- ∗ Mycelial fungi are typically multinucleate (many nuclei in a common cytoplasm) and reap both the benefits of being haploid and a "functional diploid"
- ∗ Not so for solely diploid organisms (e.g., Oomycota) and it also different for organisms like *S. cerevisiae* which can have either a persistent haploid or diploid state

◆ Nonsexual variation: heterokaryosis

- ∗ Heterokaryons have two or more genetically different nuclei in a common cytoplasm (as opposed to homokaryons)
- ∗ Heterokaryons produced in two ways:
  - ● Mutation of a wild-type nucleus
  - ● Fusion of two genetically different strains
- ∗ Ratio of genetically different nuclei can vary depending upon selection pressures, e.g., Jinks test involving *Penicillium cyclopium* (see Table 9.3 in Deacon)
- ∗ Heterokaryons do break down or segregate into homokaryons by one of two mechanisms
  - ● Uninucleate spore production
  - ● Branch contains a single nuclear type

◆ Nonsexual variation: parasexuality

- ∗ Discovered by Pontecorvo in studying heterokaryosis
- ∗ He observed that a heterokaryon having nuclear condition Ab and aB, produced not only parental types (Ab and aB), but also recombinant types, AB and ab.
- ∗ Further study of this phenomenon led Pontecorvo to propose a parasexual cycle consisting of three stages:
  - ● Diploidization
  - ● Mitotic chiasma formation
  - ● Haploidization
- ∗ Parasexuality in relatively rare and is not a regular cycle as is sexual reproduction

◆ Sexual variation

- ∗ Major mechanism for producing recombinants
- ∗ Different mechanisms of crossing have evolved due to environmental conditions
  - ● Heterothallic
  - ● Homothallic
  - ● Others
- ∗ Sexual spores tend to be dormant

- Plasmids and transposable elements
  - Transposons
    - Short regions of DNA that remain in the chromosome, but encode for enzymes that function in the replication of these transposable elements
      - Produce RNA copies of themselves
      - Encode reverse transcriptase as well
    - RNA is copied into DNA that then inserts itself into various points of a chromosome
    - Rare in filamentous fungi
    - Several types in *S. cerevisiae*, including the Ty element (about 30 copies per cell), that can alter gene expression and chromosomal arrangements
    - No known function, except for self-replication
- Viruses
  - First discovered as a pathogen of mushrooms
  - Electron microscopy revealed isometric virus-like particles (VLPs)
  - Now found in numerous fungal species
  - With few exceptions, however, VLPs appear not to cause any symptoms
  - Common characteristics of fungal VLPs
    - Genome of dsRNA
    - Capsid composed of one polypeptide
    - Genome encodes for a single protein, dsRNA-dependent RNA polymerase
    - Variable genome size
    - Occur as crystalline arrays often near the ER
    - Transmission is by hyphal fusion or via passage into asexual spores
  - VLPs are resident genetic elements, i.e., without a natural means of spreading, they don't cross species barriers
  - Can affect virulence of certain species

Genetic Variation

- Nonsexual variation: the significance of haploidy
  - Haploid fungi are under constant selection pressure, thereby increasing fitness or causing a loss thereof
    - Benefit: short term acquisition of characteristics
    - Disadvantage: cannot withstand long-term accumulation of mutations not of immediate value

- Chromosomes in fungi
  - Most are haploid
  - Difficult to quantify
    - Very condensed
    - Nuclear membrane persists
  - Number of chromosomes vary between 3 and 40 with most fungi having between 6 and 16
  - Genome size is small compared to other eukaryotes
    - 3-8 times larger than E. coli, but 5-30 smaller than fruit flies or humans
    - Reason: limited multicopy DNA, restricted mainly to rRNA and tRNA
- Mitochondrial genes
  - Fungal mitochondrial genomes are small (19-121 kb in size) compared to plants (1 Mb), but larger than humans (6.6 kb)
  - Differences due to non-coding segments
  - Both nuclear and mitochrondrial genes are essential for function of this organelle
  - Have an important role in senescence (aging)
- Plasmids and transposable elements
  - Plasmids are self replicating
    - Usually circular
    - Also, linear capped forms
  - Most common types
    - “2 micron” plasmid found in the nucleus of *Saccharomyces cerevisiae*
    - Many other plasmids found within mitochondria
    - No known function of any

Biology of Fungi, Lecture 9: Fungal Genetics, Molecular Genetics, and Genomics

Concepts

- Fungi have major tools for classical genetic studies
  - Ease of growth
  - Short life cycles
  - Most are haploid
  - Many have a sexual stage
  - Produce asexual spores that can be used or stored in bulk
- Fungi also serve as good models for biochemical studies
  - Simple nutrient requirements
  - Can be directly correlated with genetic studies, e.g., “one gene, one enzyme” hypothesis by Beadle and Tatum

Neurospora Classical Genetics

- Neurospora has 4-5 heterothallic species
  - Two mating types: A and a
  - “male spore” fertilizes a female trichogyne to eventually form asci bearing ascospores
  - Haploid nuclei fuse to form a diploid nucleus, which then undergoes meiosis followed by a second mitotic division
- Resulting 8 nuclei are arranged in a linear fashion within an ascus
- Patterns of sister chromatid segregation of can be deduced from the different types of arrangements
  - Cross-over events
  - Gene mapping

Genome Structure

- A genome is all the genetic information possessed by an organism
  - Chromosomal genes
  - Mitochondrial genes
  - Plasmids/mobile genetic elements
  - Virus genes
- Each contributes to the overall phenotype of the fungus