ООМИЦЕТЫ – ПАРАЗИТЫ ВОДОРОСЛЕЙ

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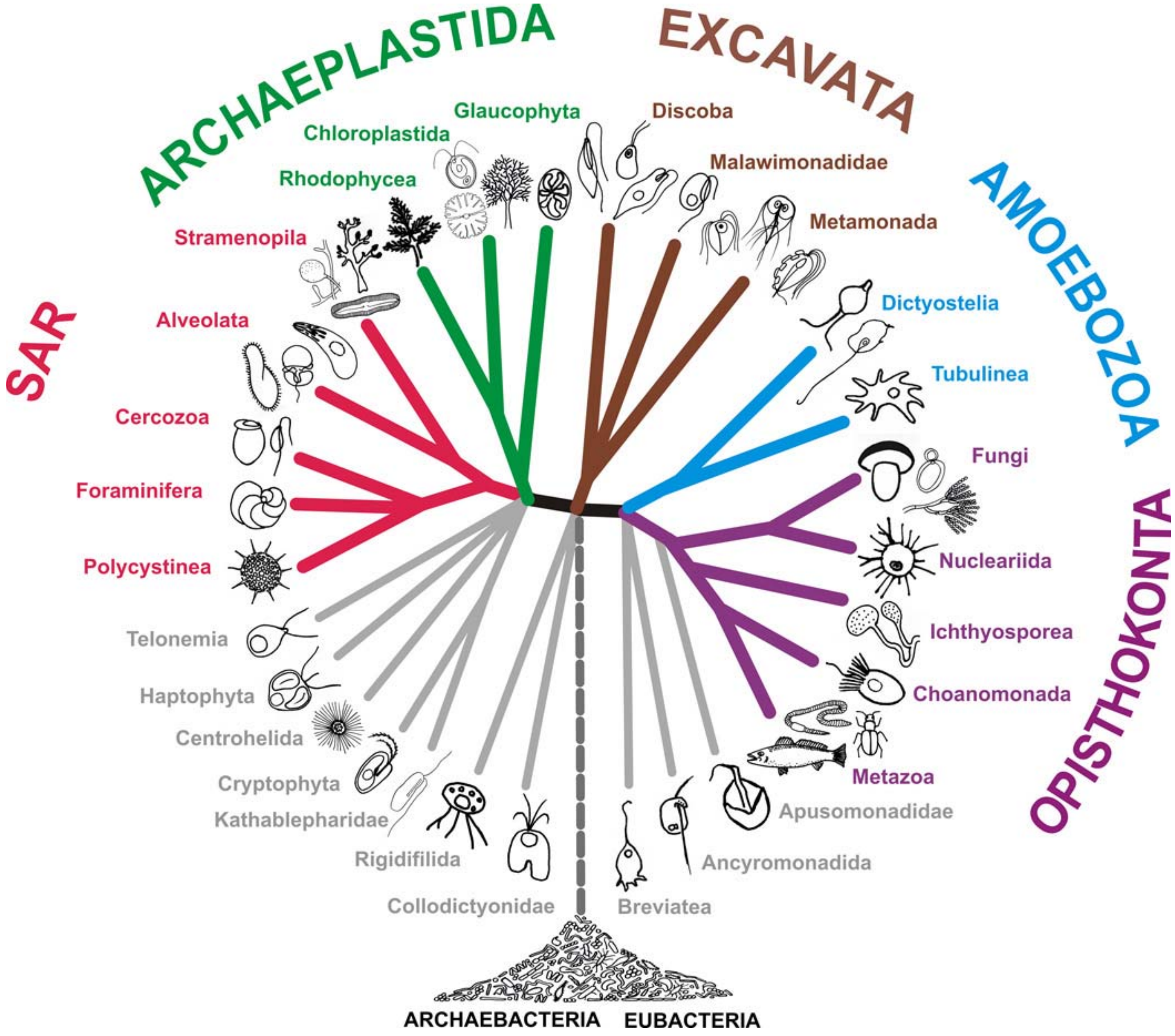
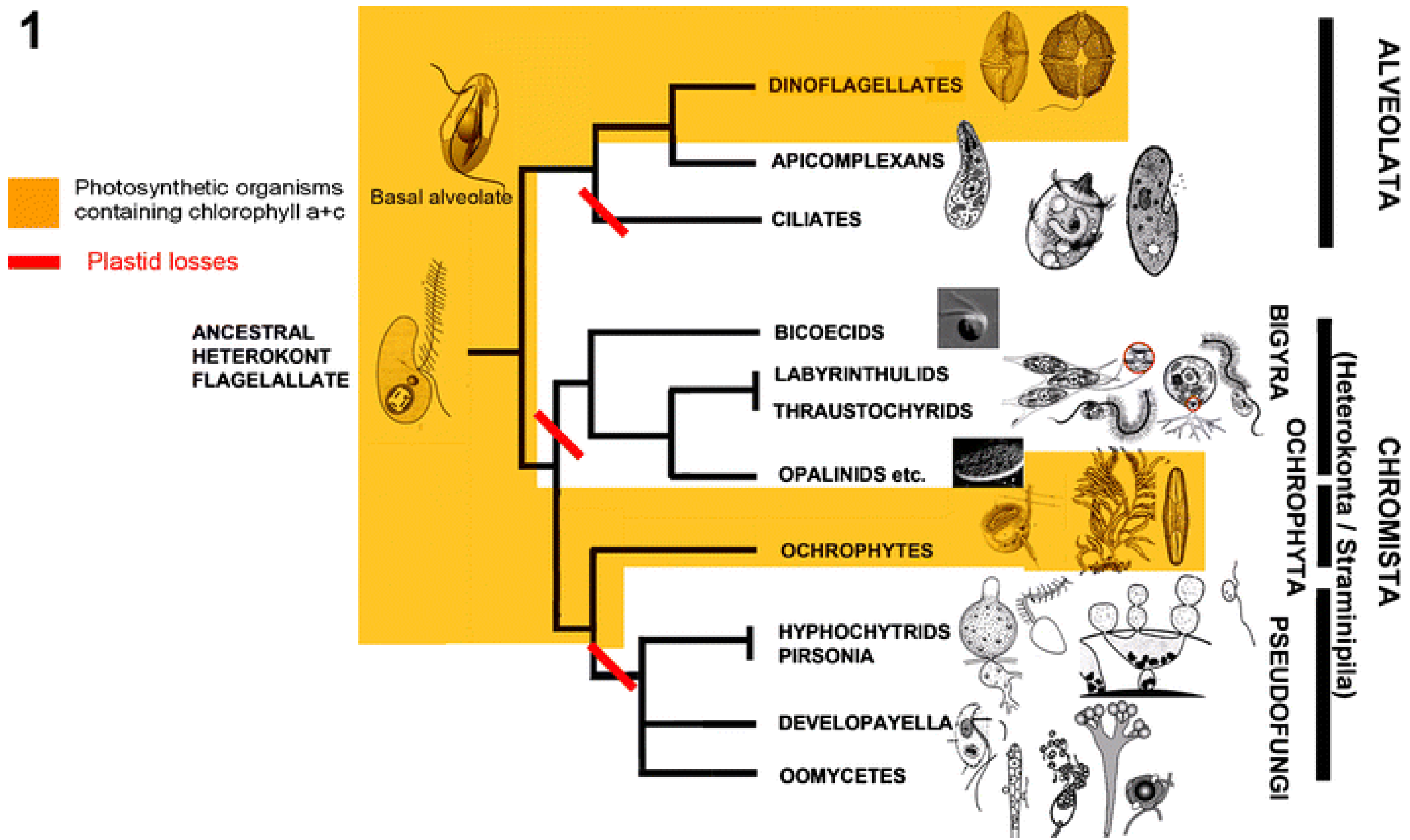
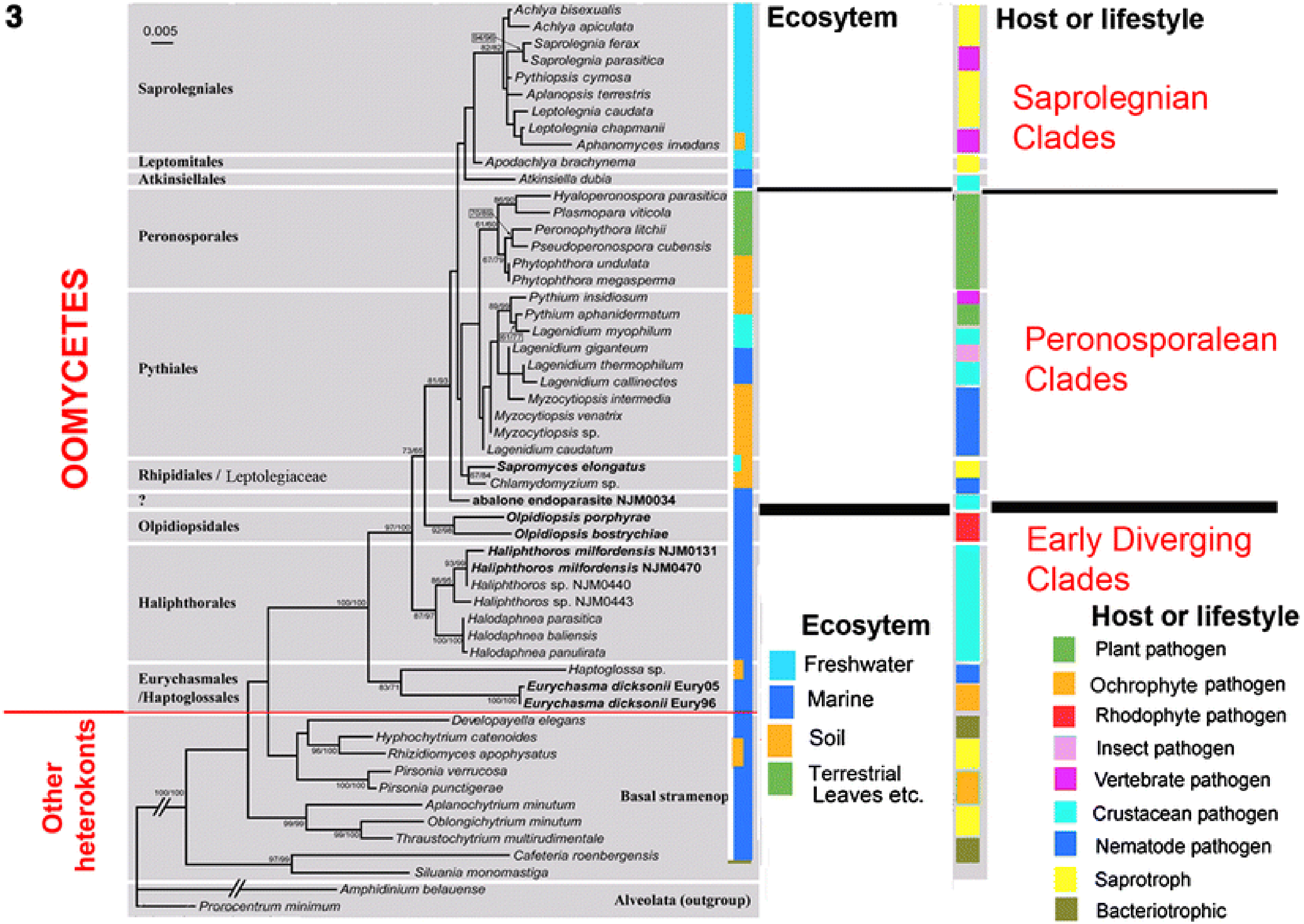


J. Eukaryot. Microbiol., 59(5), 2012 pp. 429–493



Schematic phylogenetic tree summarizing the likely phylogenetic relationships between the diverse members of the “chromalveolate” superkingdom. The photosynthetic lines are shaded in orange and postulated plastid loss events indicated by the red bars. The terminology is mostly taken from Cavalier-Smith and Chao 2006 (2006) and the tree based on a phylogenetic analysis of conserved protein genes by Tsui et al. (2006).

Beakes GW, Glocklin SL, Sekimoto S: The evolutionary phylogeny of the oomycete "fungi".
Protoplasma 2012, 249(1):3-19.



Maximum likelihood tree (1,103 sites) based on 54 SSU rRNA tree sequences of oomycetes, other stramenopiles with two members of the alveolata as an outgroup. The main oomycete order clades are labelled on right. The two left hand bars map onto this tree the ecosystems from which genera come from and their host or life style respectively. Tree adapted from Sekimoto (2008)

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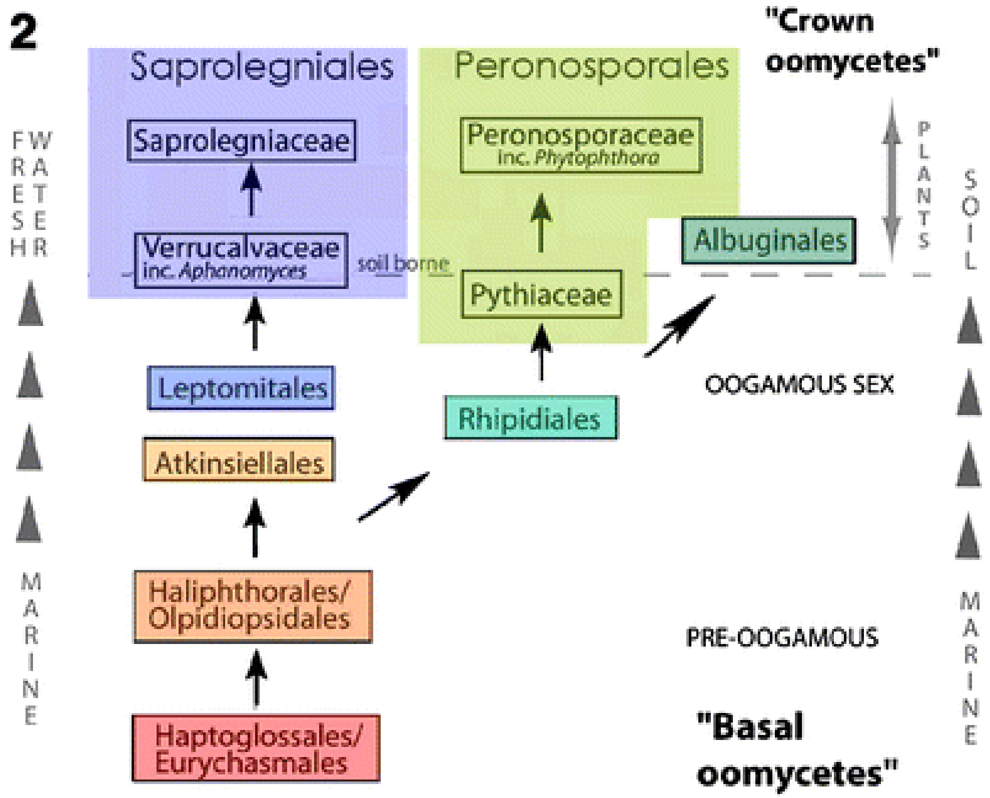
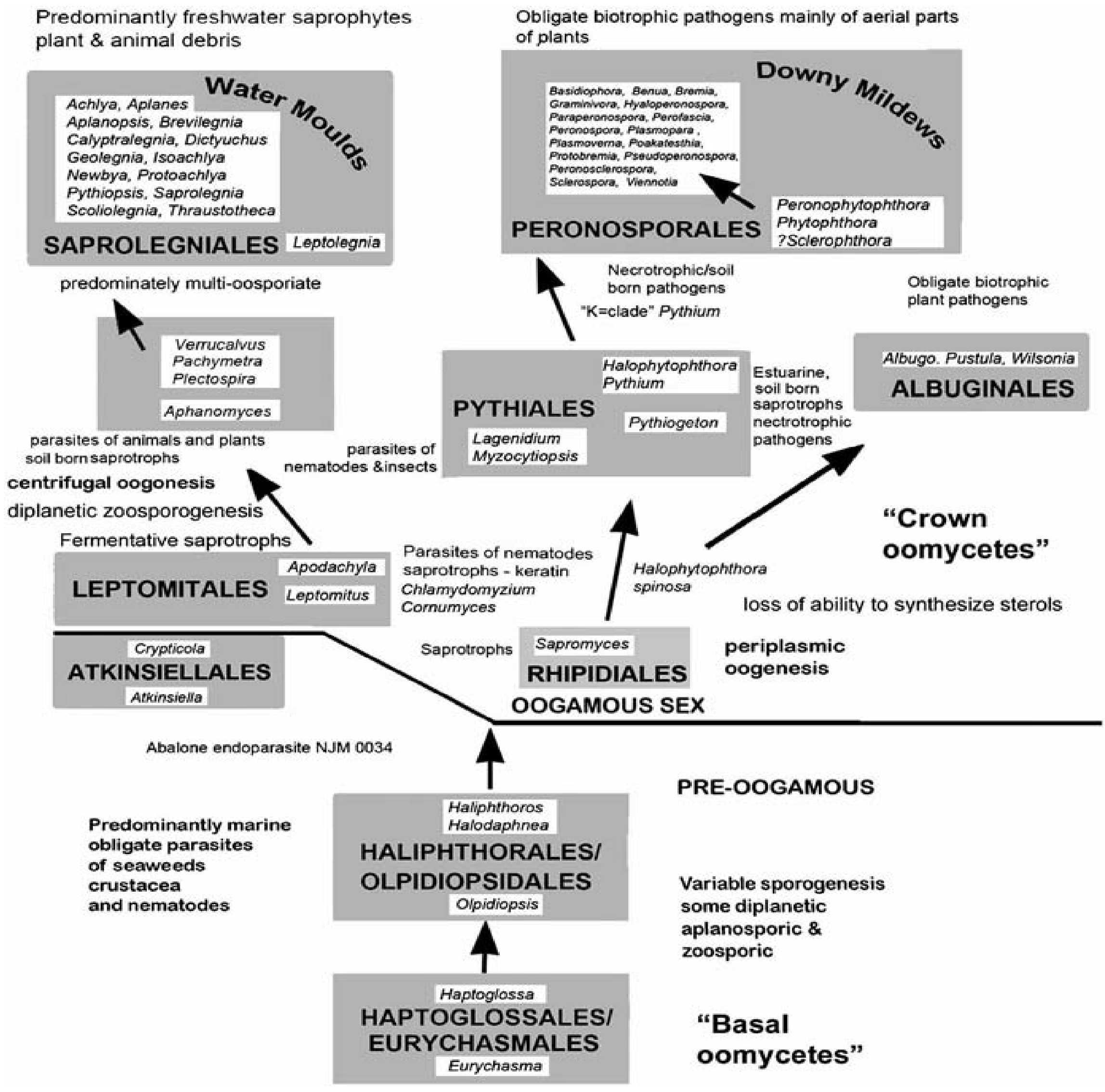
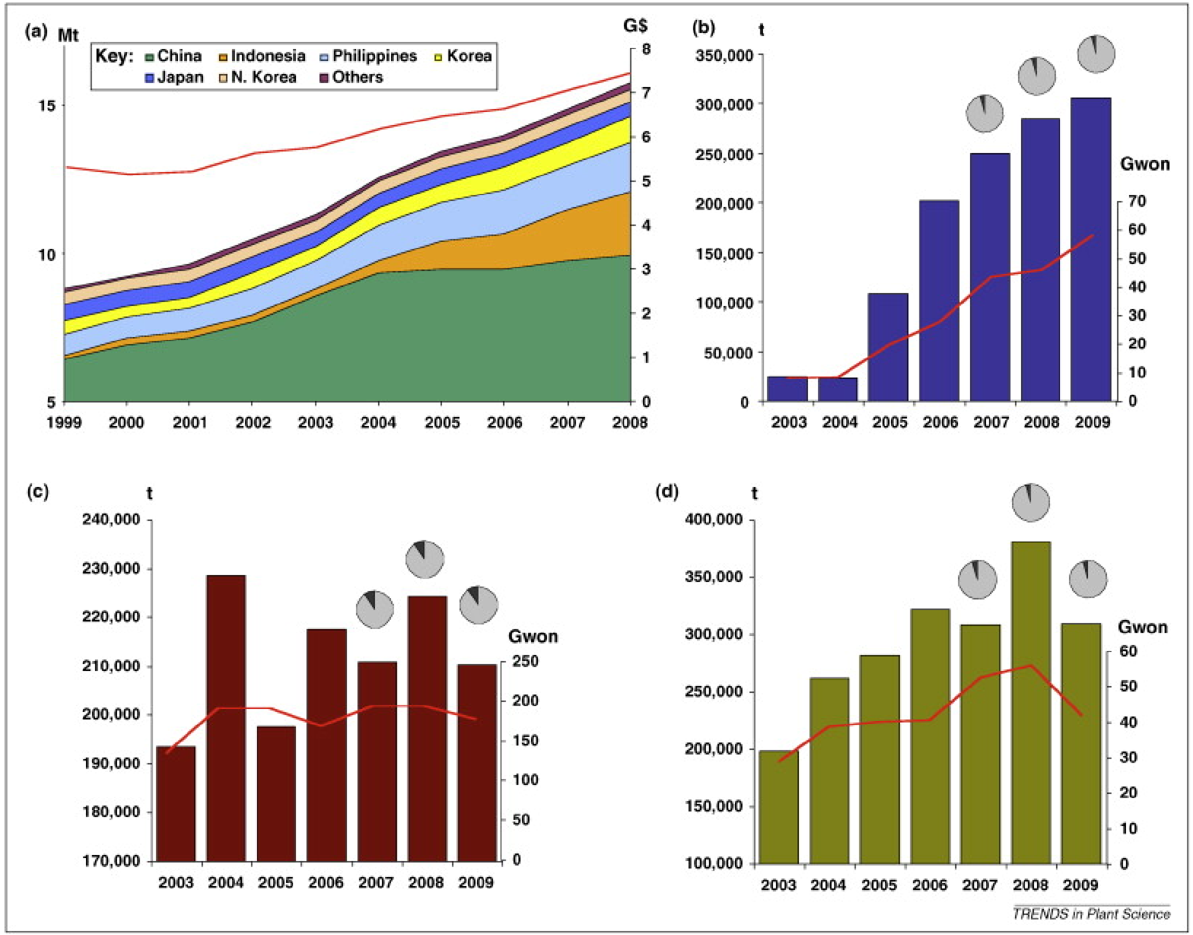


A schematic summary of the possible phylogenetic relationships between the main oomycete orders and families, based on current molecular data. Adapted from an original diagram by Beakes and Sekimoto (2009) as modified by Strullu-Derrien et al. (2010; with permission)



Beakes GW, Glocklin SL, Sekimoto S: The evolutionary phylogeny of the oomycete "fungi". Protoplasma 2012, 249(1):3-19.

Global seaweed aquaculture and losses to diseases in Korea. (a) Production of aquatic plants by country (in Mt of fresh weight). The red curve indicates the value of global production in billions US$. Source: Food and Agriculture Organisation of the United Nations, Fisheries and Aquaculture Department. Production of the kelps (b)Laminaria spp. and (d)Undaria pinnatifida, and (c) of laver Porphyra spp. in Korea over the last seven years, in tonnes of fresh weight. The corresponding value of each crop is indicated by the red curve in billions of wons (roughly equivalent to millions of US$). The pie charts indicate the proportion of the harvest lost to diseases each year since data collection began. Source: Statistical Year Book of Korean Fisheries 2009 – courtesy of the Ministry of Marine Affairs and Fisheries of Korea.



Claire M.M. Gachon, Télesphore Sime-Ngando, Martina Strittmatter, Aurélie Chambouvet, Gwang Hoon Kim

Algal diseases: spotlight on a black box

null, Volume 15, Issue 11, 2010, 633–640

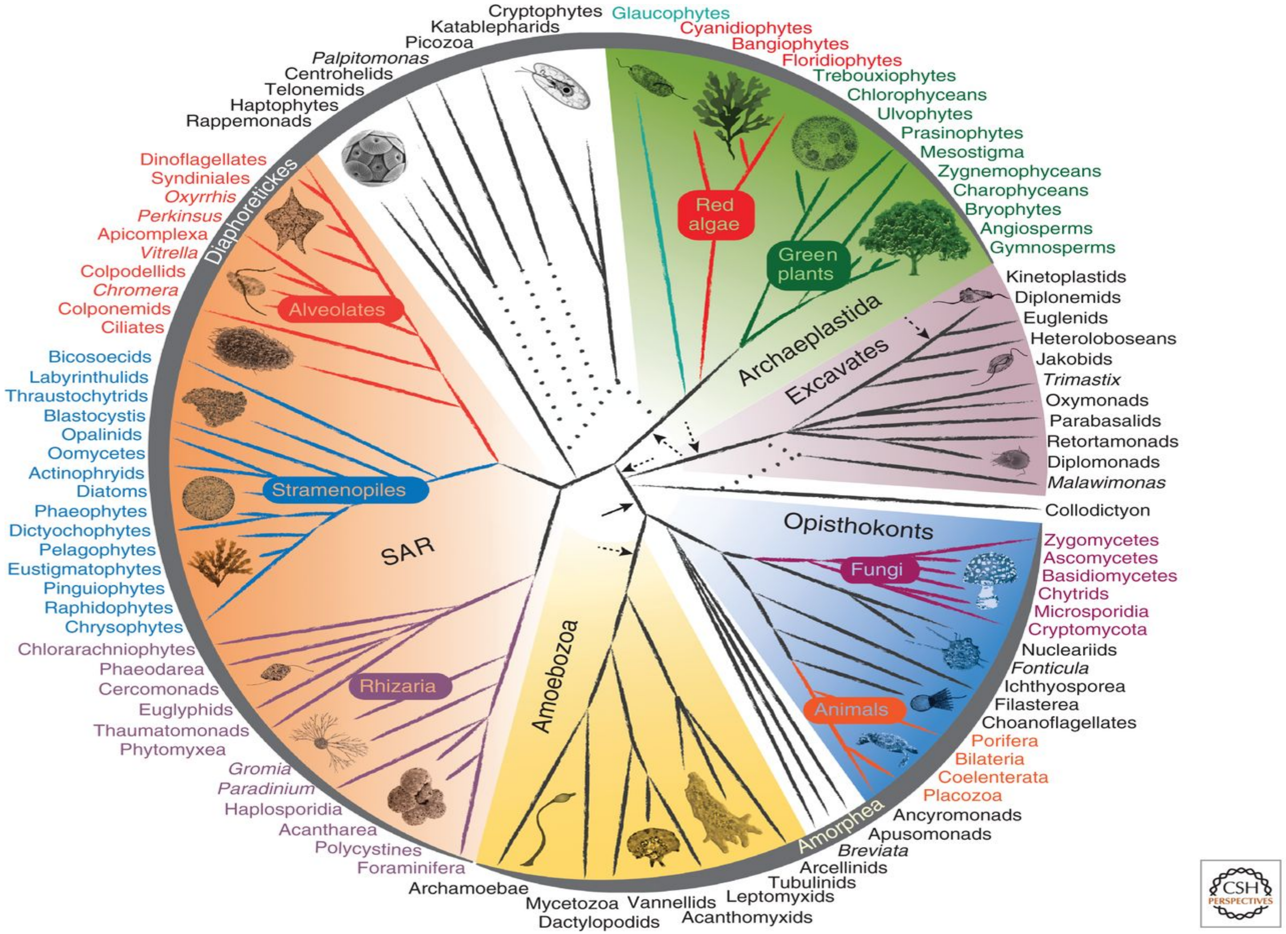
Table 1. Pathogenic species of oomycetes on marine algae

Pathogenic oomycetes on algae	Host algae (at the level of genus)	Host algae	Geographic distribution
Ectrogella perforans H.E. Petersen	*Fragilaria, Licmophora,Podocystis, Striatella, Synedra, Thalassionema*	Bacillariophyta	Europe, USA
Eurychasma dicksonii E.P. Wright	*Ectocarpus, Feldmannia, Punctaria, Pylaiella, Stictyosiphon, Striaria*	Phaeophyta	Europe, USA, Greenland
Eurychasmidium tumefaciens (Magnus) Sparrow	*Ceramium*	Rhodophyta	Europe, USA
Lagenisma coscinodisci Drebes	*Coscinodiscus*	Bacillariophyta	Canada, Europe
Olpidiopsis porphyrae Sekimoto, Yokoo, Y. Kawam. & D. Honda	*Bangia, Porphyra*	Rhodophyta	Japan
Petersenia lobata (H.E. Petersen) Sparrow	*Aglaothamnion, Callithamnion, Ceramium, Gymnothamnion, Herposiphonia, Polysiphonia, Pylaiella, Seirospora, Spermothamnion*	Phaeophyta, Rhodophyta	Europe, USA
Petersenia palmariae Van der Meer & Pueschel	*Palmariae*	Rhodophyta	Canada
Petersenia pollagaster (H.E. Petersen) Sparrow	*Chondrus*	Rhodophyta	Canada
Pontisma antithamnionis (Whittick & South) M.W. Dick	*Antithamnion*	Rhodophyta	Canada
Pontisma feldmannii (Aleem) M.W. Dick	*Falkenbergia, Trailliella*	Rhodophyta	Europe
Pontisma lagenidioides H.E. Petersen	*Ceramium, Chaetomorpha, Valoniopsis*	Chlorophyta, Rhodophyta	Europe, India, USA
Pythium marinum Sparrow	–	Rhodophyta	USA, Denmark
Pythium porphyrae Takah.{?} & M. Sasaki	*Porphyra*	hodophyta	China, Japan, USA
Sirolpidium andreei (Lagerh.) M.W. Dick	*Acrosiphonia, Ceramium, Ectocarpus, Spongomorpha*	Chlorophyta, Phaeophyta, Rhodophyta	Arctic, Greenland, Europe, USA
Sirolpidium bryopsidis (de Bruyne) H.E. Petersen	*Cladophora, Rhizoclonium*	Chlorophyta	India

Notes: –means host algae at the level of genus is unclear.

Li Wei et al.,Acta Oceanol. Sin., 2010, v.20, n 5, p 74-81

Global tree of eukaryotes from a consensus of phylogenetic evidence (in particular, phylogenomics), rare genomic signatures, and morphological characteristics.



Burki F. Cold Spring Harb Perspect Biol 2014;6:a016147

Оомицеты, паразитирующие на Rhodophyta

1.*Eurychasmidium* Sparrow, 1936
E.joycei на *Polysiphonia*, *Pterosyphonia*
E.sacculum на *Devaleraea* и *Palmaria*
E.tumefaciens – на видах *Ceramium*

2. *Olpidiopsis* Cornu, 1872
O.bostrychiae *на Bostrychia*
O.porphyrae на видах *Porphyra*, *Bangia*
O.pyropiae *на видах Pyropia*
Olpidiopsis sp. на *Heterosiphonia*, *Dasya*, *Dasysiphonia*, *Porphyra*, *Radicilingula.*

3. *Petersenia* Sparrow 1934
P.lobate на *Aglaothamnion*, *Callithamnion*, *Gymnothamnium*, *Ceramium*,, *Spermothamnion* , *Seirospora*, *Polysiphoni*a
P.polagaster на *Ceramium*, *Chondrus*
P.palmate на *Palmaria mollis*
Petersenia sp *на Ceramium*, *Acrochaetium*, *Polysiphoni*a

4.*Pontisma* H. E. Petersen, 1905
P.antithamnionis на *Antithamnion*
P.angeardii на *Radicilingua*
P.feldmanii на *Falkenbergia*, *Trailiella*
P.inhabile на *Polysiphonia*
P.lagenidioides на *Ceramium*
P.magnusii на *Ceramium*

5. *Pythium* Pringsh. 1858
P.marinum на *Ceramium*, *Porphyra*,
P. maritimum на *Ceramium*
P. porphyrae на *Porphyra*, *Bangia*, (красная гниль)

6. *Salilagenidium* M.W. Dick 2001
S. callinectes на *Ceramium*

7. *Sirolpidium* H. E. Petersen, 1905
S.andreei на *Ceramium*

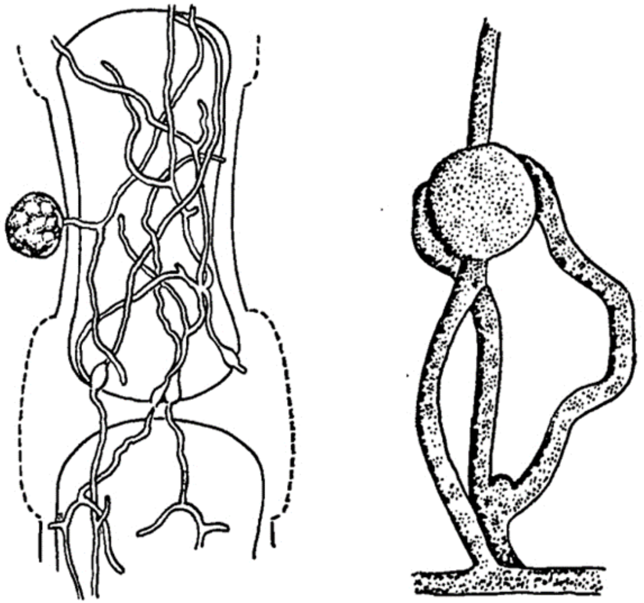
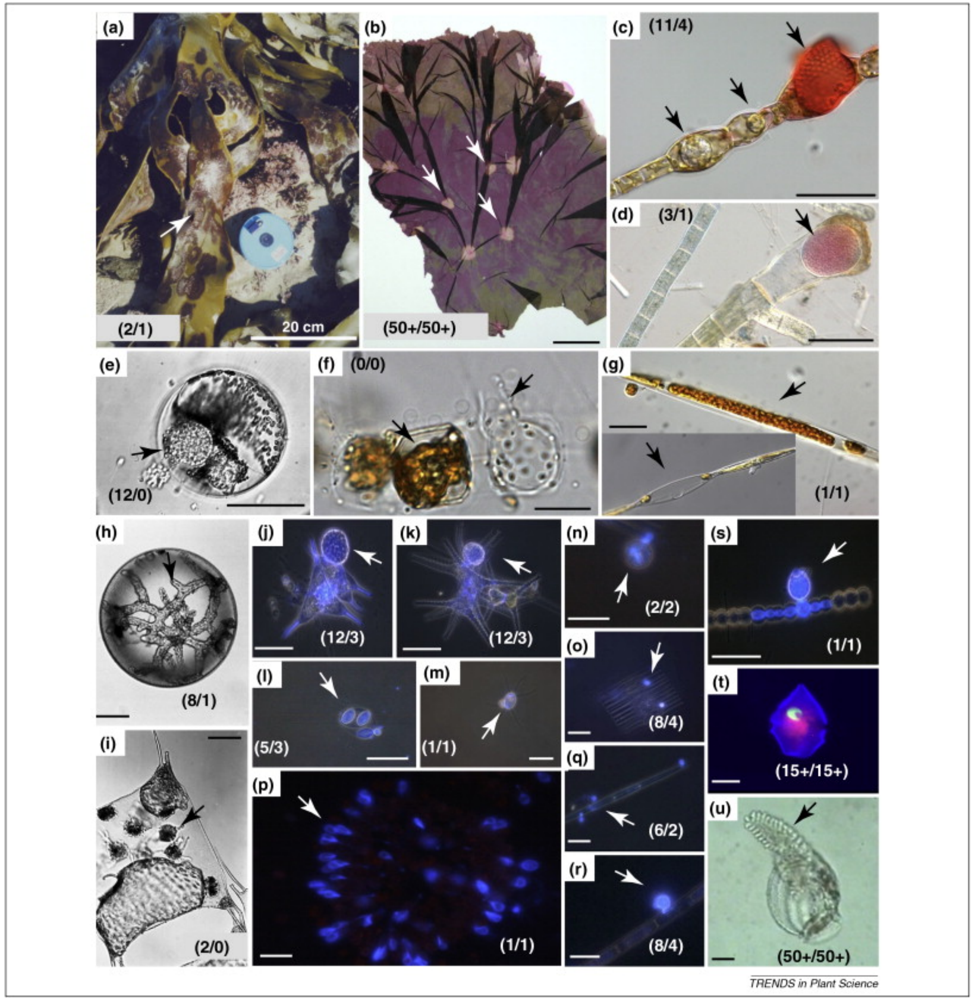


Рис. 24 (слева). Поражение красной водоросли церамиум питиумом (Pythium maritimum):
1 — мицелий внутри клеток водоросли; 2 — освобождение зооспор.

Рис. 25 (справа). Оогонии и антеридии питиума (Pythium fabae).



Eukaryotic pathogens and parasites of macro- and micro-algae are diverse, yet little studied. The numbers in brackets refer to the total number of references available in the peer-reviewed literature / and those published since 1980, illustrating the paucity of data available for most taxa. (a–d) Macroalgae: (a) macroscopic symptoms (arrow) caused by the obligate brown algal parasite Herpodiscus durvillaeae on blades of Durvillaea antartica (Reproduced with permission from [37]); (b) symptoms of red rot (Pythium sp.) on cultivated nori (Porphyra sp., courtesy of Dr Misook Hwang); (c) Congo Red staining of different stages of the oomycete Eurychasma dicksonii infecting the genome model alga Ectocarpus siliculosus (arrows); and (d) the elusive hyphochtytrid Anisolpidium sphacelarum infecting the apical cells of the filamentous brown alga Sphacelaria sp.(e–u) Microalgae: (e, f) the oomycetes Ectrogella perforans(e) and an undescribed Aphanomycopsis sp., (f) infecting diatoms closely related to the genome model Thalassiosira pseudonana; (g) an unreported Ectrogella (?) sp. in the toxic-bloom forming diatom Pseudo-Nitzschia seriata; (h) the oomycete Lagenisma coscinodisci in the bloom-forming diatom Coscinodiscus sp.; (i)Amoeba biddulphiae infecting the diatom Odontella aurita; (j–s) chytrid infections of freshwater chlorophytes (j–m), diatoms (n, o, q, r), and cyanobacteria (p, s), stained blue with calcofluor (pictures courtesy of S. Rasconi) (j) in Staurastrum incus, (k) in Staurastrum paradoxum, (l) in Oocystis lacustris, (m) in Chodatella ciliata,(n) in Cyclotella bodanica, (o) in Fragilaria crotonensis, (p) in Gomphosphaeria sp., (q) in Synedra acuus, (r) in Melosira italica.(s)Rhizosiphon crassum within the filamentous cyanobacterium Anabaena flos-aquae. (t) Early stage of the parasite Amoebophrya ceratii infecting the cosmopolitan photosynthetic dinoflagellate Scrippsiella sp. The dinoflagellate's theca was stained blue with calcofluor, the nucleus stained in red using propidium iodide, and the parasite's cytoplasm revealed by TSA-FISH technique in green. (u) Late mature stage of parasite Amoebophrya sp. infecting the photosynthetic dinoflagellate Dinophysis norvegica. The parasite disrupts the cell wall, and evaginates to form a worm-like structure. Within few hours, this structure will individualised into 60–400 new free-living infective cells (reproduced with permission from [100]). A video of the parasite leaving its host is available at http://www.bom.hik.se/plankton/. Figure 1e, h and i reproduced from the open source Plankton*Net Data Provider based at the Alfred Wegener Institute for Polar and Marine Research (http://planktonnet.awi.de/). Scale bars: b: 1 cm; c–e, h and i: 50 μm; f, g, o–r and t: 10 μm; j–n, s and u: 20 μm

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Algal diseases: spotlight on a black box

null, Volume 15, Issue 11, 2010, 633–640

Оомицеты, паразитирующие на Chlorophyta и Charophyta

1. ***Aphanomyces*** de Bary, 1860
A.apophysii на *Spirogyra*
A.phycophilis на *Spirogyra, Mogeotia, Zygnema, Nitella*
A,sparrowii на *Nitella flexilis*
2. Aphanomycopsis Scherff. 1925
A.desmidiella на Desmidiales
3. Ectrogella Zopf, 1884
E. marina на *Chlorodendron subsalsum*
4. Eurychasma Magnus, 1905
Eurychasma **sp**. на *Bryopsis*
5. Lagenidium Schenk, 1857
***Lagenidium* sp.** *на Spirogyra,* Charales, *Basicladia*

6. Myzocytium Schenk 1858
M.megastomum на *Spirogyra, Mougeotia, Zygnema,* некоторых десмидиевых, *Cladophora, Rhizoclonium*
M.netrii на *Netrium Spirogyra, Mougeotia, Zygnema,* некоторых десмидиевых
M.proliferum на *Spirogyra, Mougeotia, Zygnema,* некоторых десмидиевых, *Cladophora, Rhizoclonium*
M.rabenhorstii на *Spirogyra, Mougeotia, Zygnema,* некоторых десмидиевых, *Oedogonium*
7. Olpidiopsis Cornu, 1872
O.oedogoniarum *на Oedogonium*
O.schenkiana на *Spirogyra*
***Olpidiopsis* sp.** на Zygnematales

8.Pontisma *H. E. Petersen, 1905*
P.lagenidioides на *Chaetomorpha, Valoniopsis*

9. Phytium Pringsh. 1858
P.angustatum на ***Spirogyra***
P. apleroticum на *Spirogyra, Sphaeroplea*
P.gracile на *Spirogyra, Ulothrix*
P. mamillatum на *Cladophora sp.*
P. tenue на *Spirogyra*
10. Pseudolpidium A.Fischer, 1891
P.deformans *на Draparnaldia*

11. Saprolegnia Nees, 1823
S.asterophora *на Spirogyra*

12 Sirolpidium H. E. Petersen
S.andreei на *Spongomorpha, Acrosiphonia*
S.bryopsidis на *Bryopsis, Cladophora*
S. marinum на *Tetraselmis*
S. salinum на *Cladophora*

13. Syzygangia M.V.Dick, 1997
S.marchaliana на *Oedogonium*
S.oedogonii на *Oedogonium*

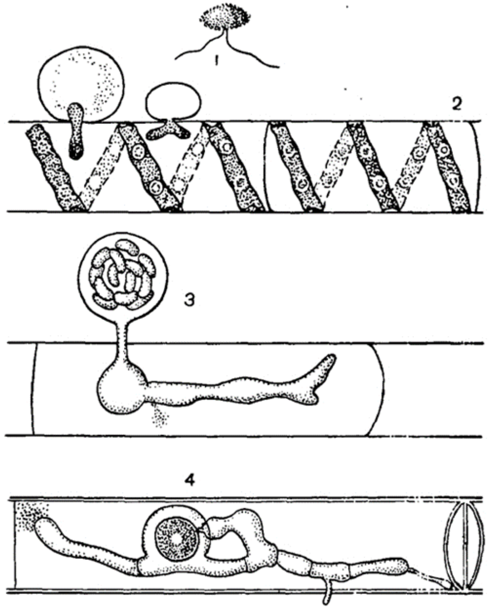


Рис. 21. Лагенидиум (Lagenidium):
1 — зооспора; 2 — проникновение паразита в клетку; 3 — образование и выход зооспор; 4 — половой процесс.

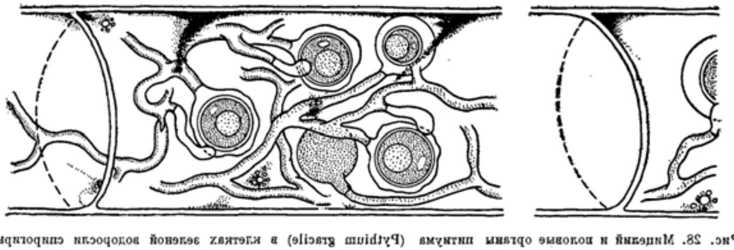
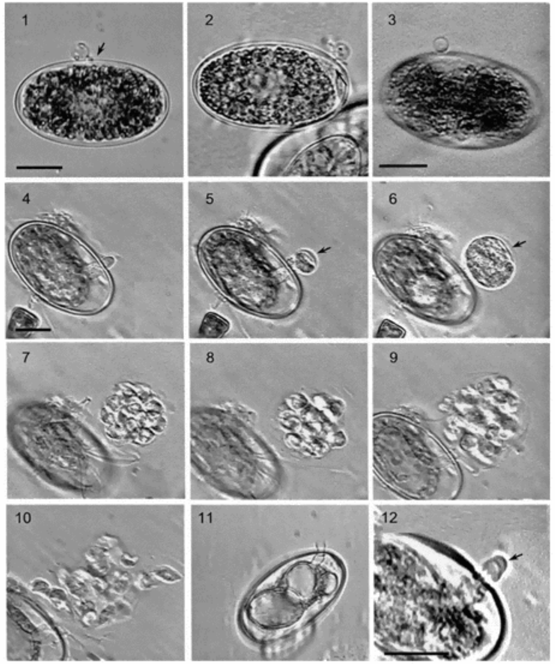


Рис. 28. Мицелий и половые органы питиума (Pythium gracile) в клетках зеленой водоросли спирогиры.

Glaucocystophyta

- ***Lagenidium*** Schenk, 1857

на *Glaucocystis nostochinearum*



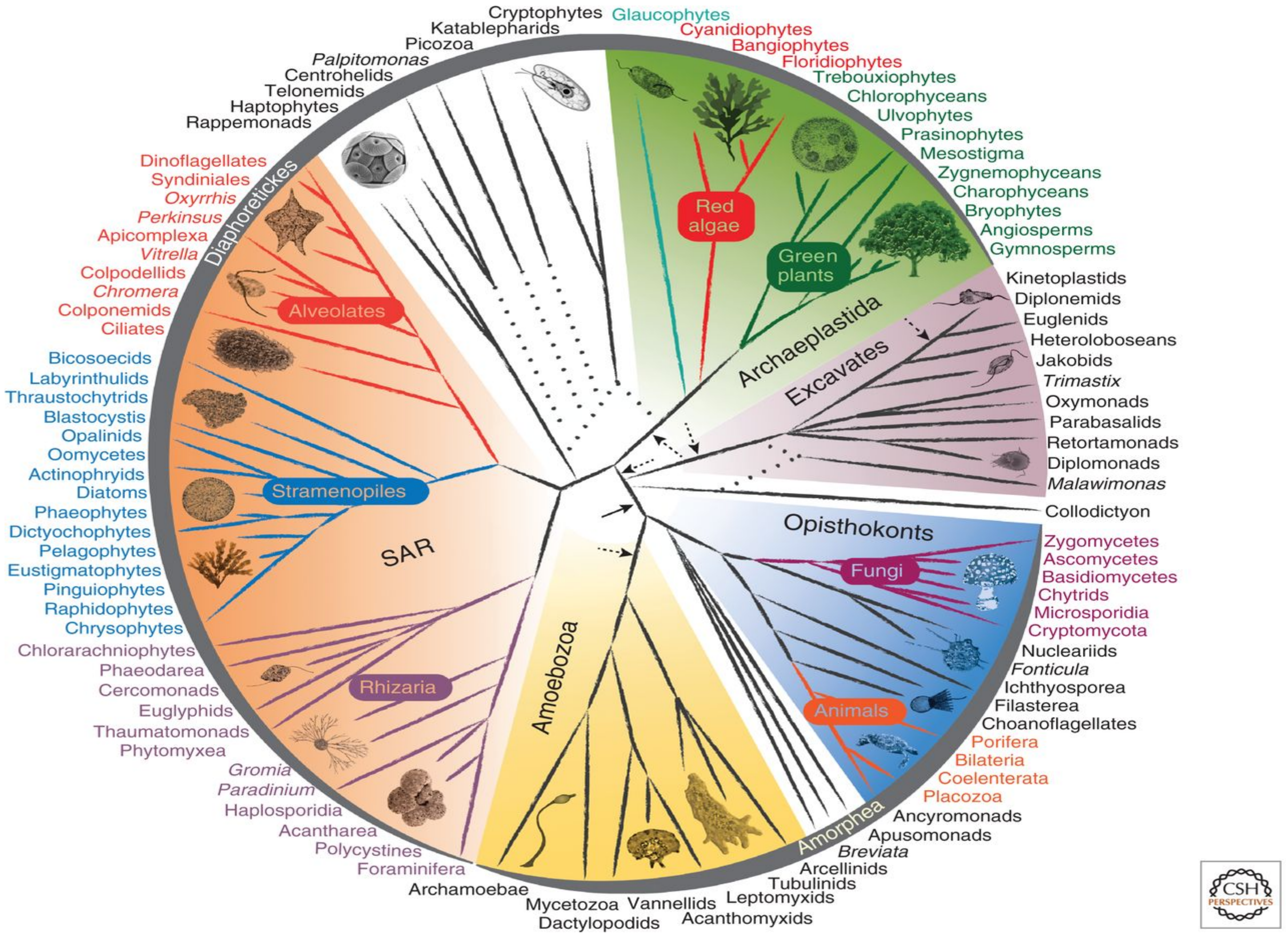
Figures 1–3. Early infection stages of *Lagenidium* sp. or *Pythiella* sp. **Figure 1.** Encysted zoospore with infection tube (arrow). **Figures 2, 3.** Freshly infected cell (host cytoplasm has partly been retracted or digested, arrow).
Figures 4–12. Lagenidium sp. **Figures 4–10.** Time series of zoospore development. Discharge tube with narrow, crescent-shaped zone of hyaline and very refractive material at the tip (t=0). **Figure 5.** Beginning of ejection of protoplasm and formation of a vesicle (arrow) (t=3 min). **Figure 6.** Expansion of vesicle (arrow) (t=3 min). **Figure 7.** Begin of cleavage (t=16 min). **Figures 8, 9.** Initially globular zoospores exhibit increasingly individual movements, short flagella which gradually increase in length can be seen at the periphery (t=22 and 30 min). **Figure 10.** After rupture of the vesicle the kidney-shaped swarmers escape (t=36 min). **Figure 11.** Empty sporangium. **Figure 12.** Hyaline cap on tip of another discharge tube. *Figures 1–2, 3, 4–11, 12* scale bar=10 μm.

alike. Although *Pythiella* zoospores apparently only attach to *Glaucocystis* cells already infested by *Lagenidium* it is at first impossible to discriminate between the two parasites since young *Lagenidium* thalli are generally not visible. Figure 33 demonstrates an early infection stage that cannot be assigned to either parasite.

Zoospores swimming in the vicinity of *Glaucocystis* need 2–3 min until they attach to a host cell. They round up (another 1–2 min) and encyst. Infecting cysts are globular and measure 4 μm in diameter (Figs 1–3). After about 15 min an infection tube (diameter 1 μm) develops penetrates the *Glaucocystis* cell wall about 6 min later. If an autospore mother cell

Hydrobiologia 481: 165–171, 2002

Global tree of eukaryotes from a consensus of phylogenetic evidence (in particular, phylogenomics), rare genomic signatures, and morphological characteristics.



Burki F. Cold Spring Harb Perspect Biol 2014;6:a016147

Оомицеты, паразитирующие на Fucophyceae

1.Eurychasma Magnus, 1905

E dicksonii на *Acinetospora*, *Ectocarpus*, *Pylaiella*, *Striaria*, *Hincksia*, *Stictyosiphon*, *Feldmannia*, *Punctaria*. Облигатный паразит на Ectocarpales

2. Petersenia Sparrow, 1934

P.lobate на *Pylaiella*

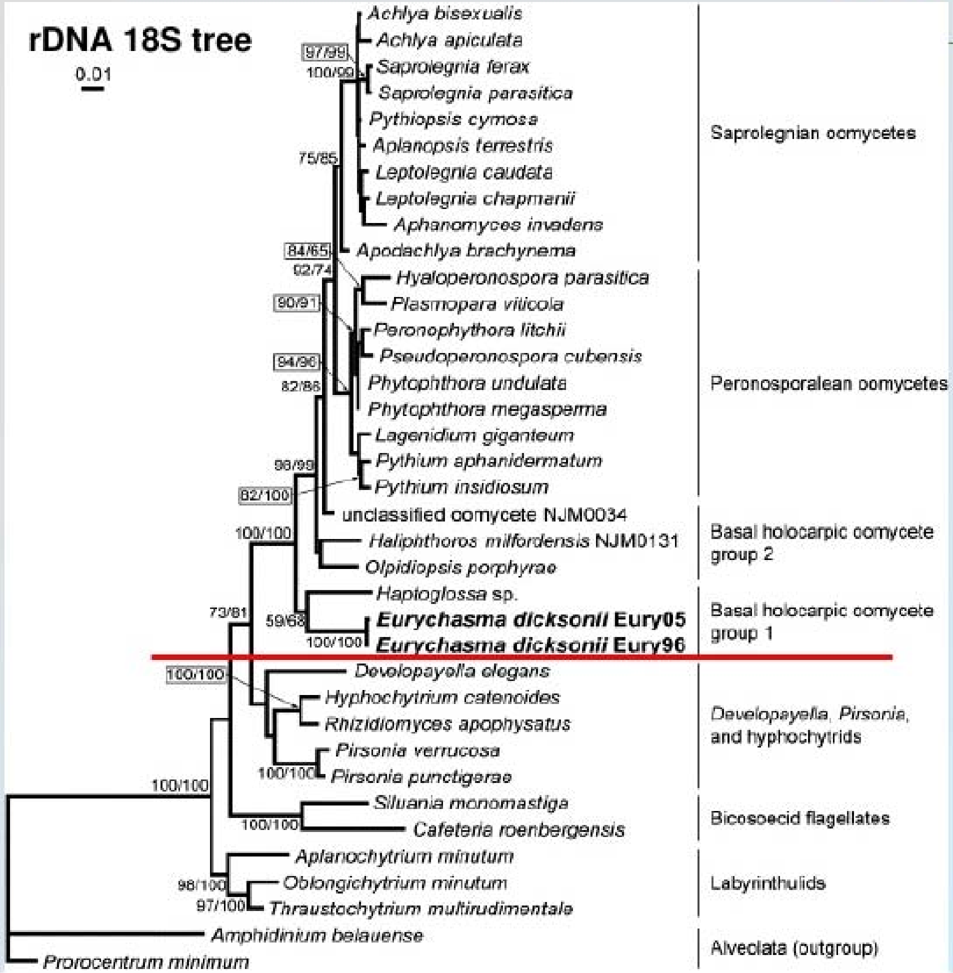
3. Salilagenidium M.W. Dick, 2001

S.callinectes на *Chordaria*, *Ectocarpus*

4. *Sirolpidium* H. E. Petersen, 1905

S.ectocarpii на *Ectocarpus*

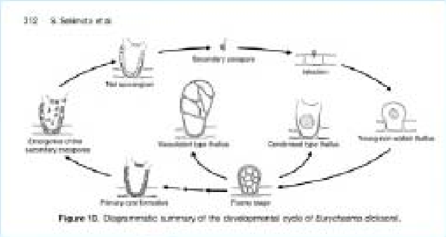
Basal oomycetes



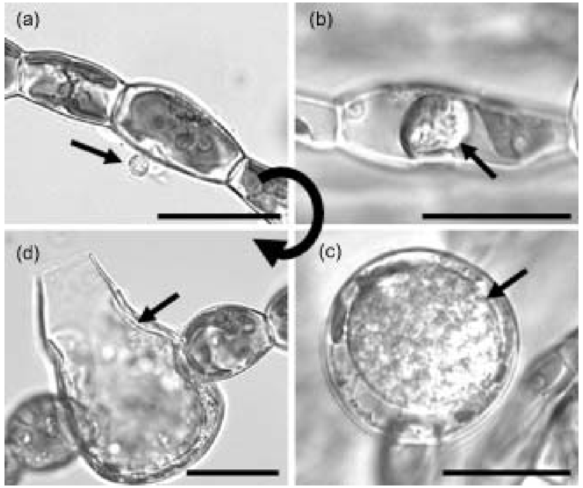
The Development, Ultrastructural Cytology, and Molecular Phylogeny of the Basal Oomycete *Eurychasma dicksonii* …

Satoshi Sekimoto, Gordon W. Beakes, Claire M.M. Gachon, Dieter G. Müller, Frithjof C. Küpper, Daiske Honda *Protist*, 2008

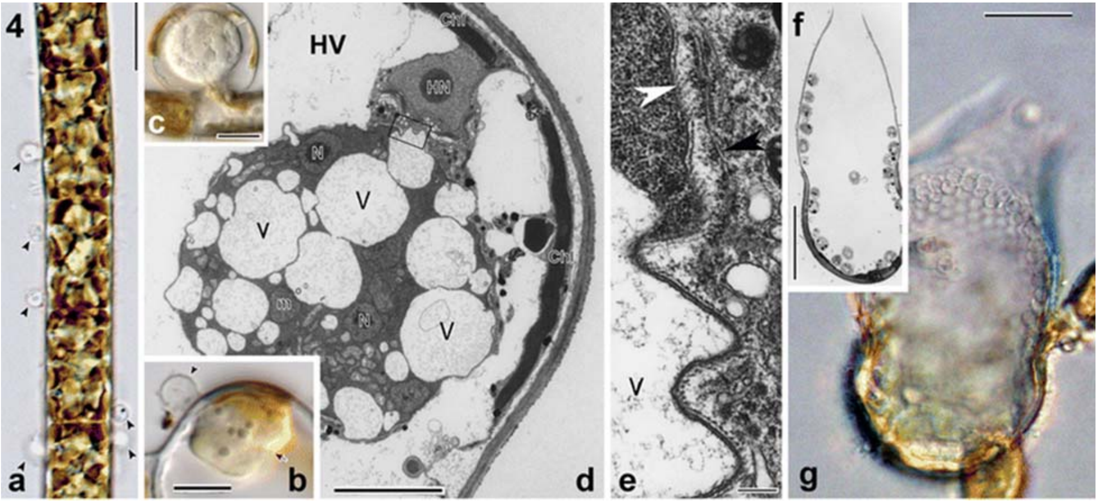
Parasites of plants across oomycete lineages



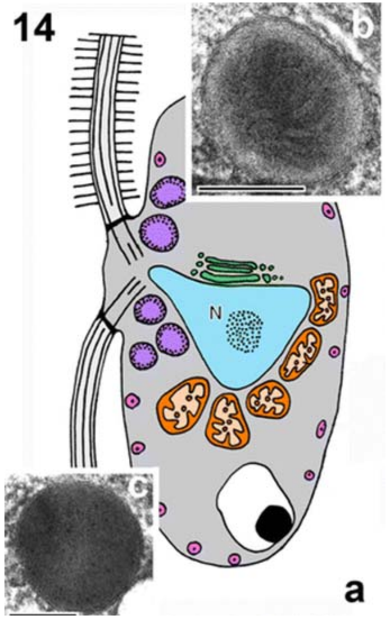
living technology



Life cycle of the intracellular oomycetes pathogen Eurychasma dicksonii in its brown algal host Ectocarpus siliculosus. A spore (arrow) attaches to the algal surface and injects its content into the host (a). Within the algal cytoplasm, the Eu. dicksonii thallus (arrow) develops which at the early stage of infection is unwalled (b). At a later stage, the pathogen thallus (arrow) has a cell wall and causes hypertrophic expansion of the algal host cell (c). At the final stage, the complete thallus differentiates into a sporangium from which motile zoospores (arrow) are produced completing the life cycle of the pathogen (d). Scale bars equal to 25 µm.



Light (a–c,g) and electron (d–f) micrographs illustrating the morphology and ultrastructure of the basal oomycete Eurychasma dicksonii infecting filaments of the brown seaweed Ectocarpus siliculosus. a Secondary cysts (arrowheads) attaching to surface of host filament. Bar 10 µm. b–c Two unwalled 'plasmodial' thalli within rapidly swelling host cells. An empty cyst can still be seen adjacent (arrowhead) to the first thallus which contains a number of dark nuclei. Bars 5 µm. d Unwalled thallus, showing the many nuclei (N), mitochondria (m) and vacuoles (V). The host cell is already highly vacuolate (HV). Note also the close associated host nucleus (HN) and plastid (chl). Bar 5 µm. e High power detail of host parasite inteface, showing both parasite (white arrowhead) and host (black arrowhead) membranes. Bar 100 nm. f LS section through a mature thallus, showing peripheral primary cysts (some of which have released zoospores) and the broad exit papillum. Bar 20 µm. g Comparable living thallus, showing peripheral network of empty primary cysts, which is such a distinctive feature of this species. Not still intact basal plastid lining host cell. Bar 20 µm. Adapted from Sekimoto (2008)



Variations in mature zoospore structure in oomycetes Eurychasma dicksonii zoospores. a Schematic median longitudinal section, showing perinuclear mitochondria (orange), ventrally clustered bodies clustered close to kinetosomes and the smaller more generally distributed EV (dark pink). b Detail of one of larger ventral vesicles, showing uniformly granular periphery and darker core, permeated by fibrils. Bar 100 nm. c One of smaller peripheral EV, with uniformly dense contents. Bar = 100 nm. All from Sekimoto (2008)

Beakes GW, Glocklin SL, Sekimoto S: The evolutionary phylogeny of the oomycete "fungi".
Protoplasma 2012, 249(1):3-19.

Оомицеты, паразитирующие на Bacillariophyceae

***1. Aphanomycopsis S**cherff. 1925*
***A.bacillariacearum на** Pinnullaria viridis, Epitemia turgid, Cymbella gastroides, Nitzschia sigmoidea*
2. Ectrogella Zopf, 1884
***E.bacillariacearum** на Eunotia, Synedra, Pinnularia, Meridion circulare,*
E.eurychasmoides на *Licmophora*
E.lauderia на центрических диатомеях
E.licmophorae на *Licmophora*
***E.monostroma** Scherffel – Synedra ulna, Synedra sp.*
E.perforans на *Fragilaria, Licmophora, Podocystis, Striatella, Synedra, Tabularia, Thalassionema.*

2. *Lagenisma* Drebes, 1968
Lagenisma coscinodisci на *Coiscinodiscus*

3. Lagenidium Schenk, 1857
На пресноводных диатомеях

The oomycete Lagenisma coscinodisci infecting a Coscinodiscus cell

http://planktonnet.awi.de/index.php?contenttype=image_details&itemid=62971#content

Оомицеты, паразиты эвгленовых

Pseudosphaerita euglenae
на *Euglena acus, E. polymorpha, E.viridis, E. caudata, E.pisciformis, E.pseudoviridis*

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