Biology of Fungi, Lecture 2: The Diversity of Fungi and Fungus-Like Organisms

Terms You Should Understand

- ‘Fungus’ (pl., fungi) is a taxonomic term and does not refer to morphology
- ‘Mold’ is a morphological term referring to a filamentous (multicellular) condition
- ‘Mildew’ is a term that refers to a particular type of mold
- ‘Yeast’ is a morphological term referring to a unicellular condition

Special Lecture Notes on Fungal Taxonomy

- Fungal taxonomy is constantly in flux
- Not one taxonomic scheme will be agreed upon by all mycologists
- Classical fungal taxonomy was based primarily upon morphological features
- Contemporary fungal taxonomy is based upon phylogenetic relationships

Fungi in a Broad Sense

- Mycologists have traditionally studied a diverse number of organisms, many not true fungi, but fungal-like in their appearance, physiology, or life style
- At one point, these fungal-like microbes included the Actinomycetes, due to their filamentous growth patterns, but today are known as Gram-positive bacteria
- The types of organisms mycologists have traditionally studied are now divided based upon phylogenetic relationships
- These relationships are:
  - Kingdom Fungi - true fungi
  - Kingdom Straminipila - “water molds”
  - Kingdom Mycetozoa - “slime molds”
- Kingdom Fungi (Mycota)
  - Phylum: Chytridiomycota
  - Phylum: Zygomycota
  - Phylum: Glomeromycota
  - Phylum: Ascomycota
  - Phylum: Basidiomycota
  - Form-Phylum: Deuteromycota (Fungi Imperfecti)

- Kingdom Straminiplia (Chromista)
  - Phylum: Oomycota
  - Phylum: Hyphochytridiomycota
  - Phylum: Labyrinthulomycota
- Kingdom Mycetozoa
  - Phylum: Myxomycota
  - Phylum: Dictyosteliomycota
  - Phylum: Acrasiomycota
  - Phylum: Plasmodiophoromycota

The Mycetozoa (Slime Molds)

- Kingdom Mycetozoa is comprised of four phyla containing three different groups of organisms that differ in their trophic (feeding) stages
  - Myxogastrids - plasmodial
  - Dictyostelids and acrasids - amoeboid
  - Protostelids - obligate parasites having two plasmodial stages
- Phylum Dictyosteliomycota
  - Monophyletic group of cellular slime molds
  - Best example: *Dictyostelium discoideum*
  - Grow and divides as unicellular, haploid amoebae
  - Feed on bacteria via phagocytosis
  - Commonly found in moist, organic-rich soil
  - Asexual reproductive phase begins upon depletion of nutrients
    - Amoebae secrete cAMP
    - cAMP acts as chemotactic agent causing aggregation (*streaming*) of amoebae into one body, termed a ‘slug’ (grex) - Note: no cellular fusion; amoebae remain as independent cells
    - Cells within the grex differentiate into two types:
      - Pre-stalk cells
      - Pre-spore cells
    - Grex undergoes a complex process whereby it forms a cellulosic sorocarp (fruiting body) comprised of thin stalk and large spore head
  - Sexual cycle involves the formation of diploid macrocysts that undergo meiosis

- Phylum Acrasiomyctoa
  - Polyphylogenetic group of cellular slime molds
  - Best example: *Acrasis rosea*
  - Cylindrical (limax type) amoebae
  - Feeds on bacteria by phagocytosis
  - Amoeba aggregate singly or in groups
  - Differences with Dicytosteliomycota:
    - Do not respond to cAMP; chemotactic factor is unknown
    - Amoebal aggregation complex does not migrate, but immediately forms a sorocarp
    - Stalk of sorocarp is not well differentiated and cells can germinate to form amoebae
    - Sexual reproduction is unknown
  - Plasmodial slime molds
  - Best example: *Physarum polycephalum*
  - Prominent feature is the multinuclear network of protoplasm that exhibits rhythmic streaming
  - Feeds by phagocytosis of bacteria
  - Plasmodium typically develops under the surface of organic substrates
  - Plasmodium moves to the surface when nutrients become depleted
    - Develops a fruiting structure (sporangium; pl., sporangia)
    - Sporangium contains haploid spores that are dispersed by the wind
    - Spores germinate to produce either amoeboid cells (myxamoebae) or flagellated swarm cells
    - Two cells fuse to form a diploid zygote
    - Zygote nucleus divides and cell grows to form a plasmodium
    - A mature plasmodium can form either:
      - A sclerotium under adverse conditions that can then regenerate as a plasmodium; or
      - Sporangia that bear haploid spores

- Phylum Plasmodiophoromycota
  - Obligate intracellular parasites of plants, algae, or fungi
  - Best example: *Plasmodiophora brassicae*
    - Infection of plant roots leads to “club foot”
    - Plant responds to infection by *P. brassicae* by undergoing rapid cell expansion and division, forming galls that require substantial nutrients
    - Gall formation involves glucobrassicin, a compound converted to a phytohormone
  - However, many species of plasmodiophorids, including *P. brassicae*, appear to live harmlessly inside many types of plant roots due to:
    - Absence of high levels of glucobrassicin; or
    - Lack of phytohormone production
  - *P. brassicae* has a complex and not completely defined life cycle that involves:
    - Two types of biflagellated zoospores
    - Two types of plasmodia (primary and secondary)
    - Alternating cycles of life in soil and in the plant root hair

The Chromistans

- The term ‘Chromistan Fungi’ is oxymoronic in that:
  - Chromists are a broadly diverse of protists containing stramenopiles (also spelled straminiples), but not true fungi
  - Phylogenetic evidence suggests a monophyletic origin quite distinct from the true fungi, most likely a red algal ancestor
- Chromists contain not only the stramenopiles, but also haptophytes and cryptophytes
- Chromists seem to share a common ancestry with alveolates (ciliates, sporozoans, dinoflagellates)

The Stramenopiles

- Stramenopiles are also known as heterokonts, referring to two types of flagella found in this group
  - Smooth (whiplash) flagellum
  - “Tinsillated” (or tinsel) flagellum
    - Contains stiff lateral hairs (mastigonemes)
    - Pulls, doesn’t push, cell through the medium
- Number/kind of flagella varies among the different groups of organisms
- Stramenopiles include diatoms and kelps in addition to fungus-like microbes

- Kingdom Straminipila
  - Comprised of three fungal-like phyla
    - Hyphochytridiomycota
    - Oomycota
    - Labyrinthulomycota
  - Phylum Hyphochytridiomycota
    - Very similar in many ways to the Phylum Chytridiomycota (Kingdom Fungi [Eumycota])
    - Live in water or soil
    - Parasites or saprotrophs
    - Thallus (body) structure:
      - Endobiotic - resides completely within the host
      - Epibiotic - reproductive structures outside a host or on the surface of dead organic matter
    - Reproductive structure types:
      - Holocarpic - entire thallus develops into a sporangium
      - Eucarpic - thallus differentiates into assimilative rhizoids and a sporangium
    - Arrangement of thallus
      - Monocentric - single center of growth
      - Rhizoidal - sporangium with rhizoids (non-septate)
      - Polycentric - branched hyphae (septate) connecting many sporangia
    - Thallus developmental patterns (i.e., monocentric, rhizoidal, or polycentric) differentiate families among the hyphochytrids
    - Motile spores (zoospore) possess a single, anterior tinsel flagellum [distinguishes the hyphochytrids from the chytrids]
    - No sexual reproduction yet observed among the hyphochytrids
    - Best example: *Rhizidiomyces apophysatus* - parasite water mold oogonia
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    - Best example: *Rhizidiomyces apophysatus* - parasite water mold oogonia

* Phylum Oomycota
  - Economically important fungus-like organisms that have extremely significant environmental roles in agriculture
  - Causes of the following plant/fish diseases:
    - Potato blight (*Phytophthora infestans*)
    - Sudden oak death (*Phytophthora ramorum*)
    - “Decline” diseases (*Pythium* spp.)
    - Downy mildews (*Peronospora* spp.)
    - Water molds/fish pathogens (*Saprolegnia* spp.)
  - Greatly mimic the true fungi in many ways probably due to convergent evolution
  - Possess the following plant-like features:
    - Glucan and cellulose-like cell walls (not chitin)
    - Diploid nuclei (most fungi tend to be haploid)
    - Membranes contain plant sterols (not ergosterol)
    - Specific energy storage compounds
    - Similar organellar ultrastructure
    - Different sensitivities to antifungal agents
  - Key features
    - Zoospores have two flagella - a forward directed tinsel type and a backward directed whiplash type
    - Sexual reproduction is oogamous, i.e., the zygote develops into a thick-walled oospore that can persist in the environment [Note: oogamy can also occur in some chytrids (Eumycota)]
  - Features of a oomycetous life cycle is typified by that of *Phytophthora infestans*
    - Asexual reproduction involves a multinucleate sporangium that releases *diploid* zoospores
    - The diploid zoospores encyst, then germinate to form somatic hyphae
    - Somatic hyphae has two fates: continued asexual reproduction via the formation zoospores, or sexual reproduction by undergoing differentiation into male and female gametangia
    - Types of gametangia: antheridium (male sex organ) and oogonium (female sex organ)
    - Meiosis occurs in both gametangia before the antheridium fertilizes the oogonium
    - Fertilization leads to the development of one or more thick-walled, diploid oospores
    - Oospores have a dormant period prior to germination

- Germinating oospores produce either diploid hyphae or a sporangium that will subsequently release more diploid zoospores

- Variations of this life-cycle theme are replete within this phylum
  - Some Oomycota are homothallic, whereas others are heterothallic
  - Some (e.g, *Pythium*) develop oogonia via parthenogenesis
  - Some water molds (e.g., *Saprolegnia*) produce primary zoospores that encyst immediately upon release, then form secondary zoospores that remain motile for hours while searching for substrate

* Phylum Labyrinthulomycota
  - Commonly referred to as “net slime molds”
  - Characterized by a network of branch, anastomosing (fusing), wall-less filaments held together by a secreted polysaccharide sheath
  - Produce biflagellated zoospores
    - Anteriorly directed tinsel type
    - Posteriorly directed whiplash type
  - Most members are marine parasites

The Chytridiomycota

- ‘Chytrids’ are considered the earliest branch of the true fungi (Eumycota)
- Cell walls contain chitin and glucan
- Only true fungi that produce motile, flagellated zoospores
  * Usually single, posterior whiplash type
  * Some rumen species have multiple flagella
- Zoospore ultrastructure is taxonomically important within this phylum
- Commonly found in soils or aquatic environments, chytrids have a significant role in degrading organics
- Exhibit many of the same thallus structure types and arrangements as hyphochytrids (e.g., eucarpic; rhizoidal; endobiotic; etc.)
- A few are obligate intracellular parasites of plants, algae, and small animals (e.g., frogs)
- Very few economically important species (*Synchytrium endobioticum* causes potato wart disease)
- More important (and fascinating) as biological models (e.g, *Allomyces*)

- Isolation of chytrids is not easy
  - Requires ‘baiting’ techniques
  - Appears to be species-substrate specificity/preference presumably due to specific receptor molecules on the zoospore surface membrane
- Five orders within the chytrids, based largely on zoospore ultrastructure
  - Chytridiales and Spizellomycetales
    - Similar to one another
      - Spizellomycetales live in soil
      - Chytridiales live in aquatic environments
    - These Orders do not produce hyphae
    - Unique to the chytrids, Spizellomycetales zoospores exhibit amoeboid movement
  - Blastocladiales
    - Produces true hyphae and narrow rhizoids
    - Some species (e.g., *Allomyces*) exhibit alternation of generations (i.e., rotating from haploid and diploid phases)
      - Haploid thalli of *Allomyces* produce gametes in specialized gametangia
      - Diploid thalli of *Allomyces* produce flagellated zoospores and resting sporangia
      - *Allomyces* also exhibits anisiogamy - two different sizes of gametes (small, highly mobile [‘male’] and larger, less mobile [‘female’])
  - Monoblepharidales
    - Unique among the true fungi for its means of sexual reproduction via oogamy
    - Not of economic importance
  - Neocallimastigales
    - Obligate anaerobes
    - No mitochondria, but instead produce energy via a hydrogenosome
    - Often found in animal rumens; highly cellulytic
    - Multiflagellated zoospores
- Phylogenetic relationships
  - Early studies did not support the placement of the chytrids within the Kingdom Fungi
  - These studies also suggested that chytrids
    - are monophyletic
    - Represent the basal group, i.e., the common ancestor of all true fungi possessed motile zoospores

- ⁎ The monophyletic nature of the chytrids may not be true for several reasons
  - ● Flagella could have been lost or added during evolution, e.g., *Basidiobolus*, previously considered a zygomycete based upon morphological features and does not have motile zoospores, was moved to the chytrids
  - ● Recent data suggest that the Blastocladiales may be more closely related to zygomycetes than other chytrids

The Zygomycota

- ◆ Five features of Phylum Zygomycota
  - ⁎ Cell walls contain chitin, chitosan, and polyglucuronic acid
  - ⁎ Some members typically bear multinucleate, coenocytic hyphae, i.e., without cross walls (septa; sing., septum)
    - ● When present, septa are simple partitions
    - ● Some Orders have regular septations that are flared having a centrally plugged pore
  - ⁎ Produce zygospores (meiospore) via sexual reproduction (gametangial fusion)
  - ⁎ Asexual spores (mitospores), termed sporangiospores, form through cytoplasmic cleavage within a sac-like structure termed a sporangium
  - ⁎ Haploid genome
- ◆ Importance of the zygomycetous fungi
  - ⁎ Organic degraders/recyclers
  - ⁎ Useful in foodstuffs/fermentations
  - ⁎ Pathogens of insects/other animals
- ◆ Generalized life cycle
  - ⁎ Asexual stage (anamorphic; imperfect)
    - ● Hyphae develop erect branches termed sporangiophores
    - ● A thin-walled sac (sporangium) is walled off at the tip and fills with cytoplasm containing multiple nuclei (with collumella underneath sac)
    - ● Cytoplasmic cleavage and separation of nuclei into walled units produces sporangiospores
    - ● Thin sporangial wall (peridium) breaks releasing sporangiospores
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    - ● Sporangiospores germinate to repeat the asexual life cycle

- The zygospore represents the teleomorphic phase (sexual; perfect form) of this phylum
  - Results from the fusion of gametangia of heterothallic (two different mating types; designated "+" and "-") or homothallic (self fertile) strains
  - Acts as a thick-walled resting spore
  - Mating process
    - Hyphae make physical contact and exchange chemical signals to establish that each is of a different mating type
    - Hyphal tips (isogamous zygophores - not distinguished from one another) grow, loop back towards one another, swell (becoming progametangia at this point) then fuse (anastomose)
    - Nuclei mix/fused and immediate region walled off from rest of hyphae (gametangium or zygosporangium)
    - Zygosporangium becomes thick walled to form the zygospore
    - Hyphae to the sides become empty appendages (suspensor cells)
    - Zygospore often forms ornate appendages
    - Zygospore is constitutively dormant for a time, but then germinates to produce a sporangium containing haploid sporangiospores
- Phylum Zygomycota - two Classes
  - Class Zygomycetes - six orders
    - Order Mucorales
      - Typical globose mitosporangium containing hundreds of non-motile asexual spores
      - Contains saprobes and the common 'black bread molds' - *Mucor*, *Rhizopus*, *Absidia*
      - Contains the corpophilous (dung-fungus) *Pilobolus*, which can 'shoot' its single spored sporangium almost 6 feet in the direction of light
    - Order Entomophthorales - insect pathogens
    - Order Kickxellales - atypical zygomycete having regularly septate hyphae
    - Order Zoopagales - mycoparasites
  - Class Trichomycetes - four Orders
    - Live nearly exclusively in the guts of arthropods
    - Does not produce sporangiospores, but instead trichospores
    - Unusual zygospore structure

- Phylogenetic relationships
  - Probably non-monophyletic
  - Order Glomales (Class Zygomycetes) was recently separated into its own Phylum, Glomeromycota
  - One order, Amoebidiales, within Class Trichomycetes is now believed to be a protist - produces amoeboid cells and chitin-less cell walls

The Glomeromycota

- These fungi were originally placed within the Phlyum Zygomycota
  - ***Do not*** produce zygospores
  - Live as obligate, mutualisitic symbionts in >90% of all higher plants - known at arbusular mycorrhizas (AM; endomycorrrhiza)
- Will not grow axenically
- Produce large, thick-walled spores in soils that germinate in the presence of a plant root

Develop non-septate hyphae that invade the root, then form a branch, tree-like arbuscules within the root

- Help plants thrive in nutrient poor soils, especially phosphorous
- Phylogenetics of the Glomeromycota
  - Based upon rRNA sequences, this phylum is monophyletic
  - Morphologically distinct from other fungi
  - Probably had same ancestor as the phyla Ascomycota and Basidiomycota

The Ascomycota

- This phylum contains 75% of all fungi described to date
- Most diverse phylum being significant:
  - Decomposers
  - Agricultural pests (e.g., Dutch elm disease, powdery mildews of crops)
  - Pathogens of humans and animals
- Asexual spores (mitospores)
  - Variety of types
  - Usually not used for taxonomic purposes
  - Generally referred to as conidia
  - Tend to be haploid and dormant
- Key feature is the ascus (pl., asci) - sexual reproductive cell containing meiotic products termed ascospores

- Another significant structural feature - a simple septum with a central pore surrounded by Woronin bodies
- The fruiting body of these fungi, termed an ascocarp, takes on diverse forms
  - Flasked shaped - perithecium
  - Cup-shaped - apothecium
  - Closed structure - cleistothecium
  - Embedded structure - pseudothecium
  - Some ascospores are borne singly or not enclosed in a fruiting structure
- Asci also vary in structure:
  - Unitunicate-operculate - single wall with lid/opening (operculum); found only in apothecial ascomata (fruiting body tissue)
  - Unituicate-inoperculate - operculum replaced with an elastic ring; found in perithecial and some apothecial
  - Protunicate - no active spore shooting mechanism; ascus dissolves to release spores; characteristically produced by fungi that form cleistothecia
  - Bitunicate - double-walled ascus in which outer wall breaks down, inner wall swells through water uptake, then expels spores
- Ascomycetes differ from zygomycetes in both their basic anamorphic and teleomorphic characteristics:
  - Anamorph - mitospores (conidia) of ascomyetes are typically derived from modified bits of hyphae, whereas zygospores result from the cleavage of a multinucleated cytoplasm within a sporangium
  - Teleomorph - in zygomycetes, the anamorph and teleomorph often occur together and share the same nomenclature; in ascomycetes, anamorphs can be completely separated from the teleopmorph and are often given different binomials
- For the Ascomycota, anamorph + teleomorph = holomorph
- Life cycle of most ascomycetes typified by *Neurospora*
  - Conidia/ascospores give rise to hyphae
  - Hyphae may continue to grow and produce conidia
  - Sexual reproduction begins with the differentiation of female hyphae into a trichogyne
  - Trichogyne is fertilized by a conidium or by an antheridium (male reproductive structure)
  - Plasmogamy occurs without karyogamy, i.e., cytoplasmic fusion without nuclear fusion, producing heterokaryotic hyphae (presence of two different nuclei in the same cytoplasm)
  - The heterokaryotic hyphae undergo crozier formation
  - Nuclear division continues followed by septation of the crozier to produce an ascus initial cell that contains one nucleus of each mating type, i.e., a dikaryotic state

- ∗ Karyogamy occurs to form a diploid nucleus that then undergoes meiosis
- ∗ Haploid nuclei are then walled off to form ascospores - typically there are 4-8 meiotic products

◆ Phylogenetic relationships

- ∗ Phyla Ascomycota and Basidiomycota are sister groups that seem to share a recent common ancestor
- ∗ Phylum Ascomycota is monophyletic
- ∗ rRNA sequence analysis divides the Ascomycota into three subgroups, termed Subphyla
  - ● Taphrinomycotina (= Archiascomycetes or Archaeascomycetes) - with one exception, members of this subphylum do not form ascomata (e.g., *Schizosaccharomyces* - fission yeast)
  - ● Saccharomycotina (= Hemiascomycetes) - with members of this subphylum do not form ascomata and are largely composed of the "true yeasts" (e.g., *Saccharomyces* - baker's or brewer's yeast)
  - ● Pezizomycotina (= Euascomycetes) - predominant hyphal forms that do form ascomata (e.g., *Neurospora*)

The Basidiomycota

◆ This phylum contains 30,000 different species or about 37% of all true fungi

◆ Most often recognized as mushrooms and toadstools, as well as other types of fruiting bodies in nature

◆ Very important for their ecological and agricultural impact

◆ Majority are terrestrial, although some can be found in marine or freshwater environments

◆ Oldest confirmed basidiomycete fossil is about 290 millions years old

◆ Some are molds, some are yeasts, and some are dimorphic

◆ Features similar to those of the Ascomycota

- ∗ Haploid somatic hyphae
- ∗ Septate hyphae
- ∗ Potential for hyphal anastomosis
- ∗ Production of complex fruiting structures
- ∗ Presence of a dikaryotic life cycle phase
- ∗ Production of a conidial anamorph

- Key differences
  - Cell wall
    - Ascomycetes - two layered
    - Basidiomycetes - multilayered
  - Septa
    - Ascomycetes
      - Hyphal forms - simple with central pore surrounded by Woronin bodies
      - Yeast forms - simple with micropores
    - Basidiomycetes
      - Sub-groups (clades) Hymenomycetes (*in Kendrick* = Holobasidiomycetes and Phragmobasidiomycetes) - dolipore type septum surrounded by a parenthosome
      - Sub-group (clade) Urediniomycetes (*in Kendrick* = Teliomycetes) - central pore blocked by a pulleywheel occlusion
      - Sub-group (clade) Ustilaginomycetes (*in Kendrick* = Teliomycetes) - dolipore-like, but parenthosome is absent
  - Dikaryophase
    - Ascomycetes
      - Restricted to ascogenous tissue
      - Nuclear fusion and subsequent meiosis involve the formation of a crozier
    - Basidiomycetes
      - Heterokaryotic nuclei (2 per cell)
      - Not restricted to a tissue phase and may continue indefinitely
      - Perpetuated by the formation of a clamp connection at each septum of a dikaryotic hypha
  - Meiospore production- meiosis occurs within a specialized cell termed a basidium (pl., basidia), but the spores are borne ***exogenously*** on tapering outgrowths termed sterigmata (sing., sterigma)
- Very complex life cycles that vary among the different classes/species
- Generalized life cycle:
  - Haploid basidiospores germinate to form hyphae with a single nucleus per cell (monokaryotic phase)
  - Monokaryons can produce oidia (= conidia)
  - Monokaryons of different mating types fuse <u>*or*</u> an odium attracts monokaryon of compatible mating type, then fuses
  - Fusion (plasmogamy) results in dikaryotic hyphae (two nuclei per cell; heterokaryotic)

- Fruiting body forms containing dikaryotic basidia
- Nuclear (karyogamy) fusion occurs followed by meiosis
- Sterigmata form on the surface of the basidium
- Haploid nuclei migrate into the sterigmata as the basidiospore develops
- Mature basidiospore in many fungi released through a ballistic-like method involving a hylar (or hilar) drop (see Chapter 1 in Money's book for historical and descriptive details about this mechanism)

◆ Phylogenetics

- rDNA analysis has separated the Phylum Basidiomycota into three separate sub-groups (clades)
  - Hymenomycetes - typical mushroom, toadstools, and "jelly fungi"
  - Urediniomycetes - "rusts"
  - Ustilaginomycetes - "smuts"
- Phylogenetic relationships between and within the sub-groups remains unclear

◆ Taxonomy

- Urediniomycetes
  - Agriculturally significant "rusts"
  - Example *Puccinia graminis* - causes black stem of wheat
- Ustilaginomycetes
  - Agriculturally significant "smuts"
  - Example *Ustilago maydis* - corn smut fungus
- Selected differences between 'rusts' and 'smuts' (adapted from Table 5.1 in Kendrick):
- Hymenomycetes - four clades
  - Homobasidiomycetes - mushrooms, toadstools, bracket fungi, puffballs, earthstars
  - Jelly fungi
    - Tremellomycetidae
    - Dacrymycetales
    - Auriculariales

The Mitosporic Fungi

◆ Many ascomycetous fungi produce asexual (mitotic) spores (anamorphic phase), but their teleomorph phase (sexual reproduction) is absent

◆ Taxonomically, such fungi are placed in an artificial category variously termed Deuteromycota (or Deuteromycotina) or Fungi Imperfecti

- Due to the absence of a teleomorph, these fungi are often given a provisional name termed a “form” genus/species
- If the teleomorph is discovered, the fungus renamed
- Example of teleomorph/anamorph dichotomy of names:
  - Anamorph - *Aspergillus nidulans* - forms mitosporically-derived conidia, therefore classified within the form-phylum Deuteromycota
  - Teleomorph - *Emerciella nidulans* - forms a cleistothecium containing ascospores, therefore classified within the Phylum Ascomycota
- Conidia are produced in a variety of ways, but never by cytoplasmic cleavage as in the Zygomycota
- Two main types of conidium development are the basis for the production for all types of conidia
  - Thallic - fragmentation process
  - Blastic - swelling process
- Most conidia are blastic in origin and are borne in various ways:
  - Budding
  - Extrusion of flask shaped cells termed phialides
  - Aggregation of condiophores in stalks termed synnema or coremium
  - On a pad-like surface (acervulus)
  - Within a flask-shaped structure (pycnidium)
- Taxonomic divisions of the Fungi Imperfecti - truly an artificial classification scheme based solely on conidial structures
  - Hyphomycetes - conidia borne on conidiophores
  - Coelomycetes - conidia borne on an acervulus or within a pycnidium
  - Agonomycetes - “Mycelia Sterilia” - no conidia; sometimes sclerotia