Reasons Sex Persists in Fungi

1. To bring together in the same nucleus genetic information from different individuals

2. To redistribute it in different combinations to different progeny

   The redistribution is the result of:
   a) Independent assortment of chromosomes (during first division of meiosis-meiosis I)
   b) Crossing over of alleles during synapsis in metaphase 1*

* Gives rise to Mendelian segregation patterns known as:
   1) 1st division segregation
   2) 2nd division segregation

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Nonsexual Mechanisms for Generating Genetic Variability or Stability

1. Heteroplasmonosis (Extrachromosomal)

2. Heterokaryosis

3. Parasexuality

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Heteroplasmonosis
(extrachromosomal or nonnuclear gene inheritance)

The co-existance in the same cytoplasm of nuclear and nonnuclear entities that affect differently the phenotype of the fungus.

Examples
- RD systems in *S. cerevisiae**
- 2μ DNA inheritance in *S. cerevisiae*
- poky in *N. crassa*
- Killer in *Ustilago*
- senescence in *Podospora*
- sexuality vs nonsexuality in *Aspergillus nidulans*
- mycoviruses

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General Properties of *S. cerevisiae* r (petite) mutants.
(non-nuclear or haploid or homozygous diploids)*

1. Cannot respire aerobically (obligately fermentative)

2. Cannot form ascospores

3. Exhibit absence of certain functional membrane-bound mitochondrial cytochromes

∴ respiratory deficient (RD) mutants (ρ)*
- nuclear mutations -> tetrads with 1 wt: 1 RD
- nonnuclear mutations -> non Mendelian ratios

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r ^{o} (neutral) petite (^{n}r $^{-}$)

N 2N

1. $\alpha^{n}\rho^{-}$ X $a^{n}\rho^{-}$ ---> $a\alpha\ ^{n}\rho^{-}\,^{n}\rho^{-}$ (presumed genotype of diploid)

(homozygous cross)
1. Respiratory deficient
2. --> Petite colonies
3. --> No ascospores

2. $\alpha^{n}\rho^{+}$ X $\alpha^{n}\rho^{-}$ ---> $a\alpha\ ^{n}\rho^{-}\,^{n}\rho^{+}$ (presumed genotype of diploid)

(heterozygous cross)
1. Respiratory sufficient
2. Normal colonies
3. Ascospores

↓

tetrad analysis

↓

---> $2a\ ^{n}\rho^{+}$ & $2\alpha\ ^{n}\rho^{+}$ (lost ρ character) \ not nuclear gene

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Segregational ($^{s}r^{-}$) petites*

1. a$^{s}\rho^{-}$ x $\alpha^{s}\rho^{+}$ ----> a$\alpha^{s}\rho^{-s}\rho^{+}$ (normal respiratory sufficient diploid)
   ascosporogenesis & tetrad analysis

	1.	2 a$^{s}\rho^{-}$ & 2 $\alpha^{s}\rho^{+}$	mating type gene & $^{s}\rho$- gene
or	2.	2 a$^{s}\rho^{+}$ & 2 $\alpha^{s}\rho^{-}$	on different chromosomes*
or	3.	infrequently** 1a$^{s}\rho^{-}$, 1$\alpha^{s}\rho^{-}$, 1a$^{s}\rho^{+}$, 1$\alpha^{s}\rho^{+}$	

**(when *pet* ^{18} on chrom III with mating locus)

*general Mendelian segregation patterns for 2 unlinked pairs of nuclear genes or for 2 pairs of linked genes.

- petite phenotype recessive because not expressed (<u>masked</u>) in diploid

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Seg x neutral petite cross

1. a$^{n}\rho^{-}$ X $\alpha^{s}\rho^{-}$ ----> a$\alpha^{n}\rho^{-s}\rho^{-}$ (presumed diploid genotype)

   1. all respiratory sufficient
   2. ∴ all can form ascospores

Why respiratory sufficient?

a$^{n}\rho^{-}$ strain has $^{s}\rho^{+}$ nuclear gene to complement $\alpha^{s}\rho^{-}$ defect in diploid.

$\alpha^{s}\rho^{-}$ strain has $^{n}\rho^{+}$ mitochondrial gene to complement a$^{n}\rho^{-}$ gene defect in diploid.

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Seg r^- X Neutral r^- =

$a\,^s\rho^- \,^n\rho^+$ X $\alpha\,^s\rho^+ \,^n\rho^-$ ----> $a\alpha\,^s\rho^- \,^s\rho^+ \,^n\rho^- \,^n\rho^+$

↓ growth &
↓ sporulation

$2a\,^s\rho^-$ & $2\alpha\,^s\rho^+$

or $2a\,^s\rho^+$ & $2\alpha\,^s\rho^-$

1:1 pattern = $2RD^+$ (petite strains)
$2RD^-$ (normal wt)

again lost the $^N\rho^-$ phenotype character because mutant nonchromosomal gene(s) lost.

Suppressive ρ^- -> non-Mendelian ratios different than that of $n\rho$-, because have mitochondrial DNA with only one of a few mutations, mitochondrial (mt) ribosome function and antibiotic resistance. e.g. – chloramphenical resistance

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Inheritance of nonnuclear trait for sexuality in *Aspergillus nidulans* using nonsexual cross

Some strains sexual
Some strains nonsexual Question: are these nuclear genes?

Nonsexual cross (by anastomosis)
G = green conidia (nuclear gene marker)
g = yellow conidia (nuclear gene marker)

Homokaryons yellow (g) sexual X green (G) nonsexual NXN
↓
Heterokaryon green (Gg) sexual N+N
isolated & analyzed
conidia w/ single nuclei

yellow (g) sexual green (G) sexual

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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)

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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. 249 of M-L for mechanisms that might produce new phenotypes)

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