by two and only two idiomorphs
   (a/α, A_1/A_2, A/a, +/-)

   b. Diphoromictic = self-sterility controlled by multiple idiomorphic series.
   ($A_1/A_2/A_3/A_4$/etc)

      1. bipolar = multiple idiomorphic series at 1 locus
      (tetrad analysis $2A_1$ $2A_2$)

      2. tetrapolar = multiple idiomorphic series at two unlinked loci (tetrad analysis

$2A_1B_1$ or $2A_1B_2$
2A B $2A_2B_1$

usual

$1A_1B_1$, $1A_1B_2$, $1A_2B_1$, $1A_2B_2$*

infrequent

Also –

Homodimictic

Homodiphoromictic

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Plasmogamy Terminology

1. Planogametic copulation-mating fusions involving at least one flagellated cell*

a. Isogamy - copulation between two morphologically indistinguishable flagellated cells

b. Anisogamy - copulation between two morphologically distinguishable flagellated cells

c. Oogamy - copulation between a flagellated cell and a nonflagellated cell (true oogamy in sense of animal biology)

Flagellation structure suggests taxonomy and trend toward more advanced forms is from isogamy to anisogamy to oogamy (as per Chytridiomycota)

Fungal Plasmogamy Terminology (cont)

2. Gametangial Contact - differentiated or undifferentiated gametangia exchange or donate and received nuclei without fusion of gametangia. e.g. Oomycota

3. Gametangial Copulation - differentiated or undifferentiated gametangia exchange or donate and receive nuclei with fusion of the gametangia. e.g. widespread in Euascomycotina, Hemiascomycotina, Zygomycota, Chytridiomycota

4. Spermatization - spores act as donor cells and provide mating nucleus to receptive hypha or vegetative hypha. e.g. Euascomycotina, Heterobasidiomycotina

5. Somatogamy - copulation of undifferentiated vegetative cells. e.g. Hemiascomycotina, Homo- and Hetero- basidiomycotina.

gametes = protoplasts of various cells

REVIEW

1. Homothallic/homomictic = self-fertility
2. Heterothallic/heteromictic = self-sterility

A. Dimictic = self-sterility controlled by two and only two idiomorphs

$(a/\alpha, a_1/a_2, a/a, +/-)$

B. Diaphoromictic = self-sterility controlled by multiple idiomorphic series.

$(a_1/a_2/a_3/a_4/etc)$

1) Bipolar = multiple idiomorphic series at 1 locus

(tetrad analysis $2a_1$ $2a_2$)

2) Tetrapolar = multiple idiomorphic series at two unlinked loci (tetrad analysis)

$2a_1b_1$	or	$2a_1b_2$
$2a_2b_2$		$2a_2b_1$

usual

$1a_1b_1$, $1a_1b_2$, $1a_2b_1$, $1a_2b_2$*

infrequent

also - homodimictic
homodiaphoromictic

Value of tetrapolarity vs bipolarity

Dimictic and bipolar diaphoromictic species can mate with themselves 50% of the time, because half of all spores are of one mating type and half are of the other. Therefore, such species are less efficient outbreeders.

Diaphoromictic tetrapolar individuals of a species can mate with themselves, in contrast, only 25% of the time, because there are four, not two, mating types represented in progeny of meiosis. Therefore, these individuals have greater outbreeding potential.

Diaphoromixis increases outbreeding potential even greater. The larger the number of mating-type alleles in the world-wide population of a species, the greater the outbreeding potential: [1/n x (n-1)] x 100%.

For *S. commune*, with 9, 32, 9 and 9 different specificities for aα, aβ, $\beta\alpha$, and bβ respectively, there are estimated to be 28,000 world-wide mating types.