Classification of Fungi

Classification Criteria

Traditional classifications were given on the basis of –

- Basic shape of thallus
- Colour
- Shape and size of spore producing structures
- Mode of sexual reproduction
- Features of Asexual and Sexual spores

Initial classification

Simple plants with thallus like body

Thallophyta

Cryptogamae

Plantae

P.A. Saccardo 1866-84 (Six classes)

- **Schizomycetes**
- **Myxomycetes**
- ***Phycomycetes***
- ***Ascomycetes***
- ***Basidiomycetes***
- ***Deuteroomycetes***

Classification

(E.A. Bessey 1950)

A. Lower Fungi (No fruit bodies)

1. Class Phycomycetes

B. Higher Fungi (Fruit bodies)

1. Class Ascomycetes
2. Class Basidiomycetes
3. Class Fungi Imperfecti

Classification

- G.W. Martin 1961 – Dictionary of fungi

A. Myxomycetes B. Eumycetes (Four Classes)

- C.J. Alexopoulos 1962

Division: Mycota (Achlorophyllous)

Subdivision: Myxomycotina (Plasmodial)

Subdivision: Eumycotina – True fungi

Classes: Chytridiomycetes, Hyphochytridiomycetes, Oomycetes, Plasmodiophoromycetes, Zygomycetes, Trichomycetes, Ascomycetes, Basidiomycetes, Deuteromycetes

Classification

- R.H. Whittaker 1969

Five kingdom system of classification

Monera

Protista

Fungi

Plantae

Animalia

Distinguishing Five main Kingdoms of Eukaryota

Based on Ultra structure, biochemical and molecular biology

Character	Animalia	Chromista	Fungi	Plantae	Protozoa
Nutrition	Heterotrophic (Osmotrophic)	Autotrophic (Photosynthetic or Absorptive)	Heterotrophic (Osmotrophic or Absorptive)	Autotrophic (Photosynthetic)	Heterotrophic (Phagotrophic or Autotrophic)
Cell wall	Absent; Cellulosic material	Cellulosic and chitin β glucan absent	Chitin and β glucan	Cellulose and other polysaccharides	Absent
Mitochondrial cristae	Flattened	Tubular	Flattened	Flattened	Tubular
Flagellar structure	Absent	Tubular	Absent	Absent	Not Tubular

Classification

- **G.C. Ainsworth 1973**

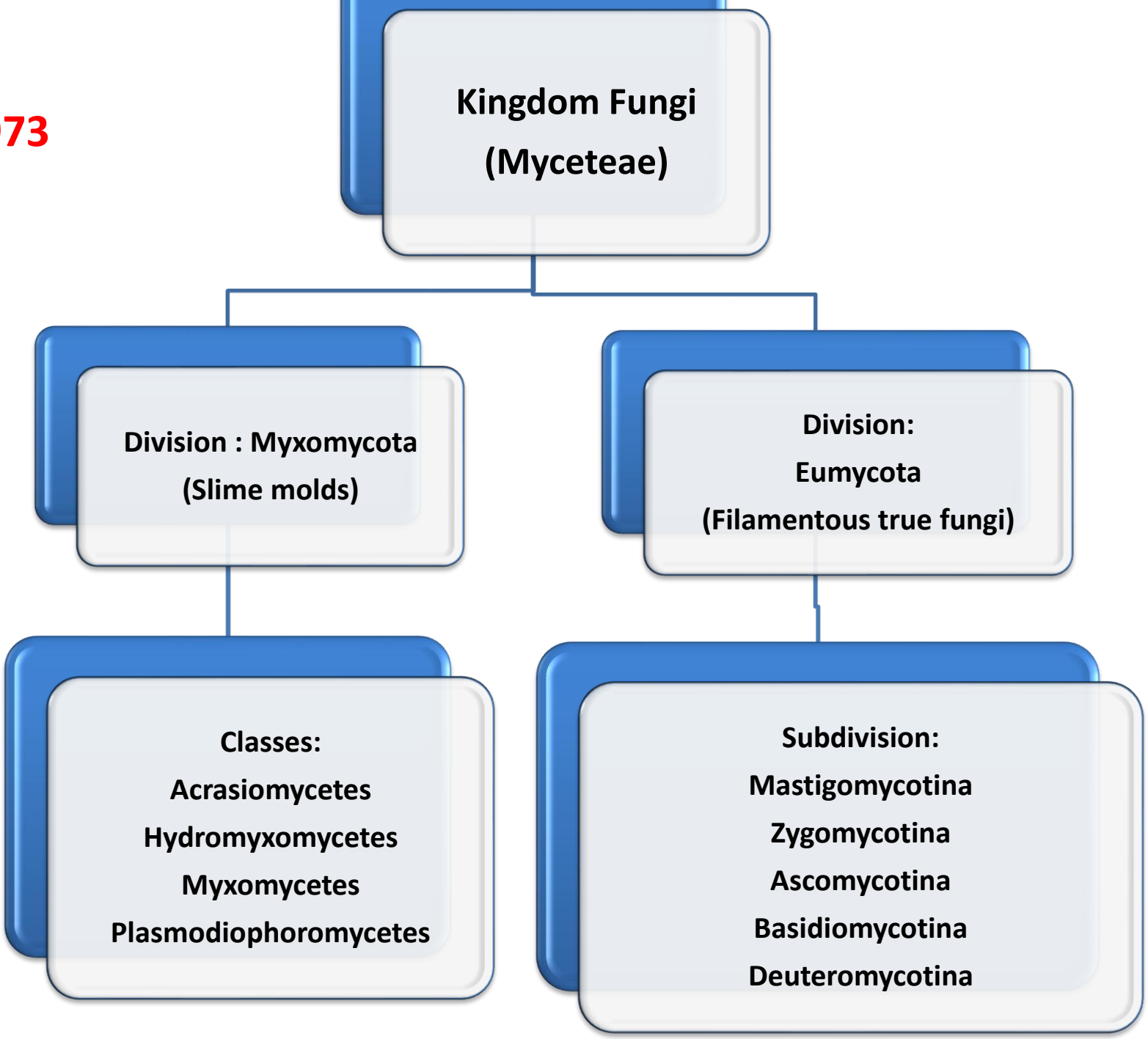
Kingdom Mycota (Fungi)

✓ **Achlorophyllus, filamentous**

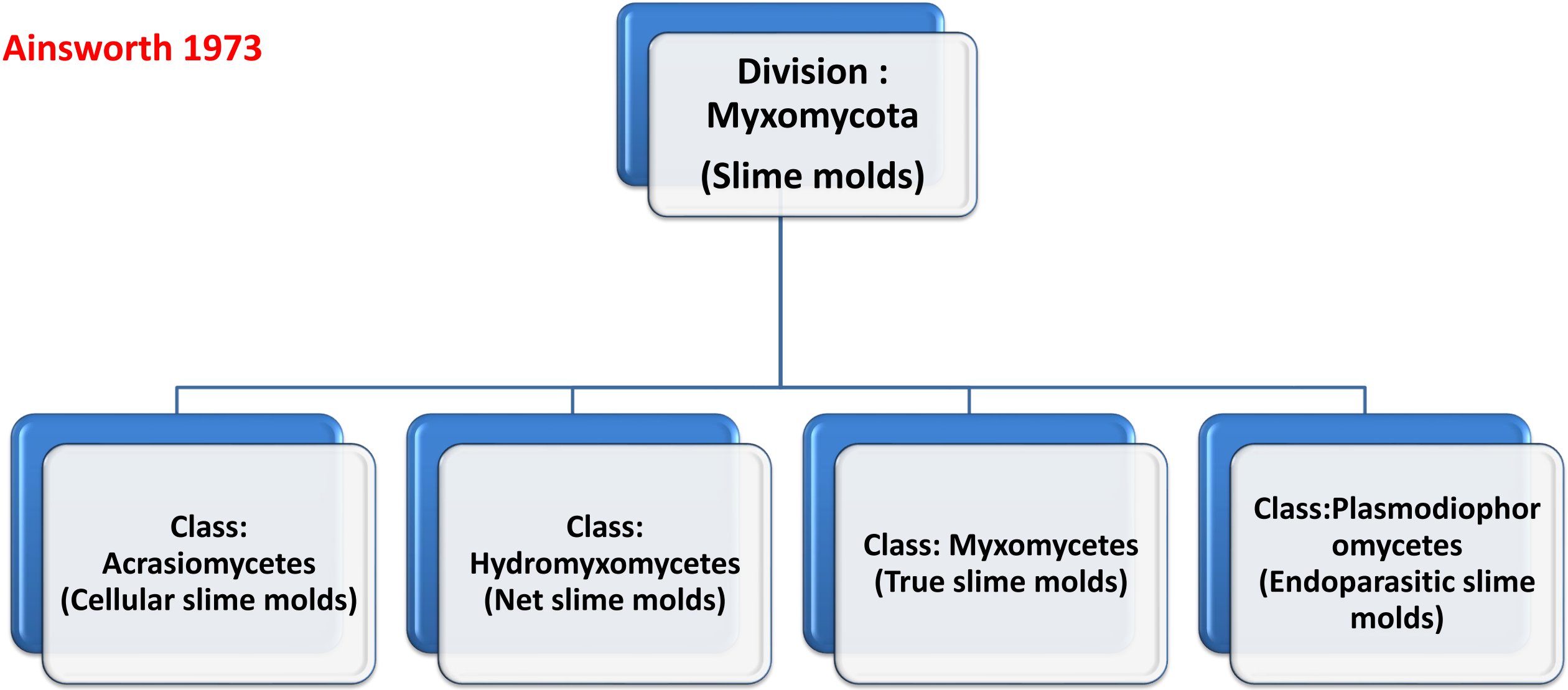
1. Division: Myxomycota – Plasmodial forms (Four classes)

2. Division: Eumycota – Non Plasmodial true fungal forms (Five subdivisions)

Ainsworth 1973



Ainsworth 1973



Kingdom — MYCOTA

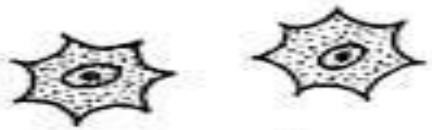
Plasmodium or pseudoplasmodium present

Division. MYXOMYCOTA

Plasmodium or pseudoplasmodium absent. Assimilative phase typically filamentous

Division. EUMYCOTA

Assimilative phase free-living amoebae which unite as pseudomycelium before reproduction

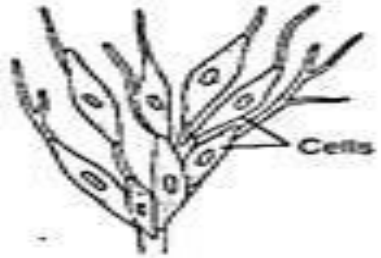


Ceratiomyxella tahitiensis

Class : Acrasiomycetes

e.g. *Acrasis, Guttulina*

Assimilative phase a net-plasmodium

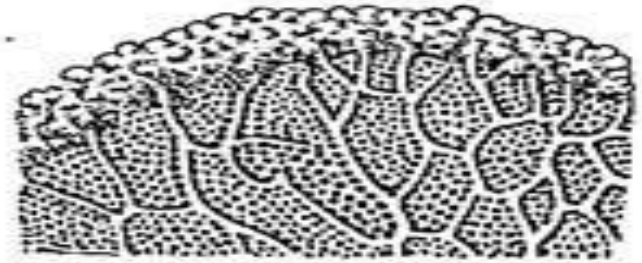


Net plasmodium of *Labyrinthula* sp.

Class : Hydromyxomycetes

e.g. *Zostera, Labyrinthula*

Assimilative phase is not a net-plasmodium, saprophytic

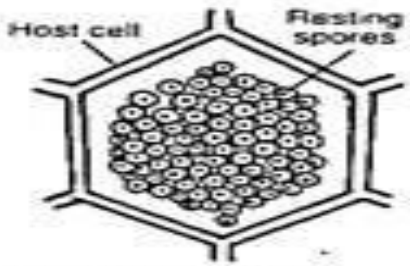


Plasmodium of *Physarum*

Class : Myxomycetes

e.g. *Stemonites, Physarum*

Assimilative phase is not a net-plasmodium, parasitic



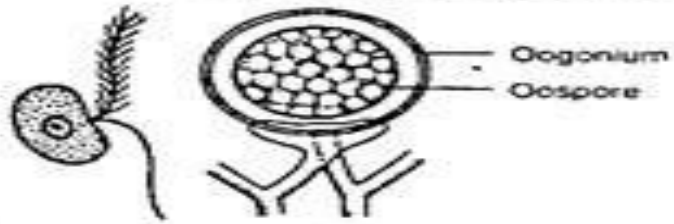
Plasmodiophora brassicae

Class : Plasmodiophoromycetes

e.g. *Plasmodiophora brassicae*

Motile cells (zoospores) present

Perfect state spores typically Oospores



Zoospore and Oospore of *Phytophthora*

Sub-division : MASTIGOMYCOTINA

Motile cells absent

Contd. →

Subdivision: Mastigomycotina (Water molds)

Ainsworth 1973

- **Motile Zoospores**
- **Sexual Oospores**

Classes –

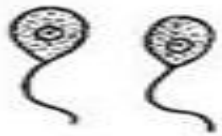
1. **Chytridiomycetes**
2. **Hphochytridiomycetes**
3. **Oomycetes**

Contd.

Sub-division : MASTIGOMYCOTINA

Motile cells absent

Zoospore uniflagellate (whiplash type)



Synchytrium
Class : Chitridiomycetes
e.g. *Olpidium, Synchytrium*

Zoospore uniflagellate (tinsel type)

Rhizidiomyces
Class : Hyphochytridiomycetes
e.g. *Rhizidiomyces, Rhizidiomycopsis*

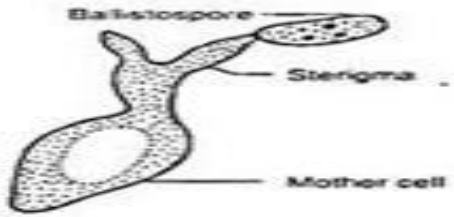
Zoospore biflagellate (one whiplash and other tinsel type)

Phytophthora
Class : Oomycetes
e.g. *Pythium, Phytophthora*

Perfect state absent
Sub-division : DEUTEROMYCOTINA

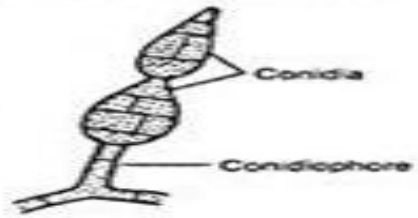
Perfect state present

True mycelium lacking or not well developed



Sporobolomyces roseus
Class : Blastomycetes
e.g. *Sporobolomyces, Bullera*

True mycelium may be sterile or bearing spores directly or on sporophores

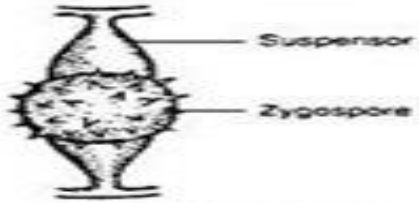


Alternaria
Class : Hyphomycetes
e.g. *Botrytis, Rhizoctonia*

True mycelium aggregated to form pycnidium or acervulus produces spores inside

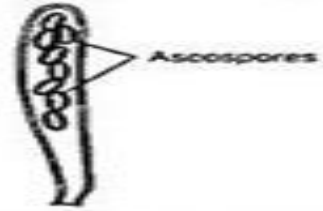
Acervulus of *Colletotrichum*
Class : Coelomycetes
e.g. *Colletotrichum, Pestalotia*

Perfect state spore-Zygospore



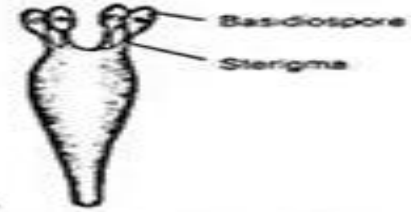
Single zygospore of *Mucor*
Subdivision :
ZYGOMYCOTINA

Perfect state spore-Ascospore



An ascus of *Ascobolus*
Subdivision :
ASCOMYCOTINA

Perfect state spore-Basidiospore



Single basidium of *Agaricus*
Subdivision :
BASIDIOMYCOTINA

Contd. →

Subdivision: Zygomycotina
(Conjugate fungi)

Ainsworth 1973

- Non motile sporangiospores (aplanospores)
- Sexual Zygospores

Classes –

1. Zygomycetes
2. Trichomycetes

Subdivision: Ascomycotina (Sac fungi)

Ainsworth 1973

- **Sexual ascospores**

Classes –

1. **Hemiascomycetes**
2. **Plectomycetes**
3. **Pyrenomycetes**
4. **Laboulbeniomycetes**
5. **Loculoascomycetes**

Subdivision: Basidiomycotina
(Club fungi)

Ainsworth 1973

- **Sexual basidiospores**

Classes –

1. **Teliomycetes**
2. **Hymenomycetes**
3. **Gastromycetes**

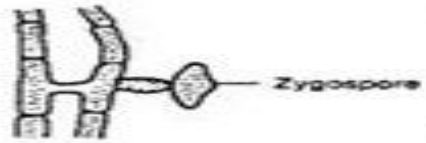
Contd.

Subdivision : ZYGOMYCOTINA

Saprobic or if parasitic or predaceous having mycelium immersed in host tissue

Thallus of *Cochlonema verrucosum*
Class : Zygomycetes
e.g. *Rhizopus, Cochlonema*

Generally associated with arthopods and mycelium not immersed in host tissue

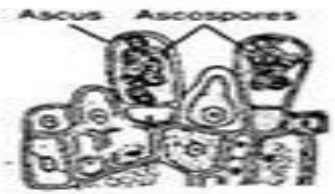


Harpella

Class : Trichomycetes
e.g. *Asellaria, Enterobotryus*

Subdivision : ASCOMYCOTINA

Ascocarp absent



Naked asci of *Taphrina* on host surface
Class : Hemiascomycetes
e.g. *Protomyces, Taphrina*

Ascocarp an ascostroma

Ascostroma of *Mycosphaerella*

Class : Loculoascomycetes
e.g. *Venturea, Pleospora*

Ascocarp cleistothecium

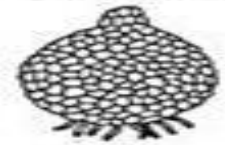
Cleistothecium of *Erysiphe*

Class : Plectomycetes
e.g. *Aspergillus, Penicillium*

Ascocarp perithecium, ectoparasite of arthopods

Sporulating thallus of *Laboulbenia formicarum*
Class : Laboulbeniomycetes
e.g. *Laboulbenia, Stigmatomyces*

Ascocarp perithecium, not ectoparasite of arthopods



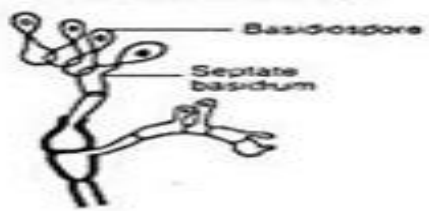
Perithecium of *Neurospora dodgei*
Class : Pyrenomycetes
e.g. *Claviceps, Xylaria*

Ascocarp apothecium

Apothecia of *Ascobolus scatigenus*
Class : Discomycetes
e.g. *Peziza, Ascobolus*

Subdivision : BASIDIOMYCOTINA

Basidiocarp lacking



Germinated teleutospore of *Puccinia graminis*
Class : Teliomycetes
e.g. *Puccinia, Ustilago*

Basidiocarp present and typically gymnocarpous or semiangiocarpous

Basidiocarp of *Agaricus*
Class : Hymenomycetes
e.g. *Agaricus, Polyporus*

Basidiocarp present and typically angiocarpous

A basidiocarp of *Cyathus* and V.S. of basidiocarp of *Cyathus*
Class : Gasteromycetes
e.g. *Cyathus, Geastrum*

Subdivision: Deuteromycotina (Imperfect fungi)

Ainsworth 1973

- **Sexual spores absent**

Classes –

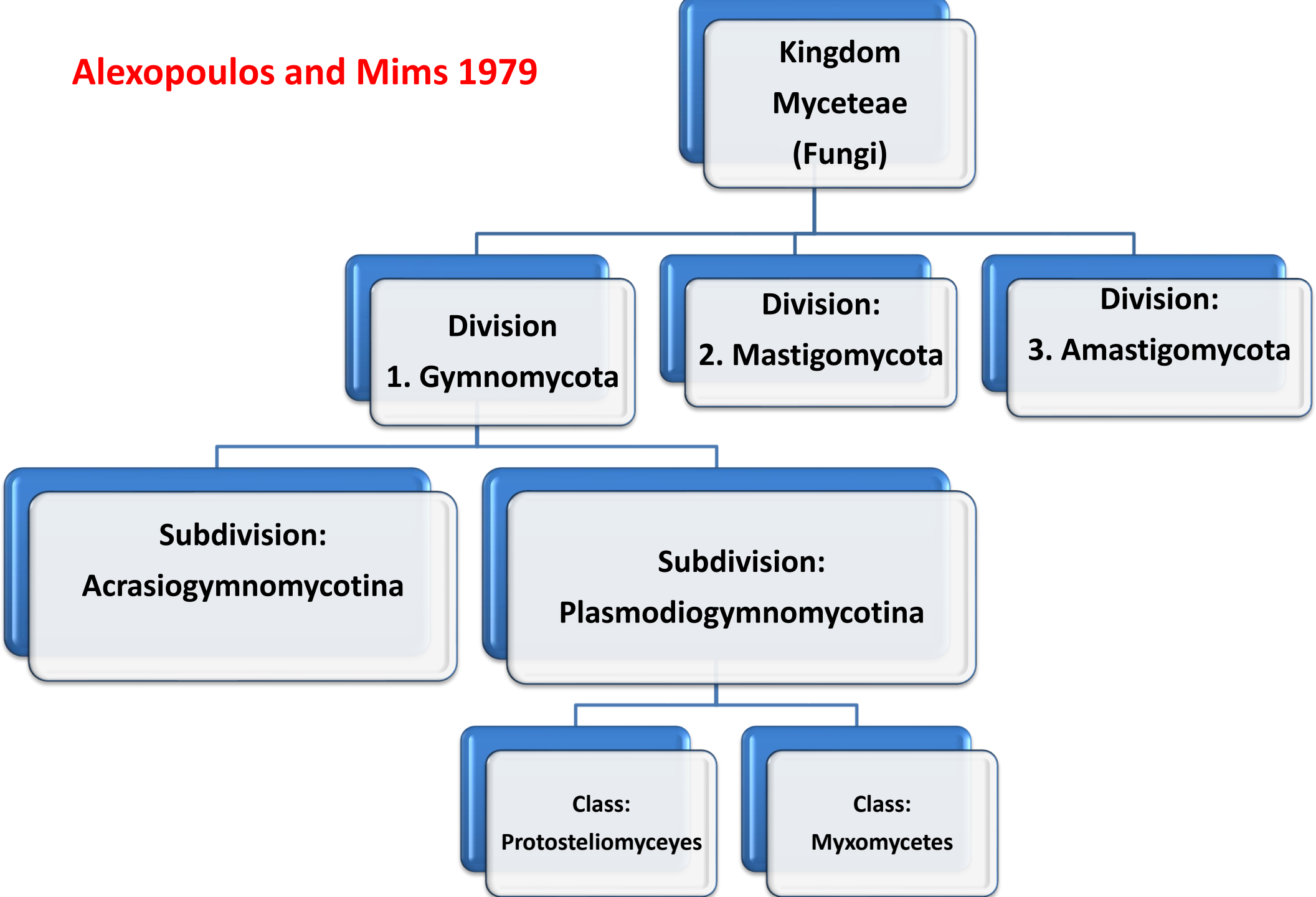
1. **Blastomycetes**
2. **Hyphomycetes**
3. **Coelomycetes**

Modified Classification

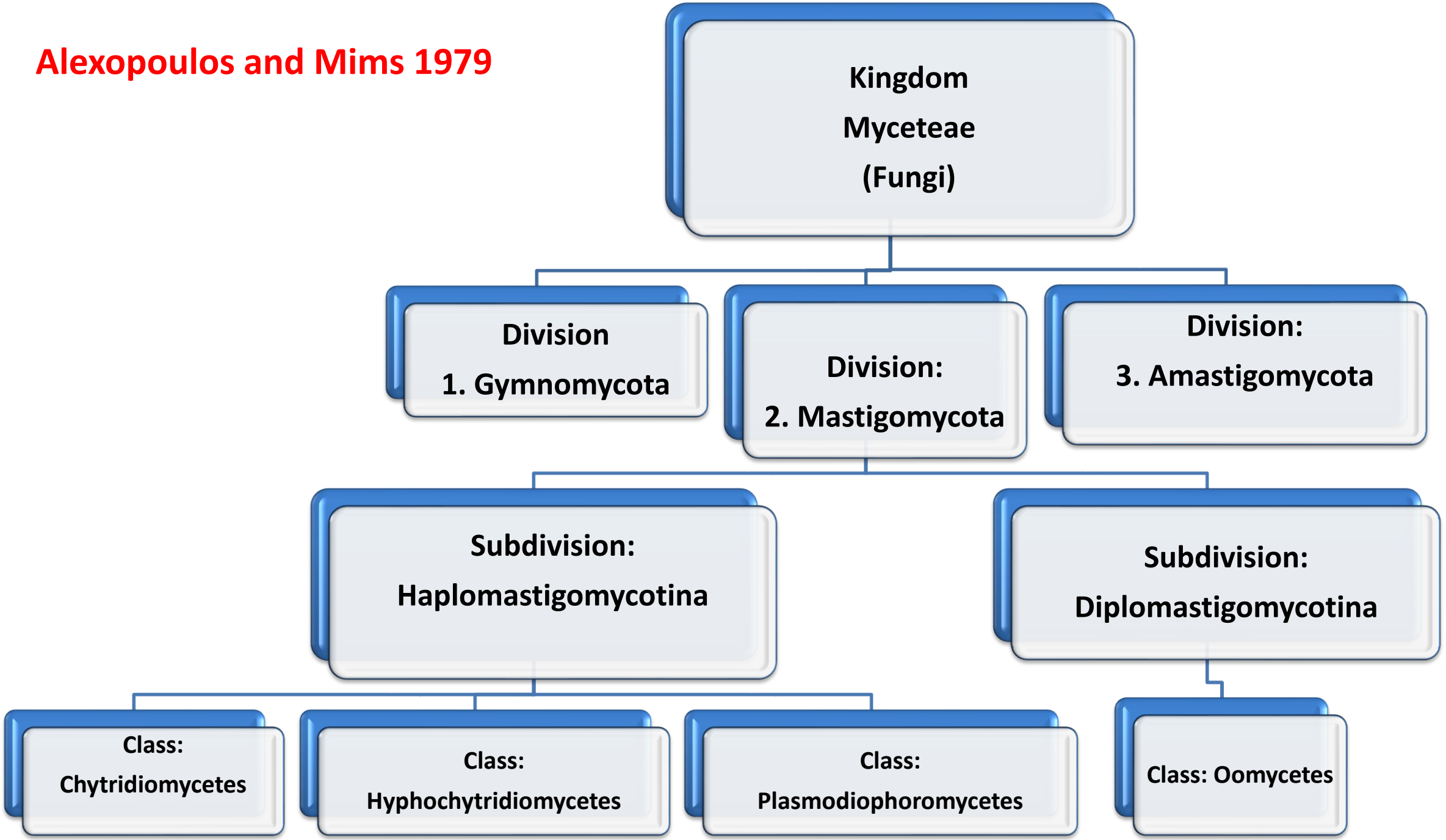
V.C.J. Alexopoulos and C.W. Mims (1979)

- **Superkingdom: Eukaryota**
  - **Kingdom: Myceteae**
    - **Division: 1. Gymnomycota**
      2. Mastigomycota
      3. Amastogomycota

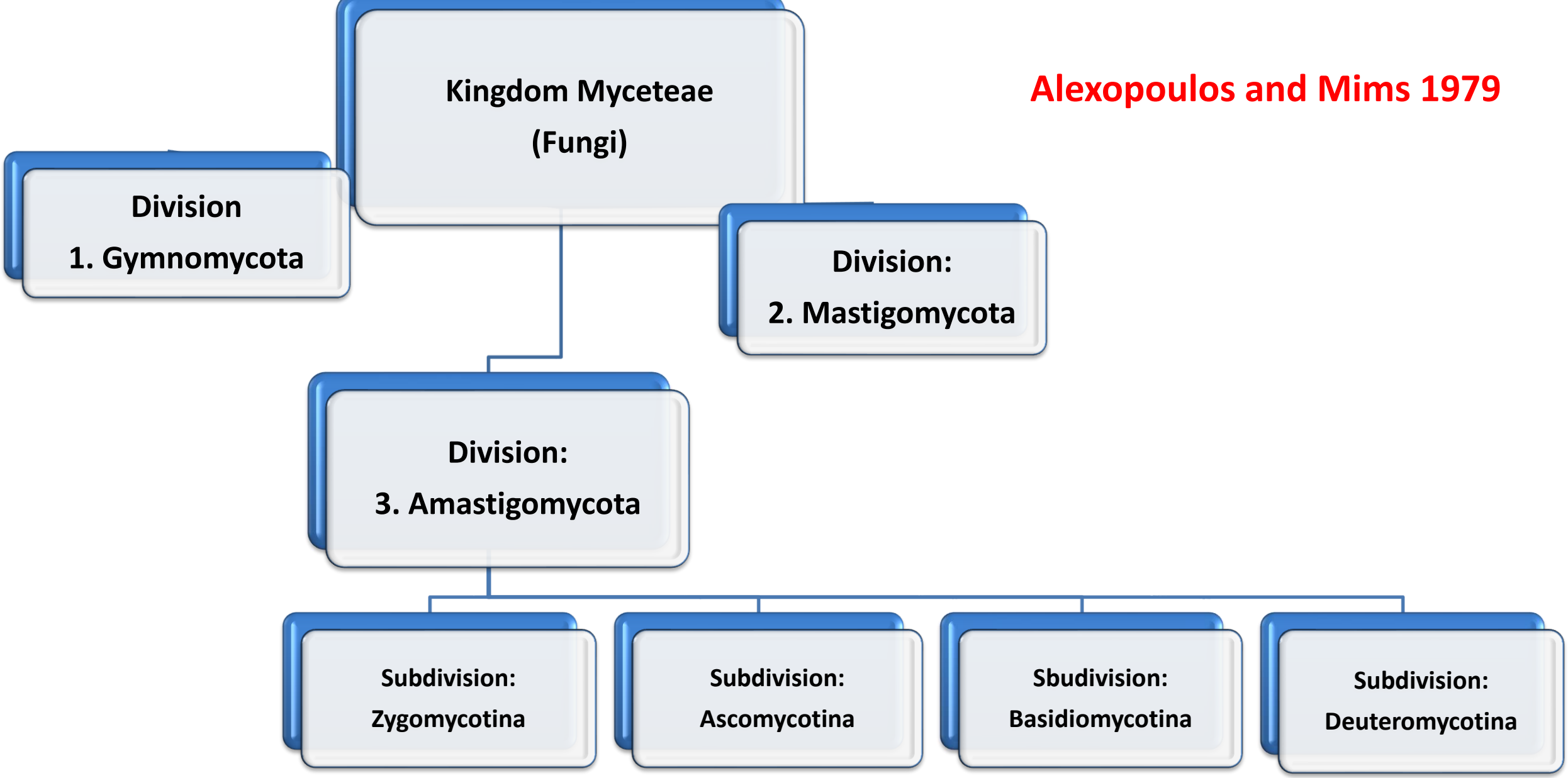
Alexopoulos and Mims 1979



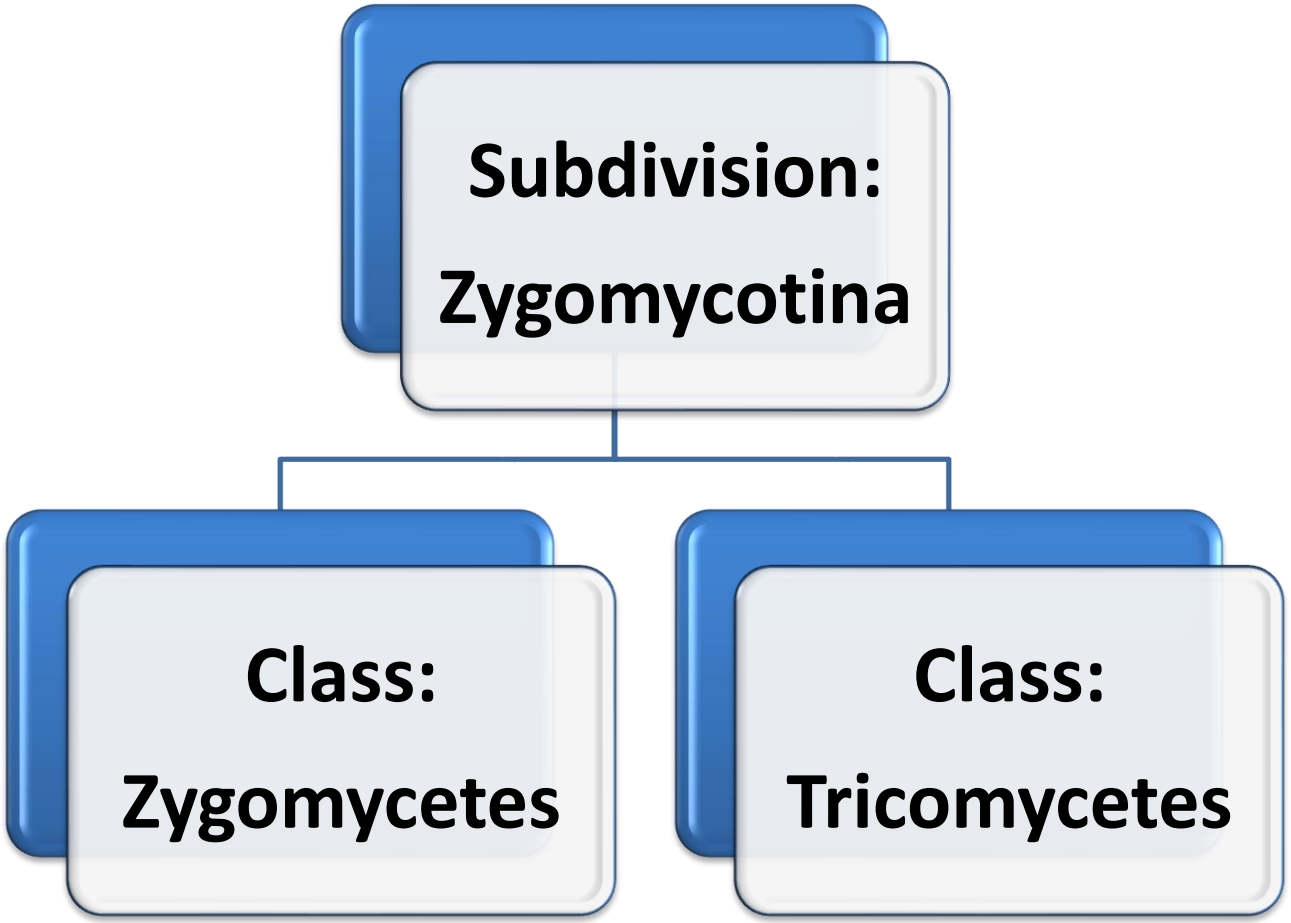
Alexopoulos and Mims 1979



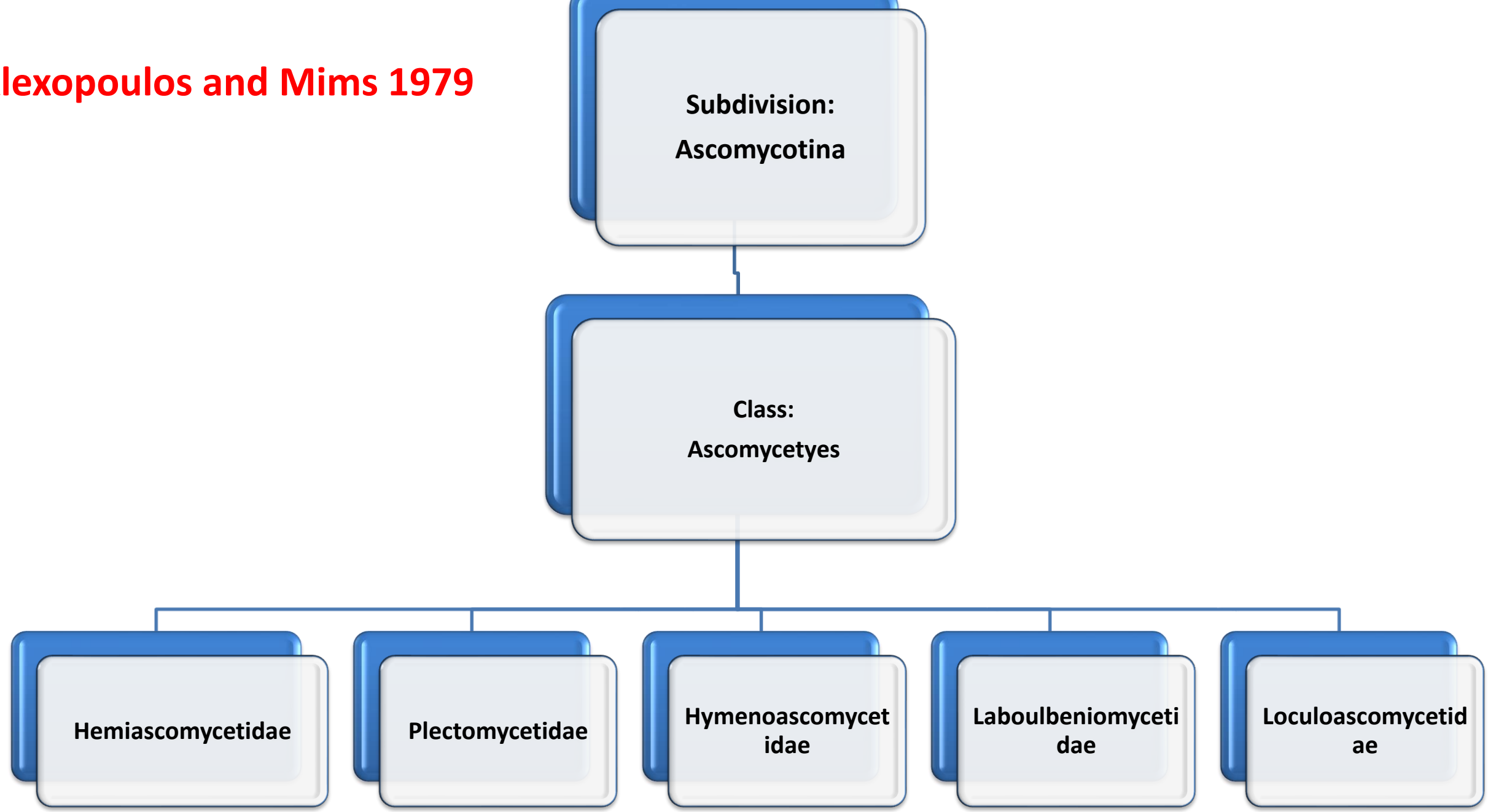
Alexopoulos and Mims 1979



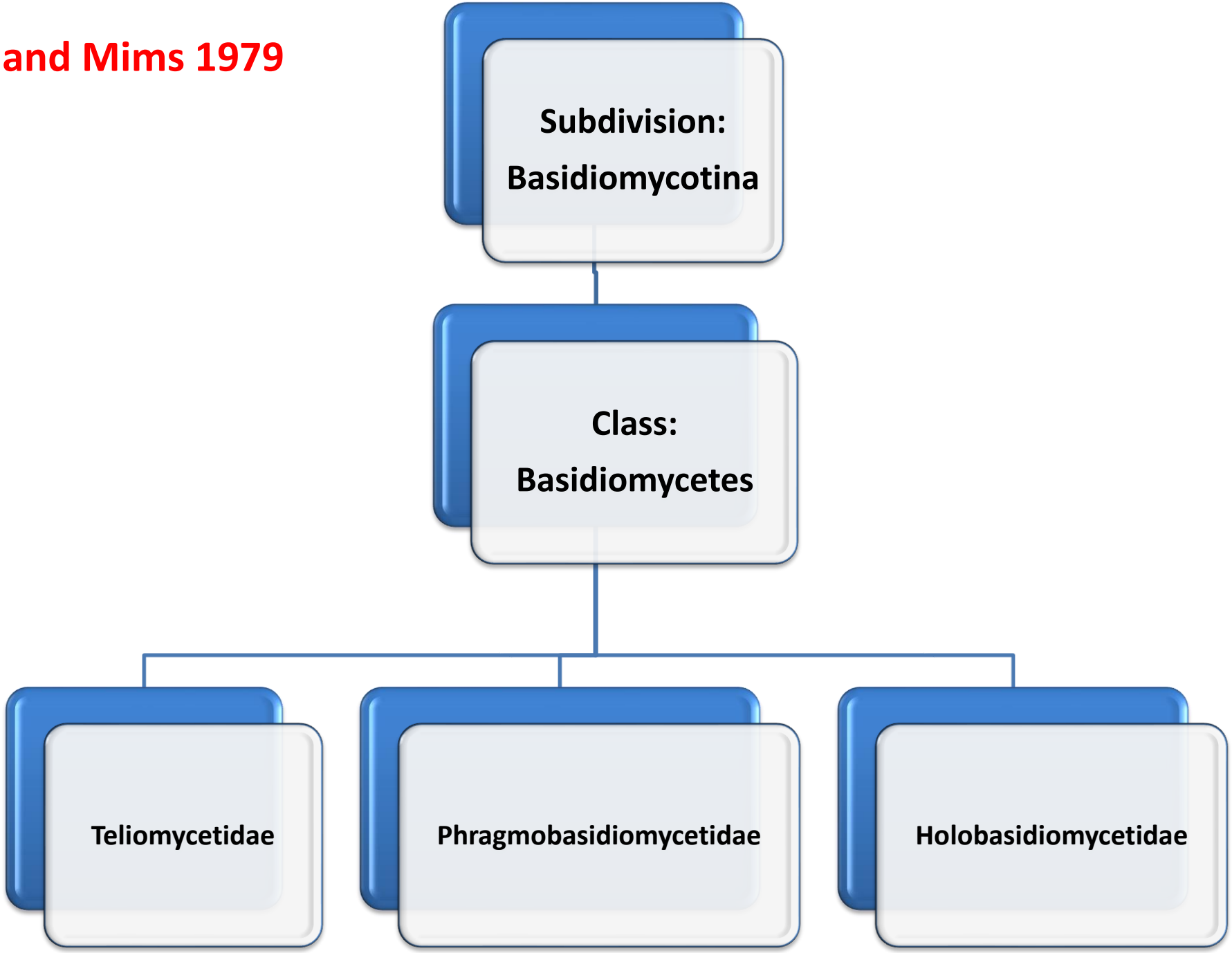
Alexopoulos and Mims 1979



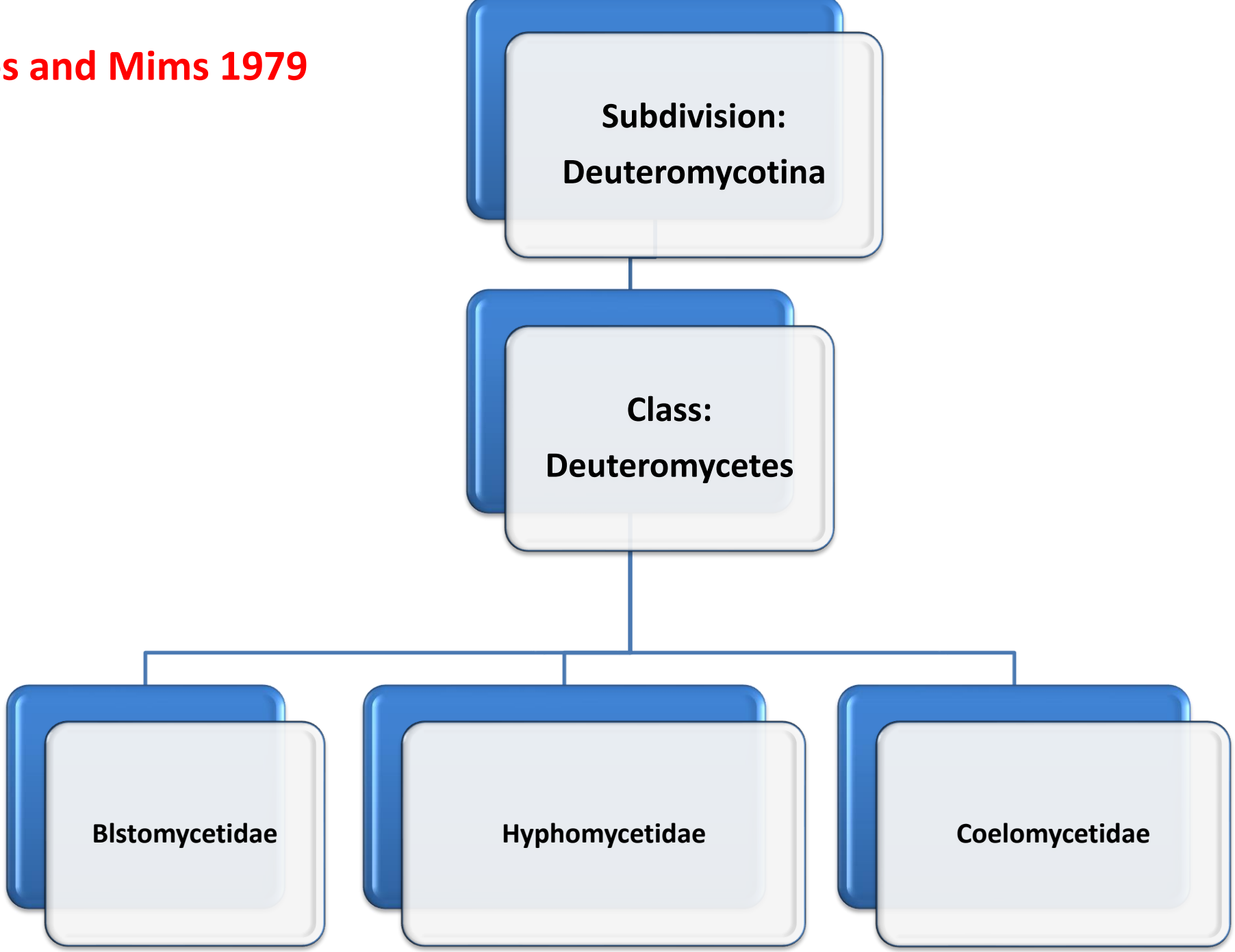
Alexopoulos and Mims 1979



Alexopoulos and Mims 1979



Alexopoulos and Mims 1979



Classification of Fungi by Hawksworth et al. (1983 and 1995)

7th edition of the "Dictionary of the Fungi"

The changes made by them are:

1. **The Division Myxomycota divided into eight classes instead of four classes**
2. **The Sub-division Ascomycotina is directly divided into thirty seven (37) orders and arranged alphabetically; there is no classes in-between**
3. **The subdivision Basidiomycotina is divided into four classes instead of three, where class Teliomycetes is replaced by Urediniomycetes and Ustilaginomycetes**
4. **In the sub-division Deuteromycotina, the class Blastomycetes was not considered**

- Hawksworth et al. (1995) thoroughly revised the classification in the 8th edition of the "Dictionary of the Fungi"
- The new classification was based on the sequence of 18s rRNA among the different members

The different taxa considered in this system along with their 'ending' are:

- **Phylum — mycota**
- **Sub-phylum — mycotina**
- **Class — mycetes**
- **Sub-class — mycetidae**
- **Order — ales**
- **Family — aceae**

Criteria of Recent Fungal Classification

1. DNA-DNA hybridization:

- Separation of DNA from two fungi in two strands
- Extent of Re association
- Extent of successful pairing
- % DNA relatedness

2. DNA fingerprinting: specific probes

- Characterization of individual strains, population in medical mycology

3. DNA probes: labelled DNA fragments (1970)

- Valuable identification tool
- Mol % G+C contents in DNA are determined by thermal denaturation profiles

4. PCR reaction:

- Series of heating and cooling steps to amliphy DNA fragments

5.RFLP(Restriction fragment lenth polymorphism):

- Restriction digestion of nuclear and mitochondrial DNA
- Electrophoresis
- Hybridization to labelled DNA probs
- Identification of individual genes or gene clusters

6. RAPD (Random amplified polymorphic DNA): 1990-2003

- For race, phenotype and population studies
- Origin and phylogenic studies
- Comparison of actual sequences of bases in particular part of DNA (or rRNA 5.8S, 18S, 28S)

Ex. Identification of *Phytophthora* sp., *Colletotricum* sp., *Fusarium* sp., *Saccharomyces* sp.

Relationship among Chytridiomycota, Zygomycota, Ascomycota and Basidiomycota

Outline of Recent classification of fungi and fungus like organisms (Alexopoulos *et al.*,1996)

1. Kingdom: Protists

Phylum: Plasmodiophoromycota; Dictyosteliomycota; Acrasiomycota; Myxomycota

2. Kingdom: Stramenopila

Phylum: Oomycota; Hyphochytrodiomycota; Labyrinthulomycota

3. Kingdom: Fungi

Phylum: Chytridiomycota; Zygomycota; Ascomycota; Basidiomycota

Schuessler *et al.* 2001

- **Fifth Phylum in Fungi**

Glomeromycota for AM fungi (Zygomycota)

3. Kingdom: Fungi

Phylum: Chytridiomycota; Zygomycota; Glomeromycota; Ascomycota; Basidiomycota

Latest Classification of Fungi

- **Based on 10th Edition of 'Ainsworth and Bisby's Dictionary of Fungi'**

By

P.M. Kirk, P.F. Cannon, D.W. Minter and J.A. Stalpers, 2008, CAB International, UK