Micorriza (Mykes = fungo e Rhiza = raíz – A. B.Frank 1885)

Micorriza (Mykes = fungo e Rhiza = raíz – A. B.Frank 1885)

3 componentes básicos:

-micélio do fungo colonizando o solo e captando nutrientes minerais (fosfato, cloreto de amónio, fósforo) (Micobionte)

- interface planta - fungo (rede de Hartig ou haustório) onde ocorre a troca de nutrientes (minerais e carbono orgânico)

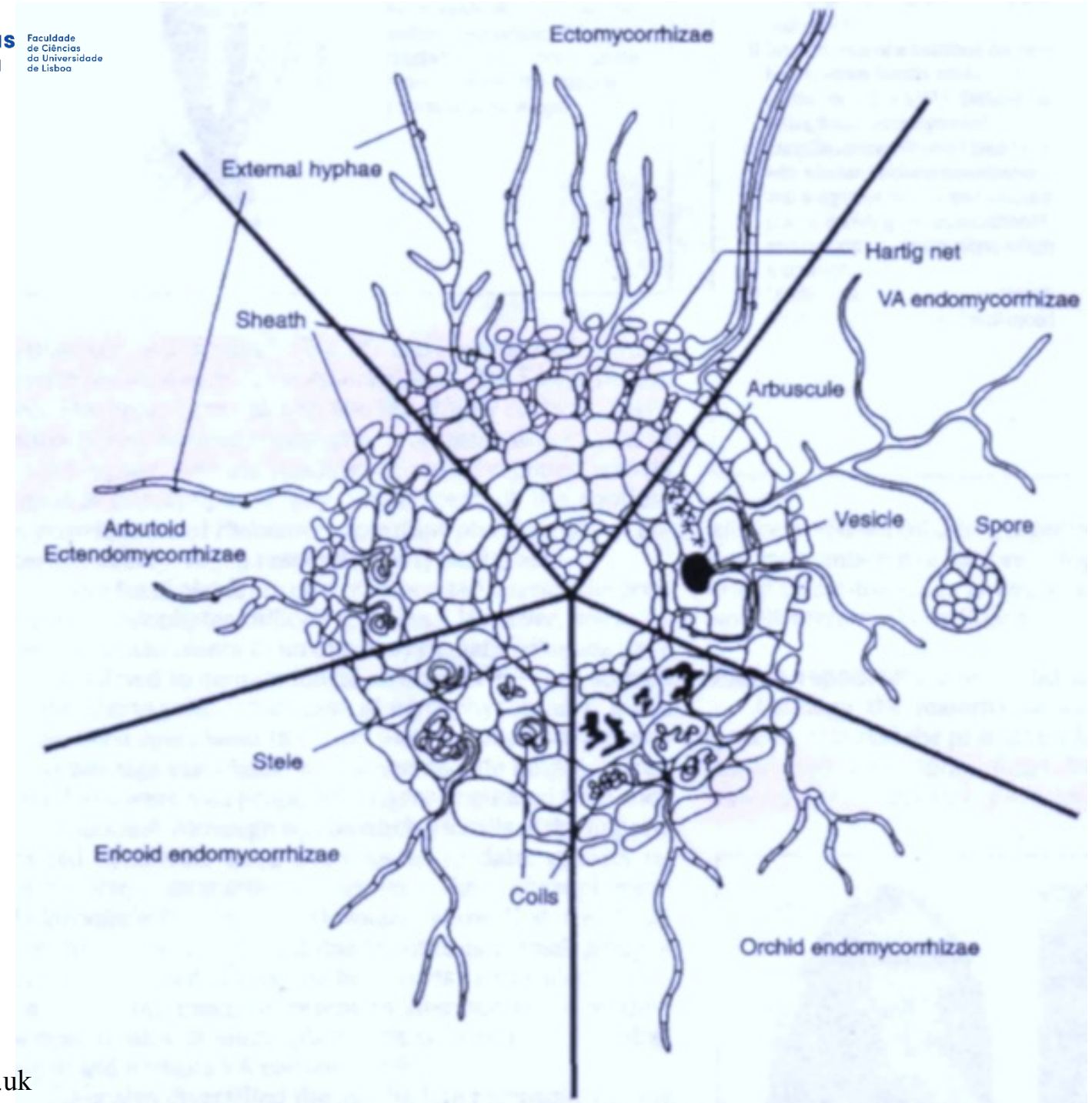
- tecidos da planta que produzem e armazenam carbono orgânico (Fotobionte)

Micorrizas

Table 13.1 The major types of mycorrhiza and their ecological significance.

Mycorrhizal type	*Typical host plants*	*Fungi involved*	*Major significance*
Arbucular mycorrhizas	Many	Glomeromycota	Phosphorus uptake from soil
Ectomycorrhizas	Forest trees, mainly in temperate and boreal regions	Basidiomycota, Ascomycota	Nitrogen uptake from soil
Ectendomycorrhizas	Mainly pines, spruce, and larch	Ascomycota of the genus *Wilcoxina*	Mineral nutrient uptake from soil
Arbutoid mycorrhizas	*Arctostaphylos, Arbutus, Pyrola*	Basidiomycota, similar to ectomycorrhizal fungi	Mineral nutrient uptake from soil
Monotropoid mycorrhizas	Nonphotosynthetic plants, e.g. *Monotropa*	Basidiomycota such as *Boletus edulis*	Plants obtain sugars from ectomycorrhizal fungi attached to trees
Ericoid mycorrhizas	Heathland plants. *Erica, Calluna*, etc.	Ascomycota and mitosporic fungi; *Hymenoscyphus ericae*	Nitrogen uptake from soil
Orchid mycorrhizas	Orchids	*Rhizoctonia*-like fungi (basidiomycota)	Fungi supply the plant with sugars

Deacon, 2006


Ectomycorrhizae
External hyphae
Hartig net
VA endomycorrhizae
Sheath
Arbuscule
Vesicle
Spore
Arbutoid
Ectendomycorrhizae
Stele
Ericoid endomycorrhizae
Coils
Orchid endomycorrhizae

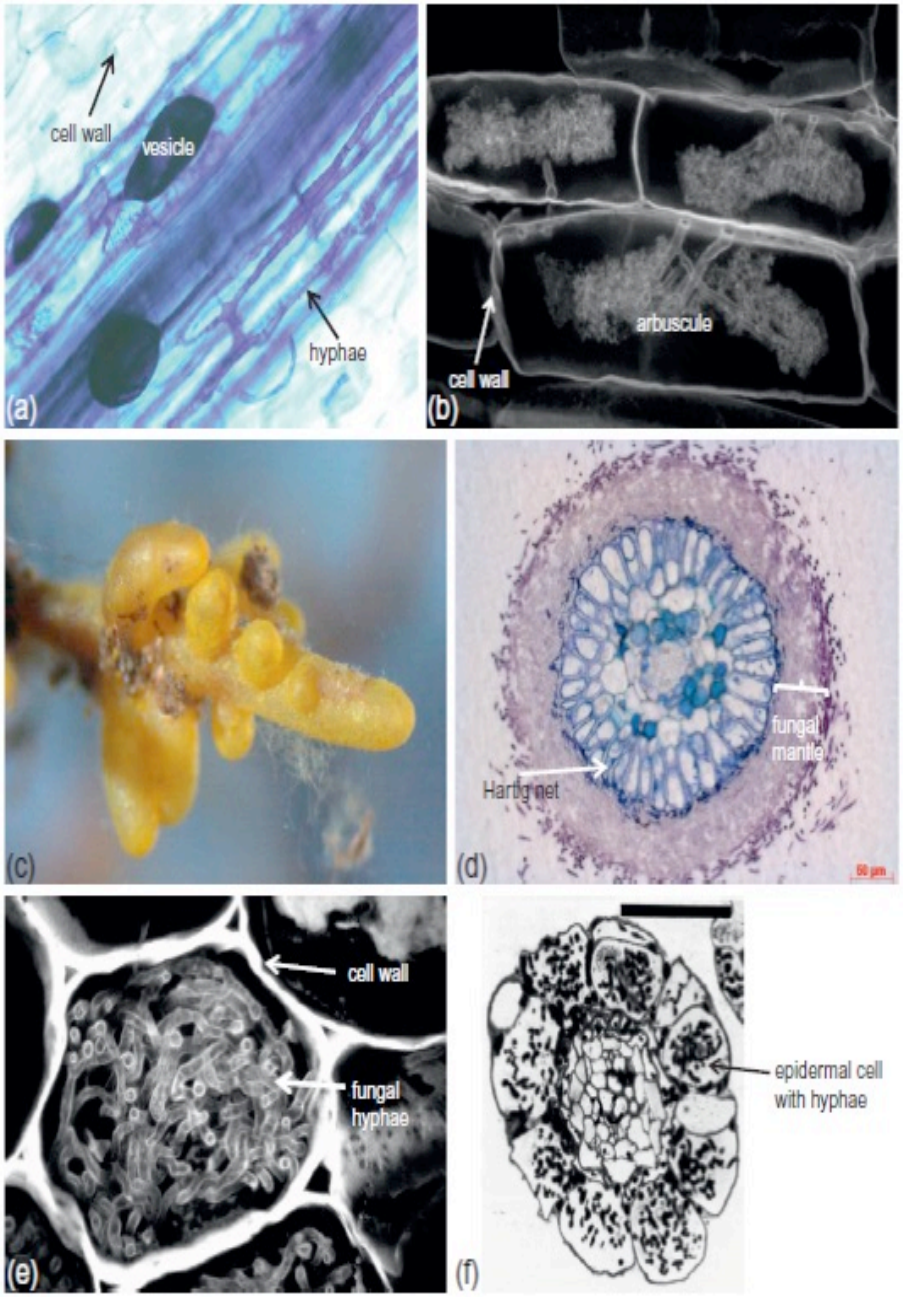
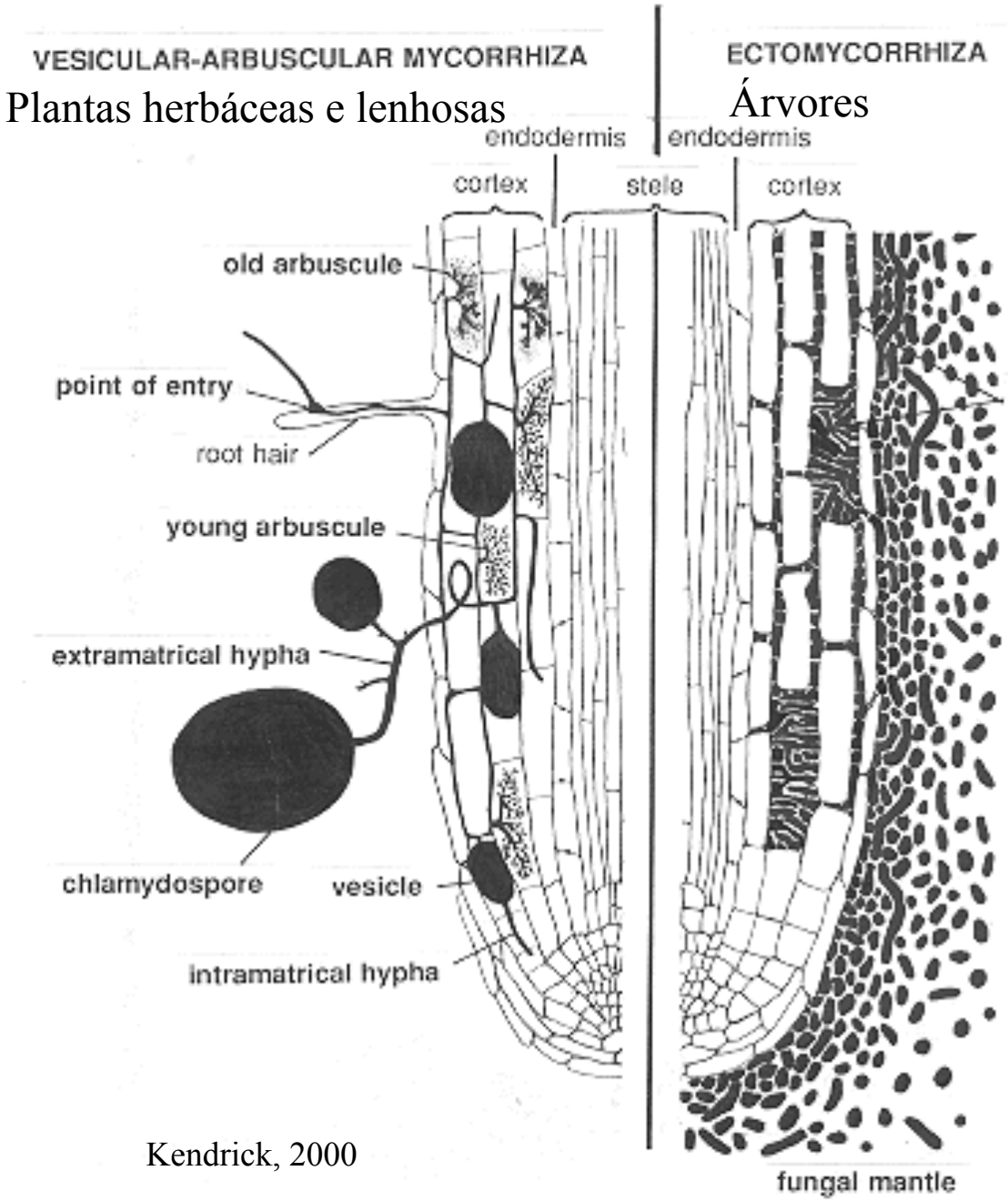


FIGURE 7.2 Typical structures of arbuscular mycorrhizas (a, b), ectomycorrhizas (c, d), and ericoid mycorrhizas (e, f). *Source: van der Heijden et al. (2015).*

The Fungi (Third Edition)
Author(s):
Sarah C. Watkinson, Nicholas Money and Lynne Boddy
ISBN: 978-0-12-382034-1
Add to Favorites



Plantas herbáceas e lenhosas

Árvores

Kendrick, 2000

Dicarya
(90 *Géneros*)

Basidiomycota

Géneros:
Amanita, Boletus, Cortinarius, Inocybe, Russula, Lactarius.....

Ascomycota

Géneros:
Peziza, Helvella, Terfezia, Tuber.....

(5000 *Espécies*)

Maioria cresce em meio de cultura, e quase todos diferenciam basidiocarpos e ascocarpos no seus ambientes naturais

Ectomicorrizas


Larix laricina / Suillus cavipes


Pinus strobus / Amanita muscaria

1 – introdução de hifas septadas entre as células corticais da raiz – **rede de Hartig**

(interface extra-celular entre o fungo e a planta);

2 – formação de um **manto de hifas** à volta da superfície da raiz;

3 – a extensão das hifas a partir do manto para o solo circundante

Os açúcares são transportados da raiz para o manto fúngico, onde são convertidos em "açucares fúngicos"

Kendrick, 2000

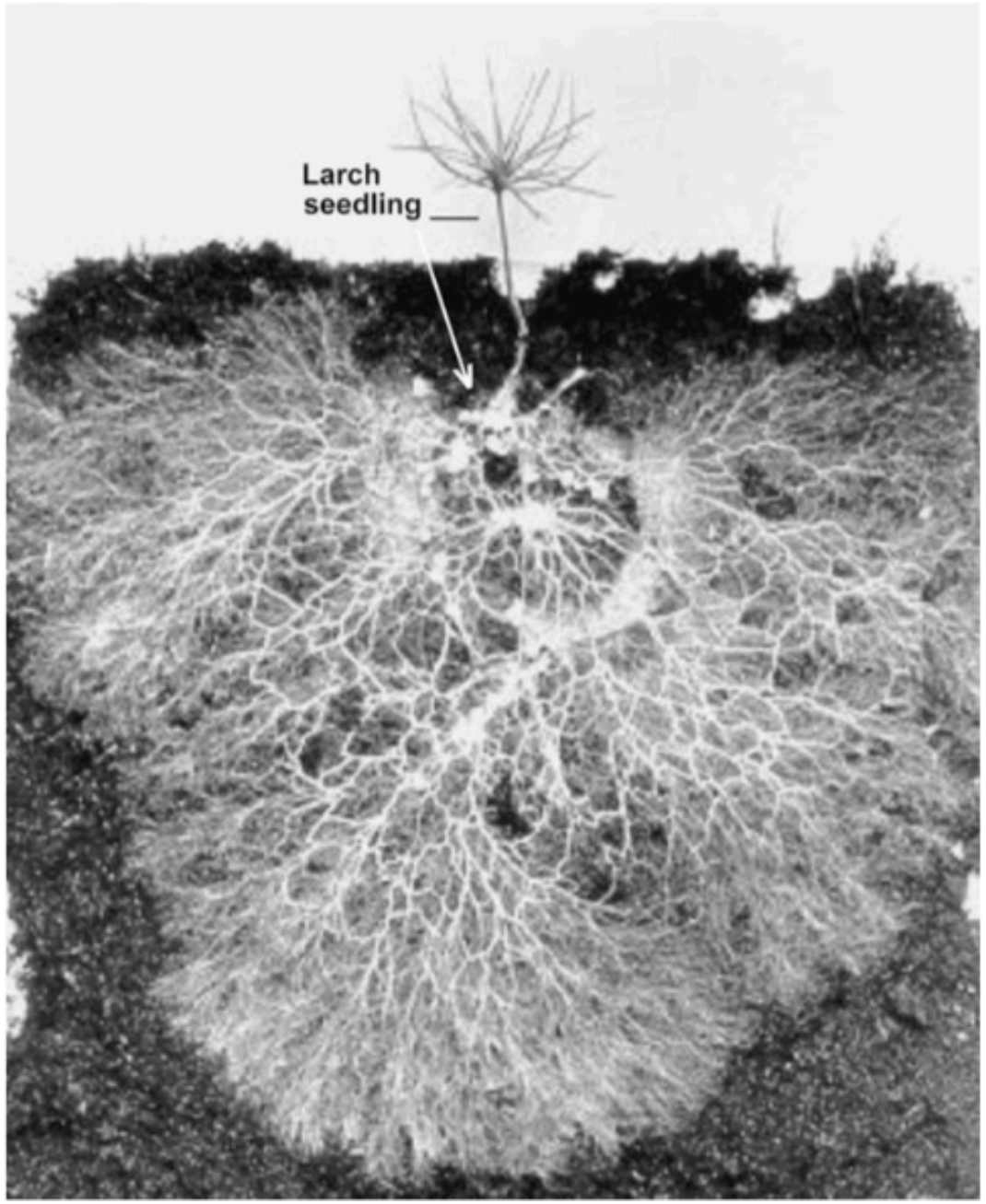


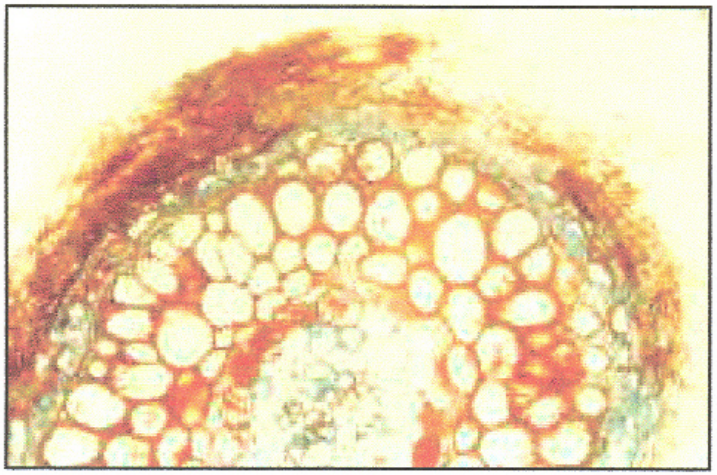
Fig. 13.8 A young larch seedling, about 3 cm high, growing in a peat-based substrate against a sloping face of an observation chamber. Mycorrhizas can be seen at the base of the stem (arrow) but almost all the visible growth is mycelial cords that explore the soil for nutrients. (Courtesy of D. Read.)

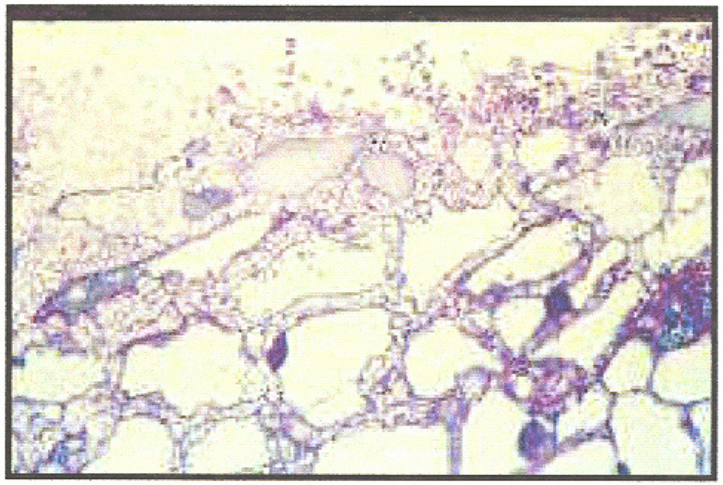
Deacon, 2006

The development of a mycorrhiza involves:

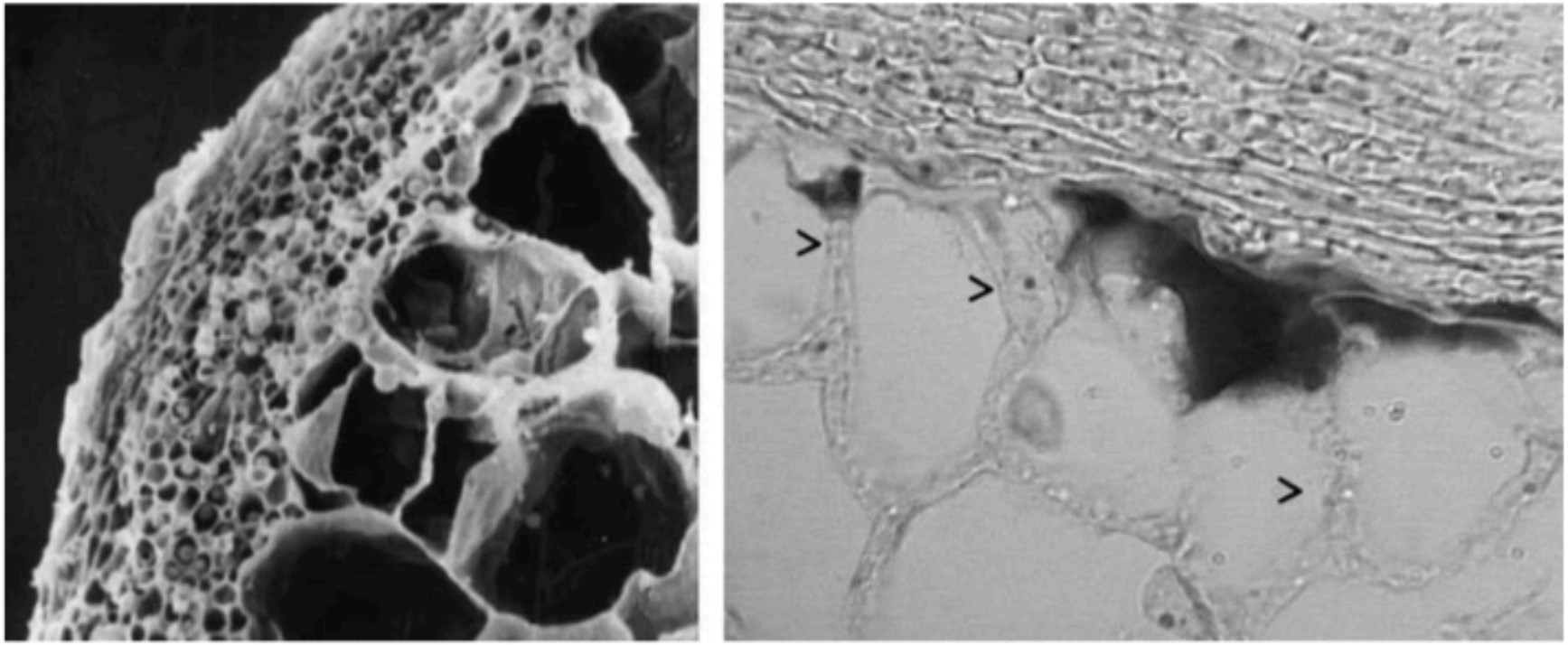
(A) penetration of hyphae between the cells of the root cortex to form a characteristic Hartig net [right-hand photomicrograph below

(B) establishment of a mantle of hyphae around the outside of the root (the thick brown layer in the left-hand picture, below, and the dots and tiny circles in the upper part of the right-hand picture, below - both micrographs show transverse sections of mycorrhizal roots);





Kendrick, 2000



(a) (b)

Fig. 13.7 (a) Scanning electron micrograph of a cross-section of part of a mycorrhizal root, showing the fungal sheath that surrounds the root. (b) Thin section of part of an ectomycorrhizal root. The arrowheads show hyphae invading between the root cortical cells, forming the Hartig net. Nutrient exchange between the fungus and the root is thought to occur in this region.

Deacon, 2006

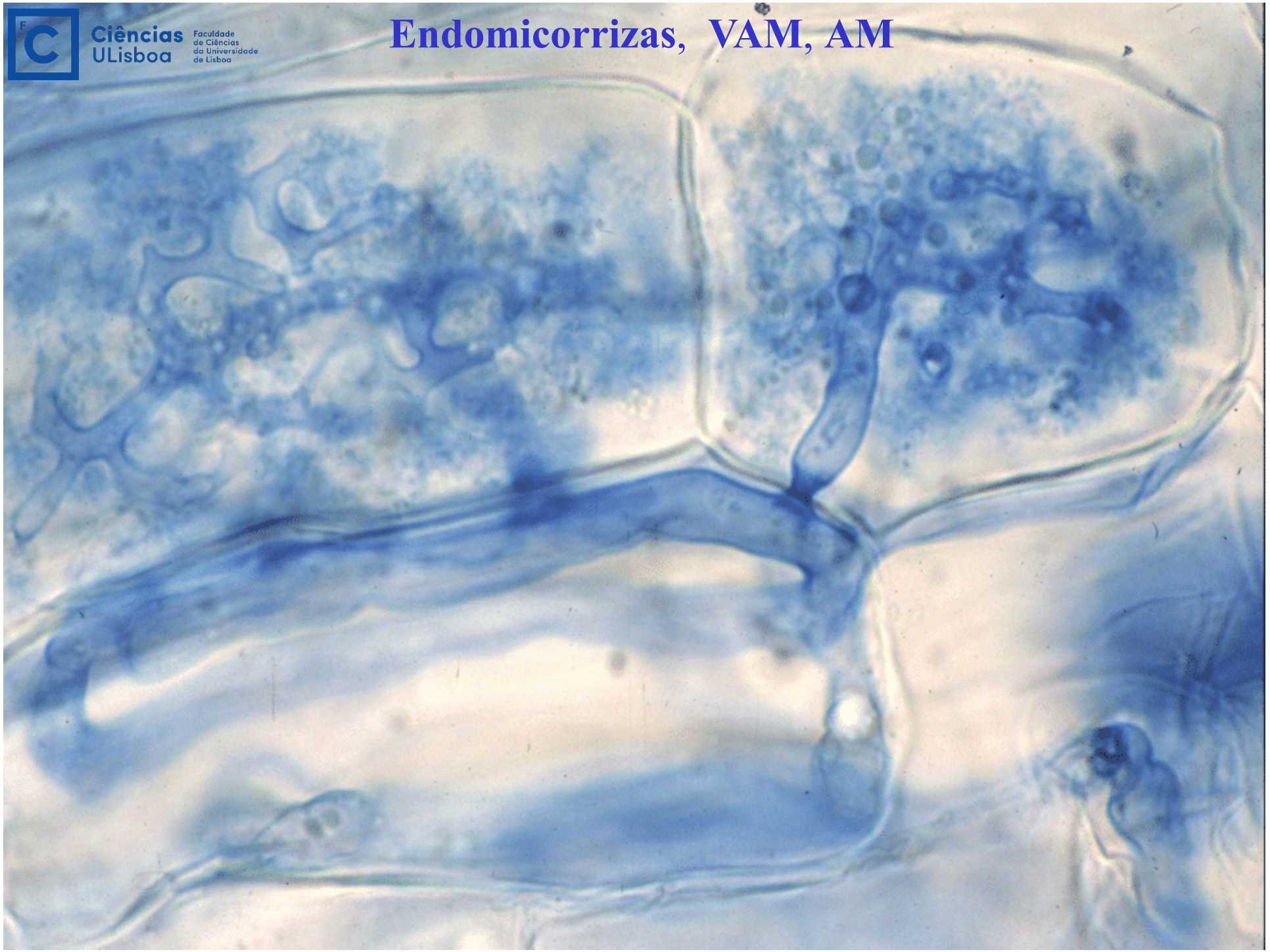
Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

Parceiros ectomicorrizicos das árvores (*Suillus luteus* e Pinheiro)

Kendrick, 2000

Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

Endomicorrizas, VAM, AM



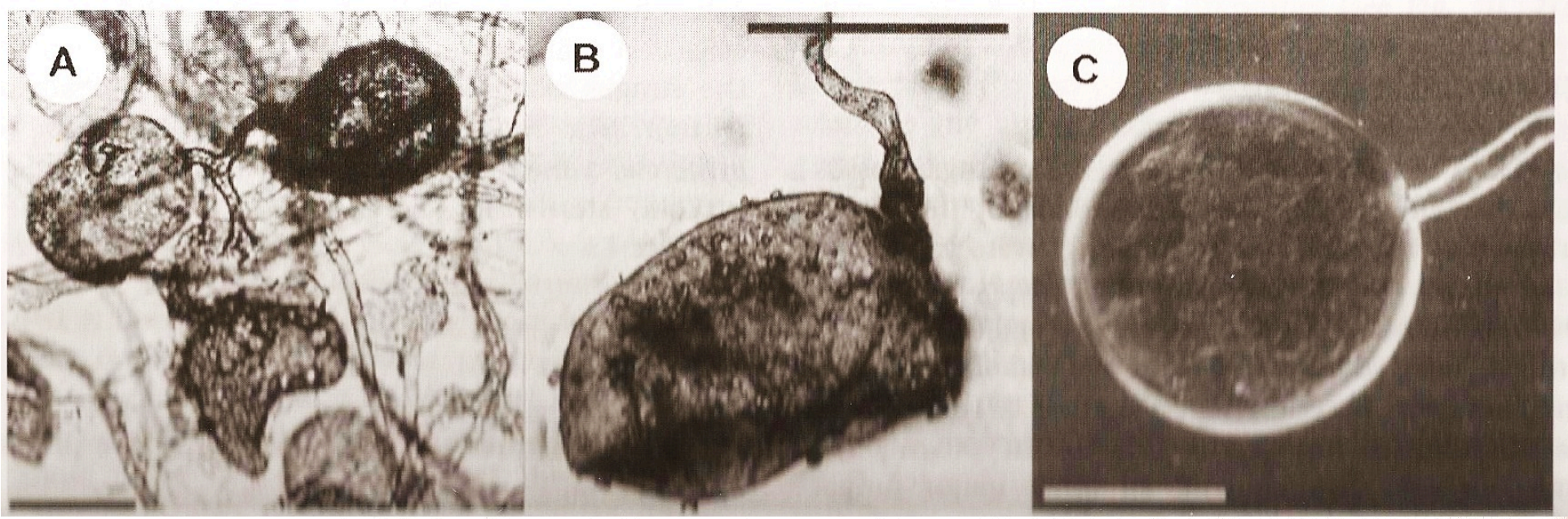


Fig. 2.6 (A,B) Fossil hyphae and spores from the Ordovician, about 460 mya, compared with a spore (C) of a present-day *Glomus* species (an arbuscular mycorrhizal fungus). All scale bars = 50 µm. (Images courtesy of Dirk Redecker; see Redecker *et al.* 2000.)

Deacon, 2006

Plantas herbáceas e lenhosas

Árvores

Biotróficos obrigatórios

PhylumZygomycota

(2001) – *Phylum Glomeromycota*

10 *Géneros:*

Glomus (grupos A e B)

Acaulospora

Entrophospora

Glomus (grupo C)

Pacispora

Gigaspora

Scutellospora

Archaeospora

Geosiphon

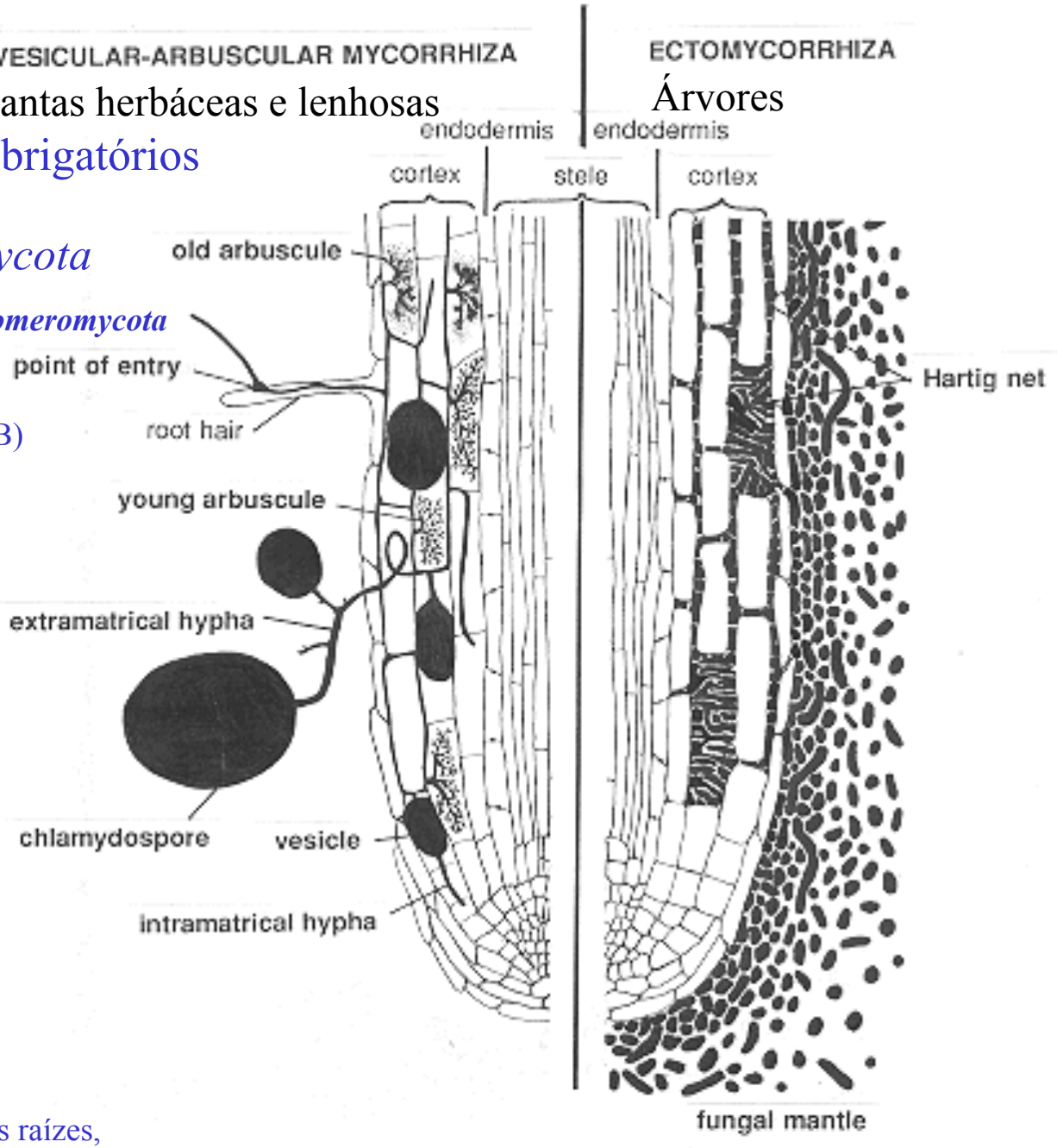
Paraglomus

(**200 *Espécies***)

O fungo só cresce

em associação com as raízes,

e nunca produz meiósporos



Kendrick, 2000

Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

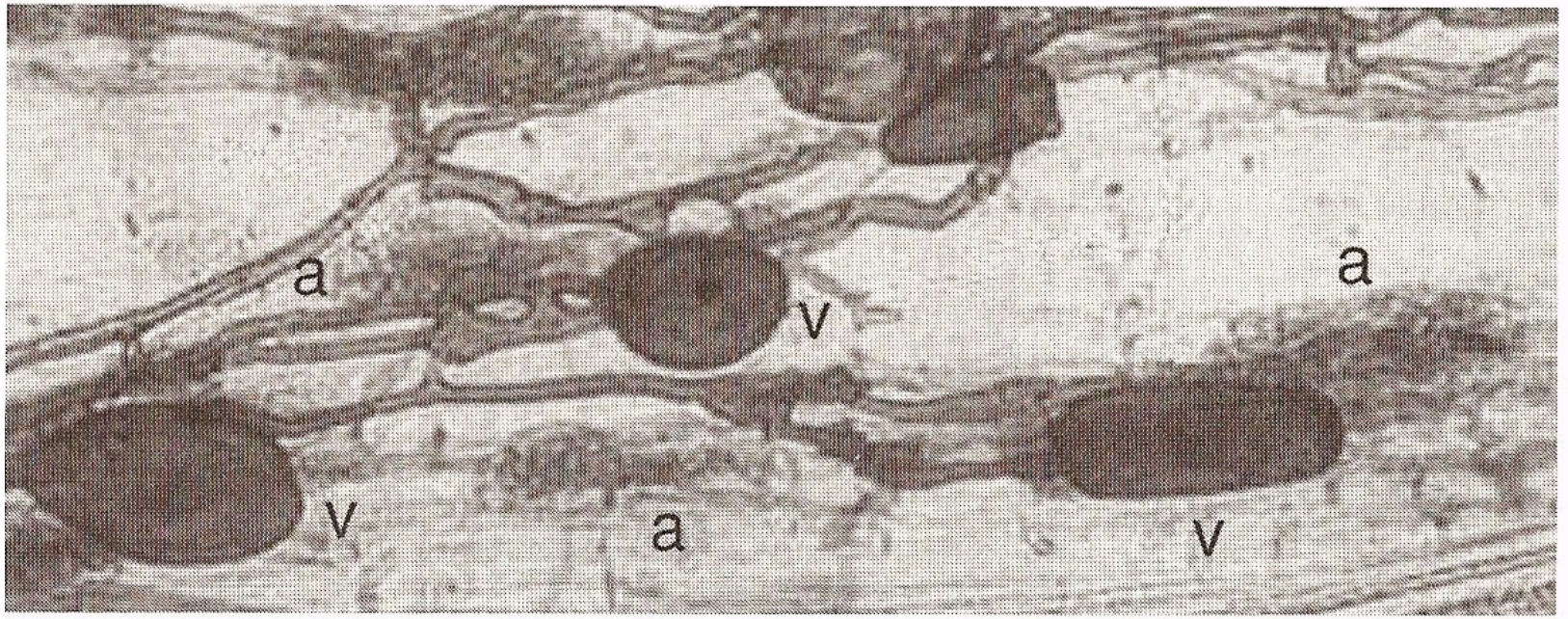
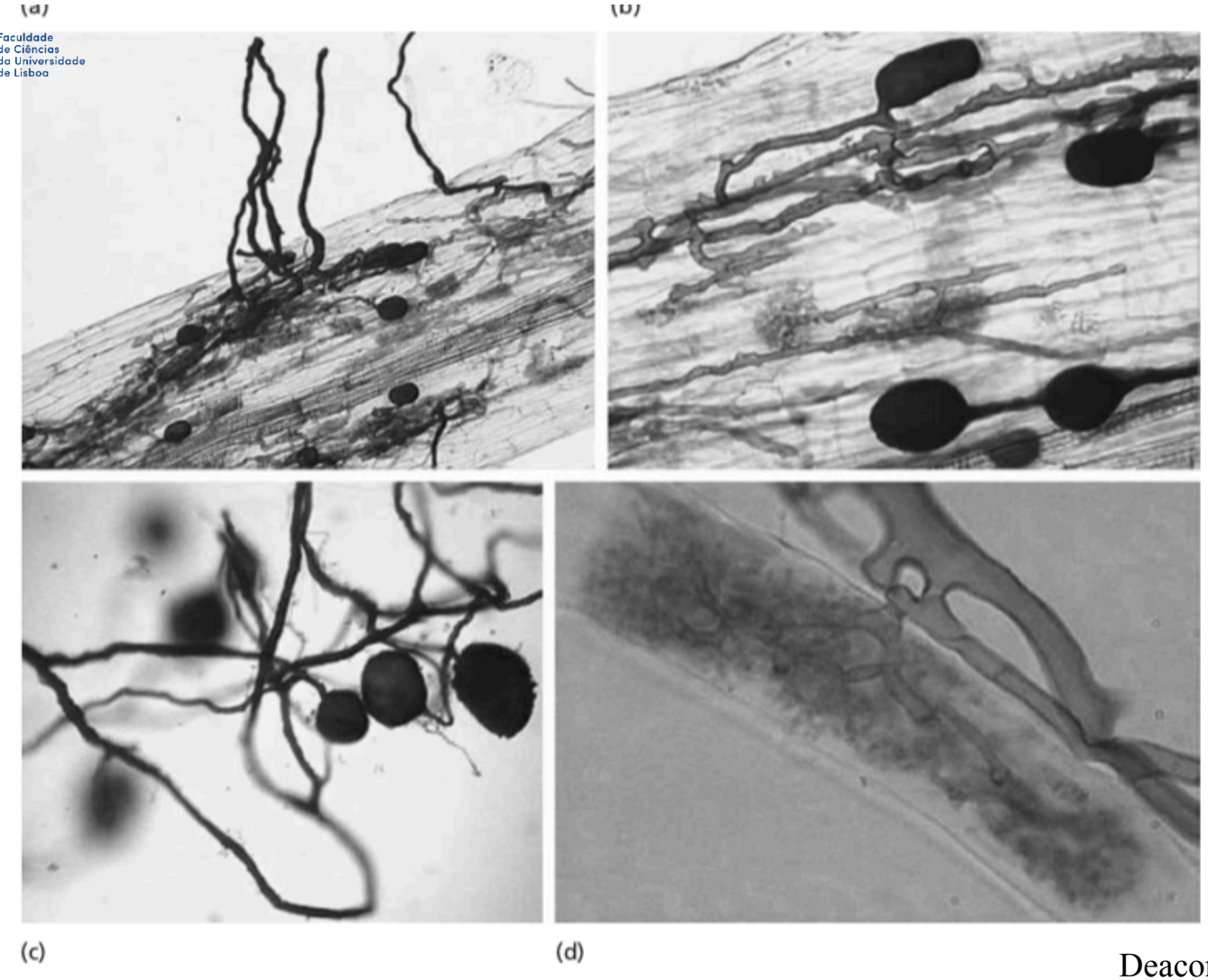


Fig. 2.5 Vesicles (v) and arbuscules (a) of present-day arbuscular mycorrhizal fungi in clover roots.

Deacon, 2006



Deacon, 2006

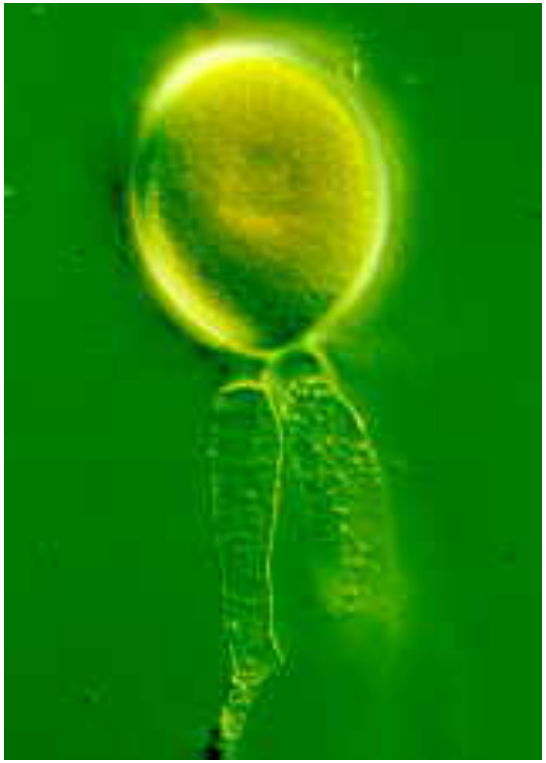
Fig. 13.1 The principal features of arbuscular mycorrhizal (AM) fungi, observed by clearing the root tissues with strong alkali and then staining roots with the fungal dye, trypan blue. (a) A root heavily colonized by AM fungi, with hyphae that radiate into the soil. (b) When observed through the depth of the root cortex, AM fungal hyphae are often seen to run parallel to the root axis, growing between the root cortical cells. These hyphae are irregular, with constrictions and bulges, quite unlike the hyphae of most other fungi. They frequently produce large, swollen vesicles within the root tissues. (c) Some of the external hyphae and hyphal aggregates produce clusters of spores in the soil. (d) Some of the root cortical cells are penetrated by hyphae that branch repeatedly to produce intricately branched arbuscules, often completely filling the root cells.

Fungos AM

Simbiontes obrigatórios e Assexuados

Anterior a 1974 fungos AM – pertenciam todos ao género *Endogone*

Fungos AM morfologicamente idênticos com o género *Endogone* (género com sexualidade reconhecida- Zigósporo com suspensores).



Zigósporo de *Endogone pisiformis*

1974 – Gerdemann e Trappe colocaram os fungos AM na ordem *Endogonales* em 4 géneros (*Glomus*, *Sclerocystis,Gigaspora*, *Acaulospora*)

1990 – Morton e Benny criaram uma nova ordem *Glomales* no Filo *Zygomycota*, com 6 géneros.

2001 – SchűlBler et al. a ordem *Glomales* foi elevada para o nível taxonómico de Filo *Glomeromycota*

Glomerales denominação correcta para a ordem *Glomales* e várias outras ordens foram estabelecidas (com um total de 10 géneros)

Com base em características moleculares (SSU rRNA), morfológicas e ecológicas os Fungos AM são colocados num *Phylum* monofilético que partilha um antepassado com os *Ascomycota* e *Basidiomycota*

Phylum Glomeromycota - *Mycological Research* **105** (12): 1413 – 1421 (**2001**)

A new fungal Phylum, The *Glomeromycota*: phylogeny and evolution

Classe *Glomeromycetes*
(+ de 150 espécies descritas)

Phylum Glomeromycota

-Fungos hipógeos

-Formam micorrizas com micélio e arbúsculos

-Raramente formam vesículas

-Produzem esporos

Classe Glomeromycetes

-Fungos com micélio cenocítico

-Vivendo na sua maioria debaixo do solo

-Formando clamidósporos por desenvolvimento blástico do ápice da hifa e espessamento da parede celular

Clamidósporos produzidos:

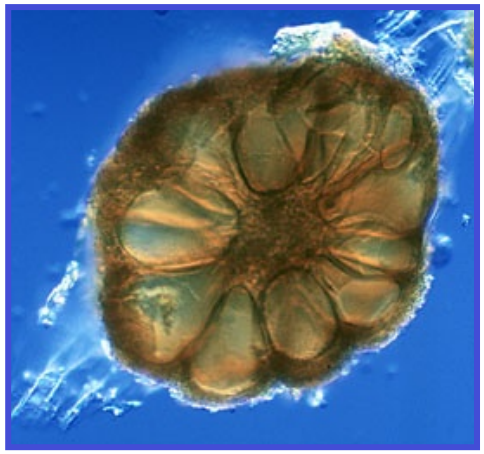
-Isoladamente

-Em grupos (cachos)

- Em esporocarpos (com perídio)

-No interior das raízes das plantas

Esporocarpo de *Glomus sinuosum*



"Habitat"

-solo

-raízes

-na superfície do solo ou da vegetação.

Vivem em simbiose com organismos fototróficos - autotróficos produzem micorrizas arbusculares (AM) ou (VAM) vesiculares – arbusculares micorrizas (simbiontes obrigatórios).

Mycologia, 98(6), 2006, pp. 885–895.

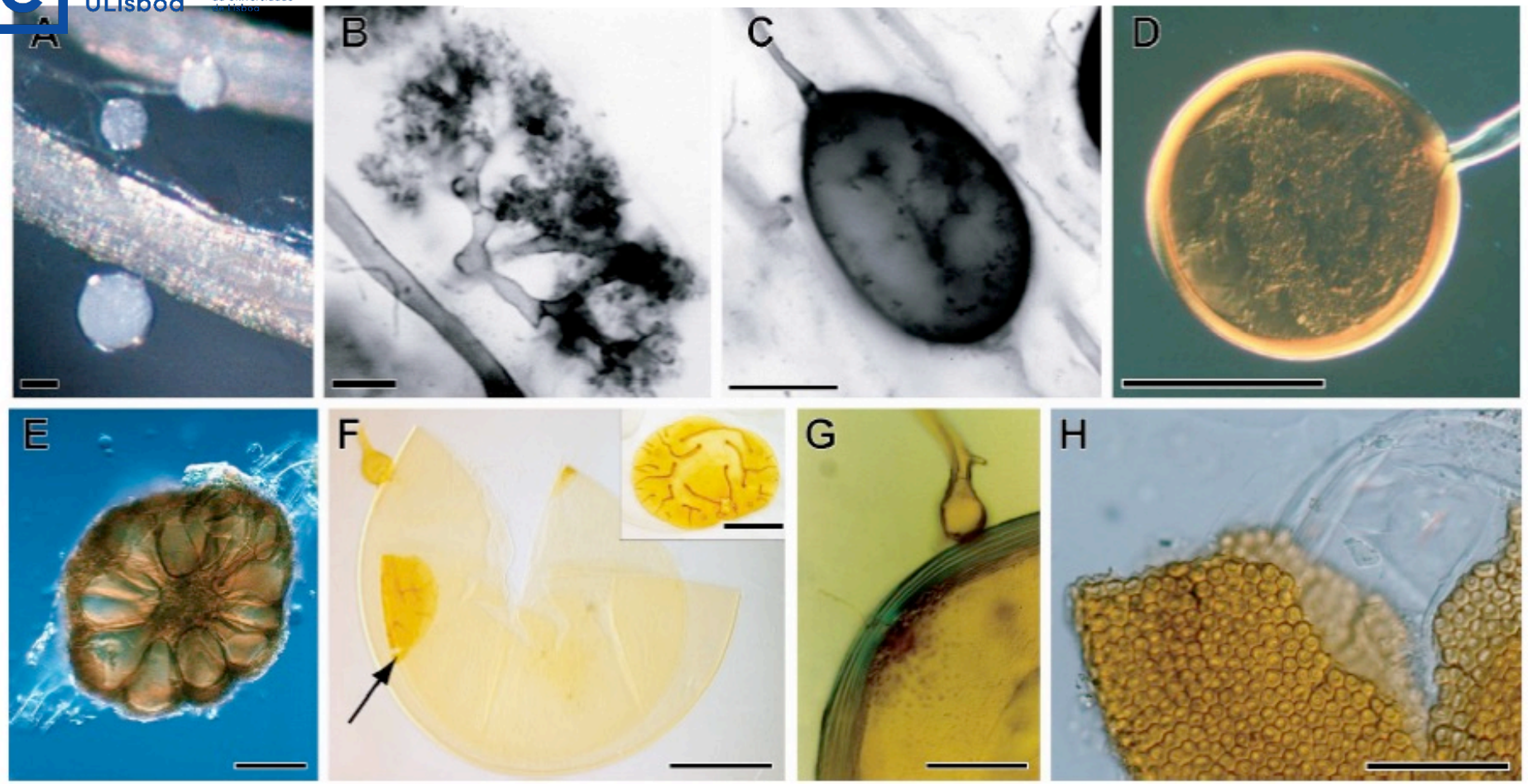


FIG. 1. Some characteristic morphological features of glomeromycotan fungi. A. Colonized roots of *Plantago media* with hyphae and spores of *Glomus clarum*. B. Arbuscule of *Glomus mosseae* stained with chlorazol black. C. Vesicle of *Glomus mosseae*. D. Spore of *Glomus* sp. S328 showing the hyphal attachment. E. Section of a sporocarp of *Glomus sinuosum* with spores grouped around a hyphal plexus and covered by a layer of hyphae. F. Spore of *Scutellospora cerradensis*, showing bulbous sporogenous cell and inner flexible walls with germination shield (arrow). Inset: germination shield of *S. scutata* in face view. G. Germinating spore of *Gigaspora decipiens* with sporogenous cell, warty germination layer and germination hypha. H. Spore of *Acaulospora denticulata* with tooth-like wall ornamentations and inner germinal walls. Spores in D, E, F, G and H were embedded in polyvinylalcohol lactoglycerol and in F, G and H they were cracked under the cover slip. Images courtesy of Kerstin Wex (B, C), Fritz Oehl (F) and the American Society for the Advancement of Science (D). Bars = 100 µm (A, E, F, G), 50 µm (D, H), 5 µm (B, C).

Geosiphon pyriformis is the only member of the phylum that is known to engage in a different type of symbiosis (Schüßler et al 1994). It forms an endocytosis containing the cyanobacterium *Nostoc punctiforme*, harboring these photobionts in fungal bladders up to 2 mm large. It forms glomoid spores and first was identified as a basal relative of AM fungi by rDNA phylogeny (Gehrig et al 1996). The exact phylogenetic relationship of *Geosiphon* relative to *Paraglomus*, *Archaeospora* and the clade with the previously known three families was not resolved well in earlier studies (Redecker et al 2000b). An updated sequence of *Geosiphon* in the databases now places this fungus closer to *Archaeospora leptoticha/gerdemannii* (Redecker 2002, Schwarzott et al 2001).

Mycologia, 98(6), 2006, pp. 885–895.

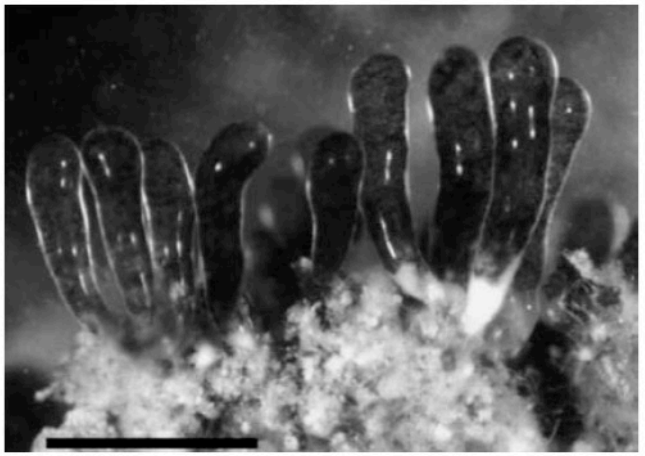
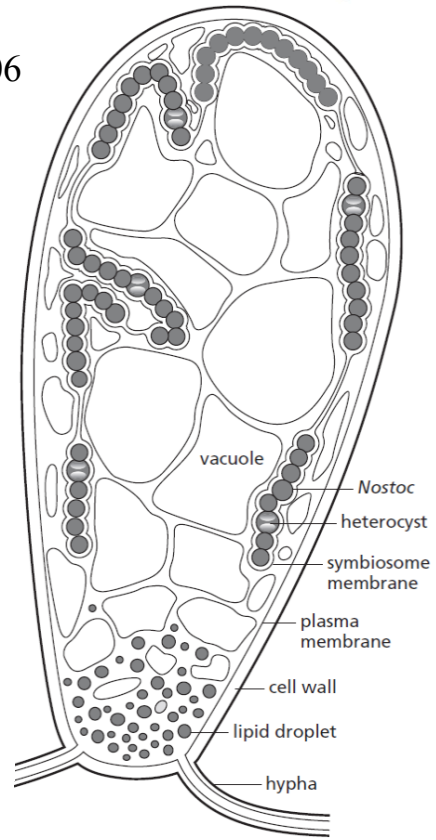


Fig. 13.24 Bladders of *Geosiphon pyriforme* growing on the surface of soil. Scale bar = 1 mm. (Courtesy of A. Schuessler.)

Deacon, 2006



Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

Fig. 13.25 Drawings of the *Geosiphon* bladder compartmentation. (a) Cells of *Nostoc* are located in membrane-bound symbiosomes towards the periphery of the fungal cell. (b) Detail showing a bacteria-like organism (BLO), cell wall (CW),

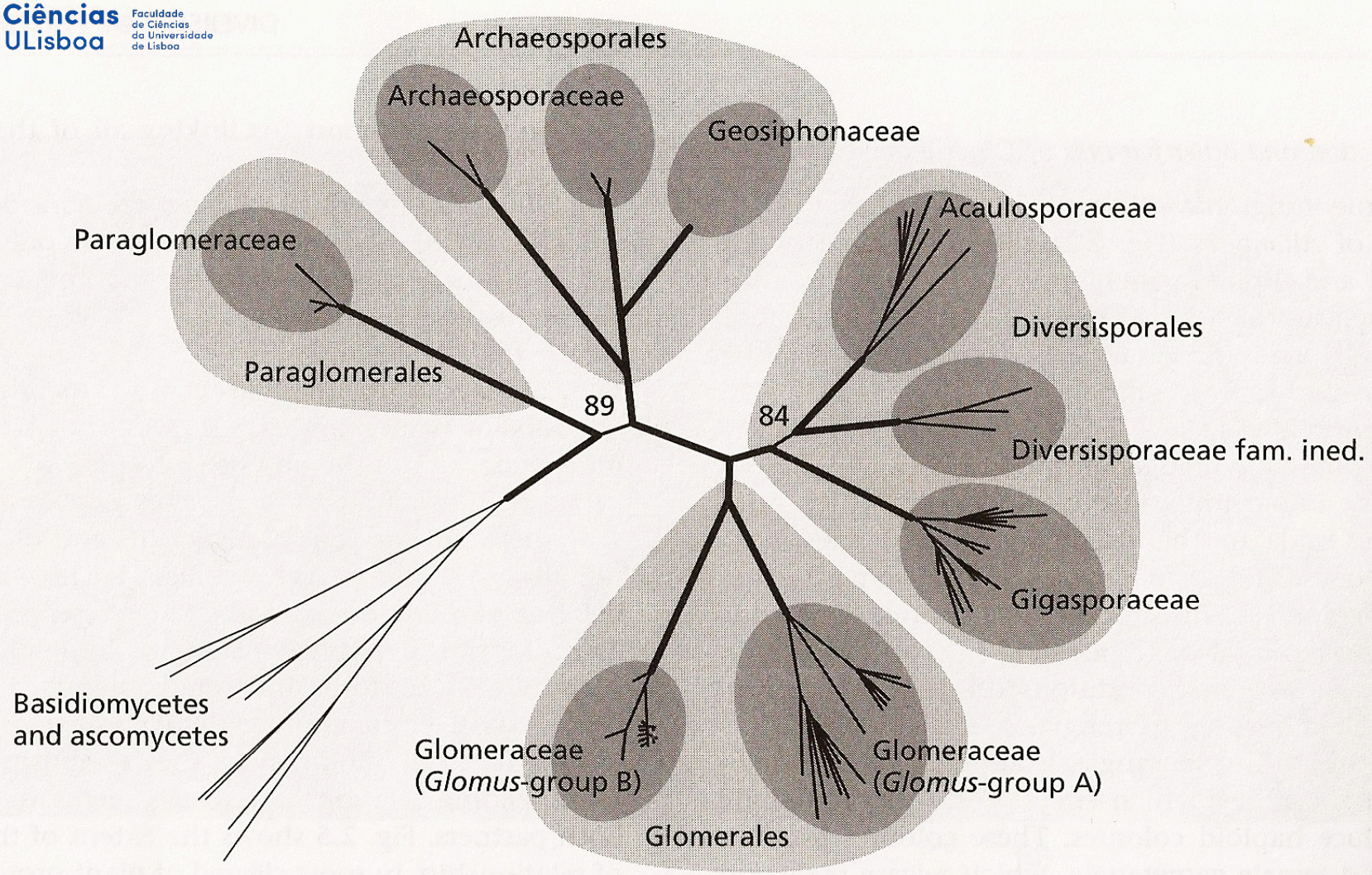
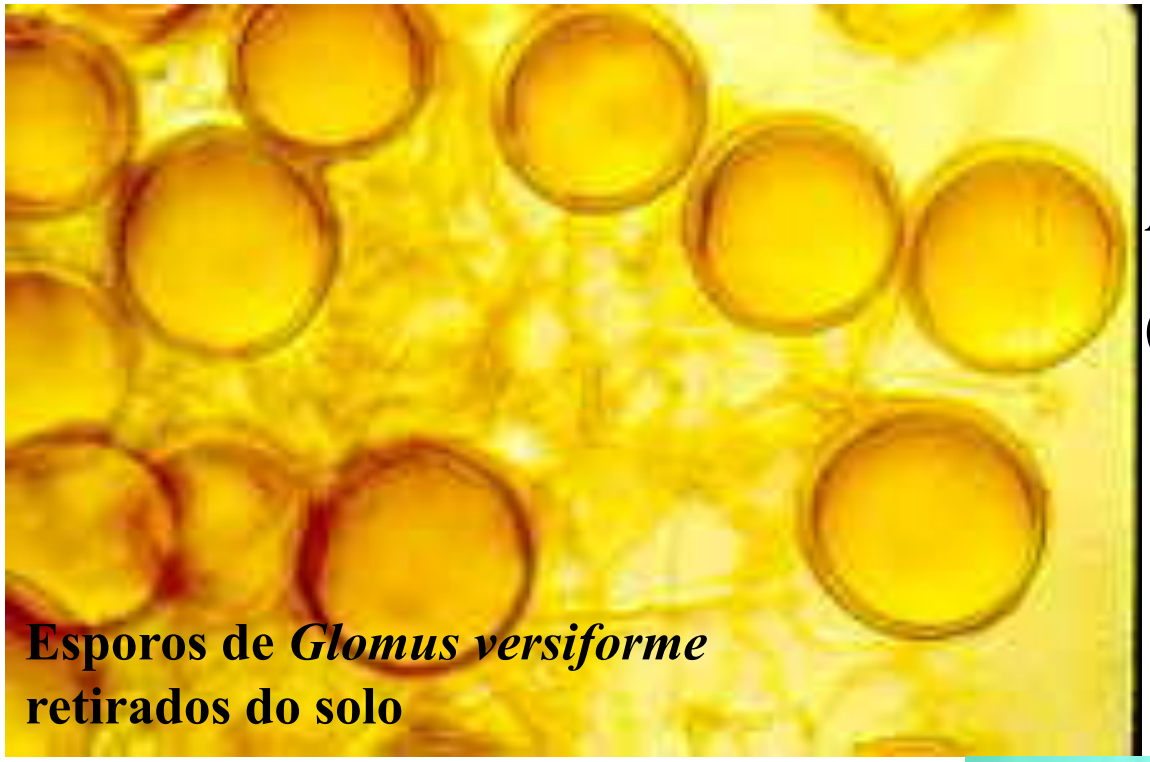


Fig. 2.4 Proposed generalized taxonomic structure of the AM fungi and related fungi (Glomeromycota). Thick lines delineate "bootstrap" values (indicating relatedness between the main branches) above 95%. Lower values (89% and 84%) are shown on two of the branches. (Reproduced by courtesy of Schuessler *et al.* 2001, and the British Mycological Society.)

Deacon, 2006



Esporos de *Glomus versiforme* retirados do solo

Endomicorrizas

AM (micorrizas arbusculares)

(VAM) (micorrizas vesiculares arbusculares)

O esporo (clamidósporo) germina e diferencia um apressório que adere à raíz

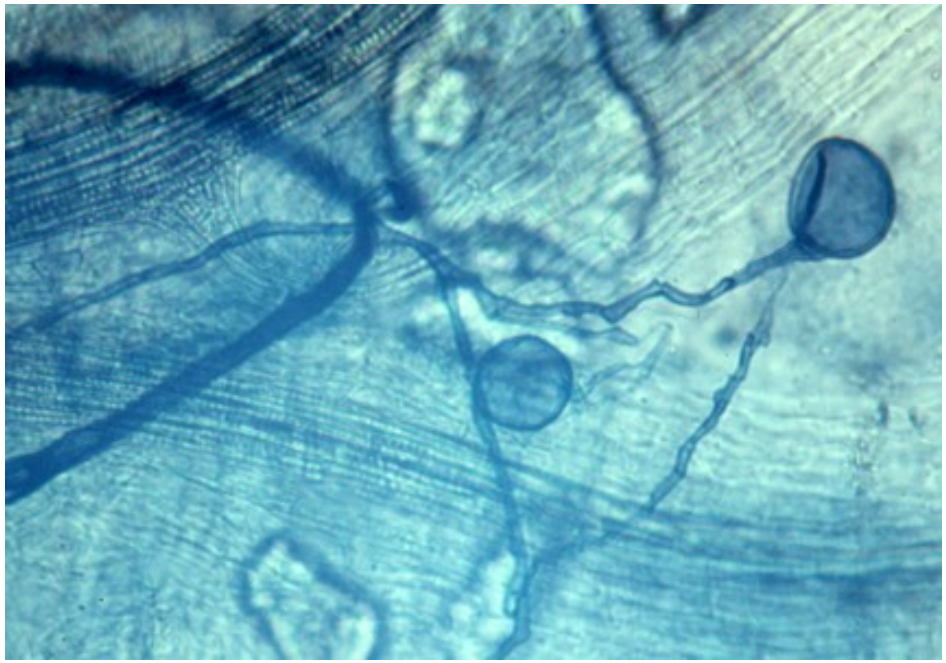
A identificação dos géneros faz-se com base na caracterização morfológica dos esporos (mitósporos - clamidósporos)

•Modo de formação do esporo (delimitação de géneros e famílias);

•Estrutura da parede celular do esporo (nº de camadas) (diferenciação das espécies);

•Ornamentação da superfície do esporo.

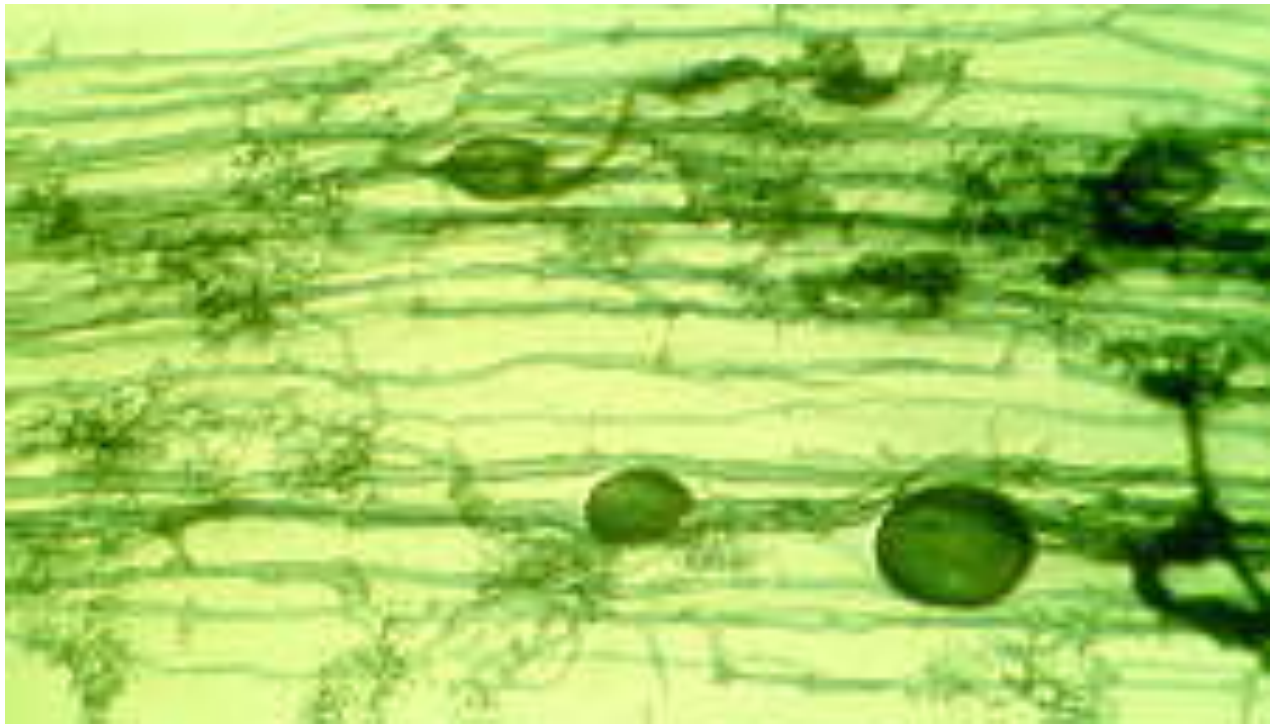
Esporo de *Glomus mosseae*

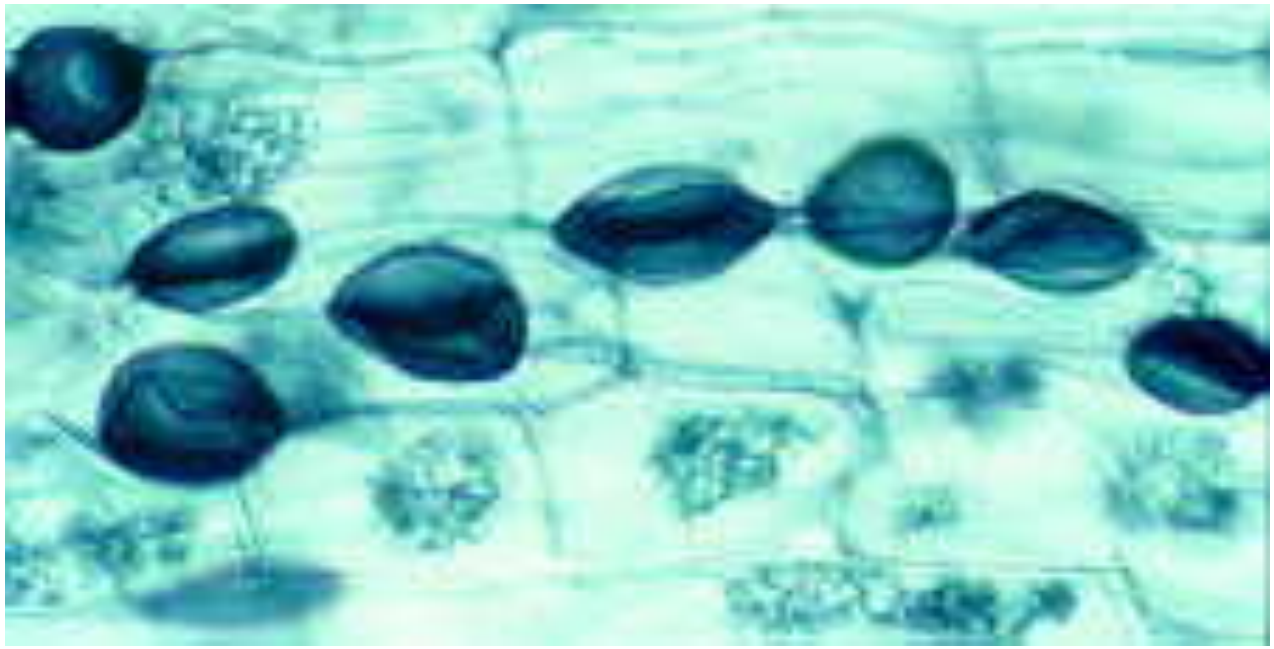


Reproduction of the fungi forming arbuscular mycorrhizae is by thick-walled spores produced on the extra-radicular hyphae. These are thick-walled and often remain in the soil for long periods. Many are quite large and can be recovered by sieving the soil. Although these spores will germinate and produce hyphae in the laboratory no one has yet succeeded in growing the fungus independently of a root. The picture at right shows spores of a species of *Glomus* produced on a branched extra-radicular hypha

Kendrick, 2000

Arbúsculo (fornece fósforo à planta)





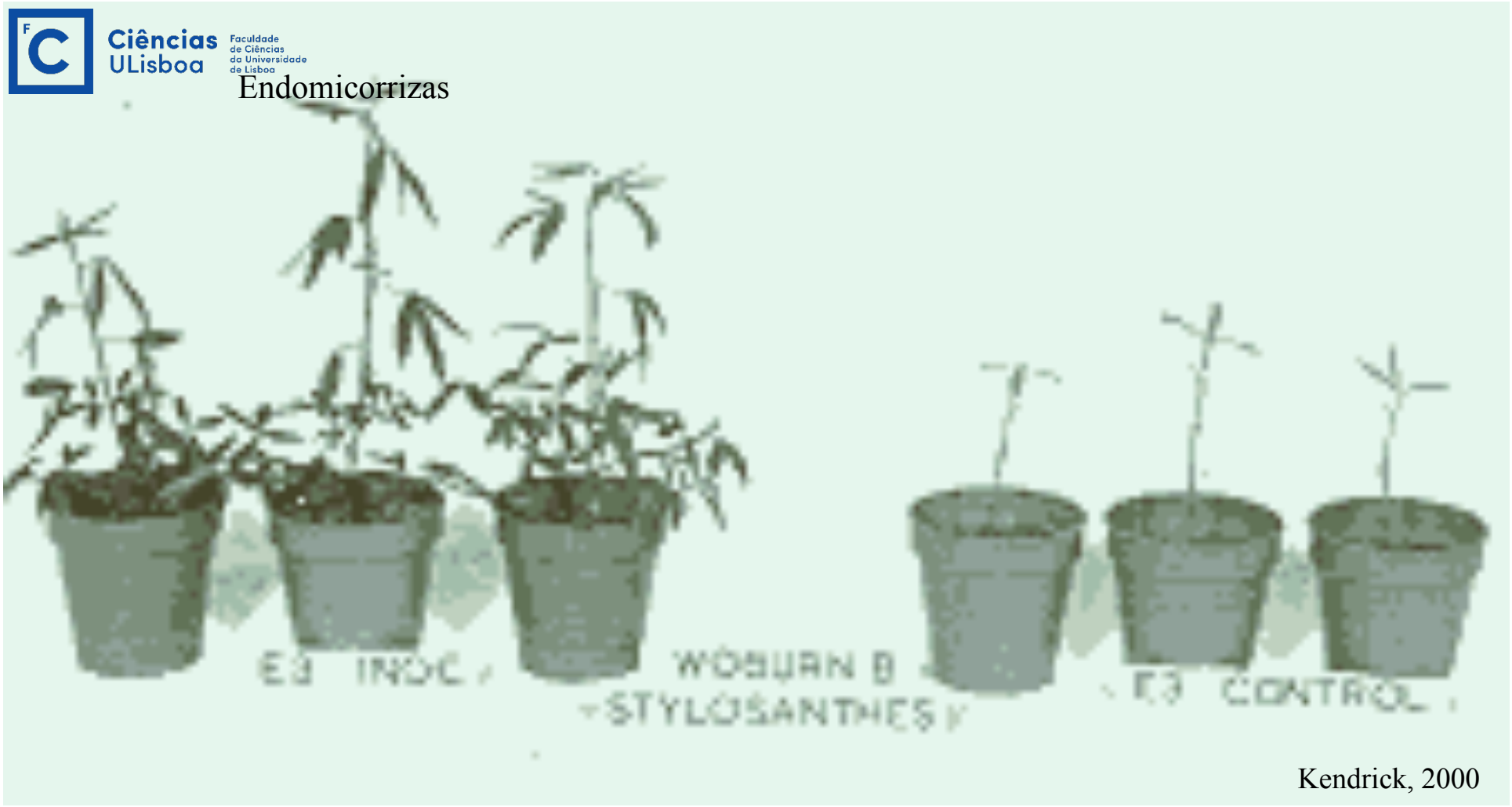
Arbúsculos e vesículas

À medida que o nºde arbúsculos diminui aumenta o nº de vesículas

Vesículas de parede fina mais ou menos elípticas, com substâncias de reserva

Kendrick, 2000

Endomicorrizas



Kendrick, 2000

-Micorrizas conferem protecção contra :

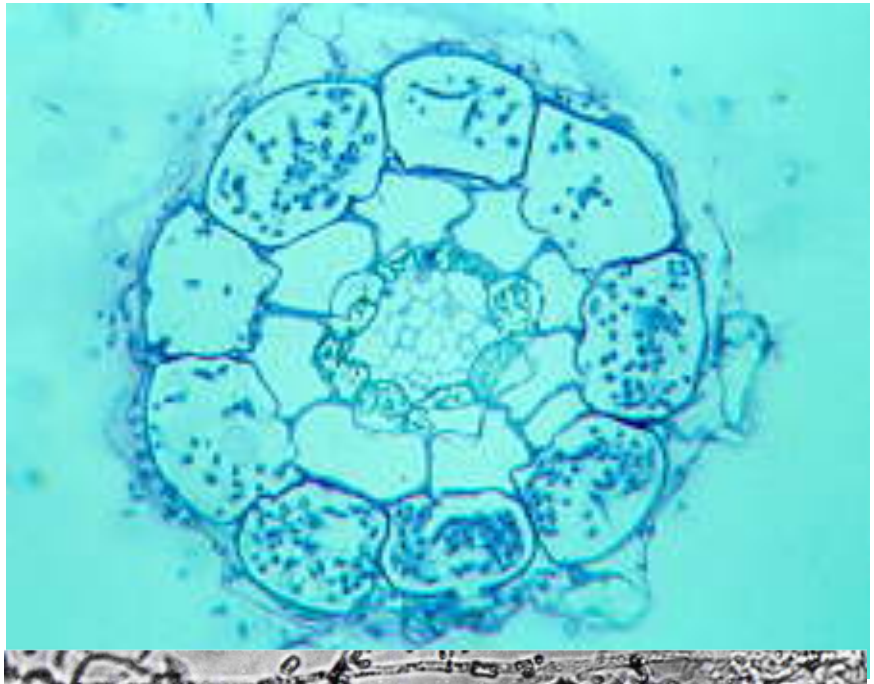
-organismos patogénicos das raízes (memátodos e outros fungos);

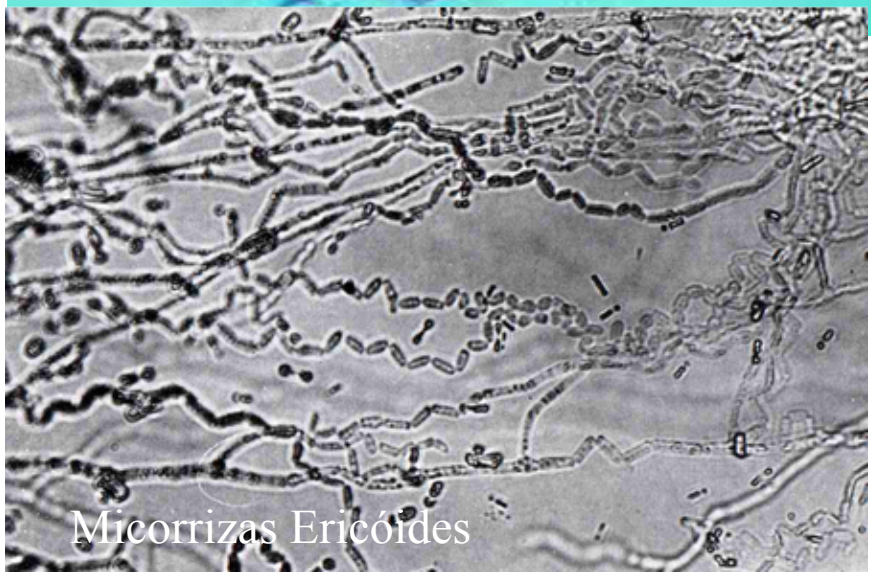
- a poluição por metais pesados, que ficam aprisionados e imobilizados na bainha fúngica das ectomicorrizas

Micorrizas Ericóides

•Rede de hifas envolvem a raíz

•Enrolamentos (de hifas septadas) intracelulares





•Em meio de cultura : cresce diferenciando hifas em zig-zag

Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

Micorrizas Orquidáceas

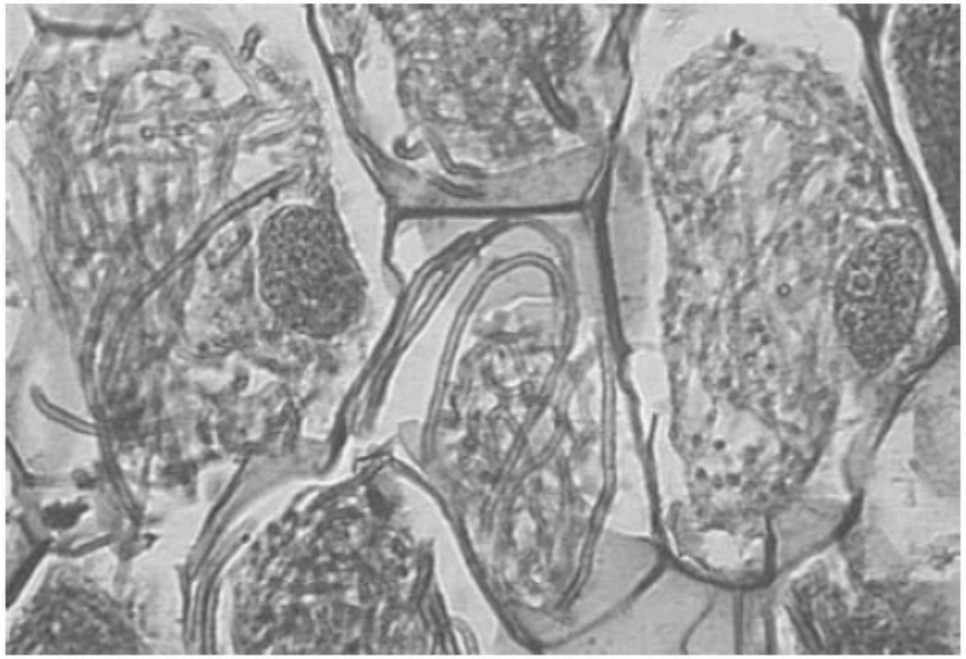
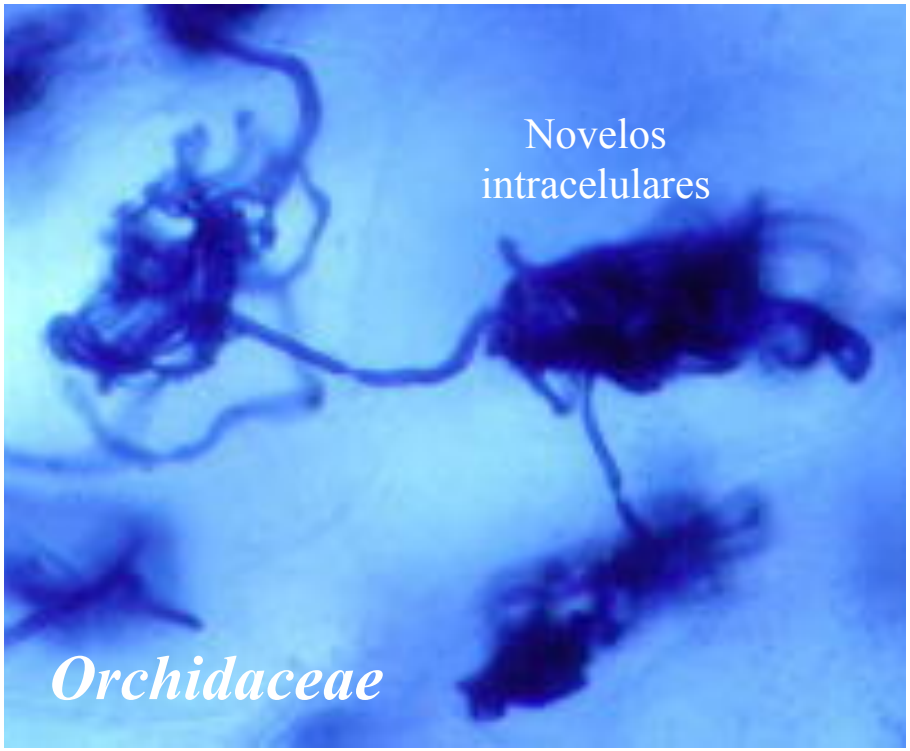


Fig. 13.10 Section through part of the protocorm (basal stem region) of an orchid, *Neottia*, showing coils of hyphae (peletons) within the orchid cells. The cells were alive, as evidenced by the presence of nuclei (darker structures) in two of the orchid cells.

Deacon, 2006



Kendrick, 2000