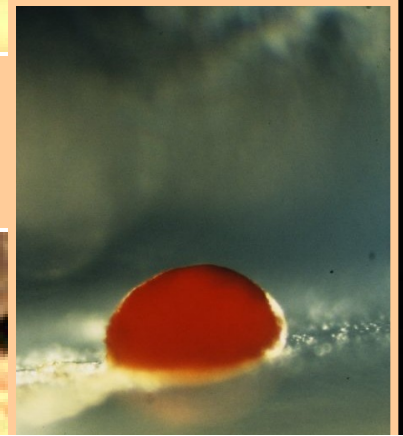


Myxobakterie

Tvoří bioaktivní sekundární metabolity



- G- tyčinky, půdní bakterie, degradace MML
- řád *Myxococcales*, Deltaproteobacteria
- klouzavý pohyb (gliding motility)
- komplexní růstový cyklus s tvorbou plodnic a klidových stádií – myxospor
- nejprostudovanější druhy

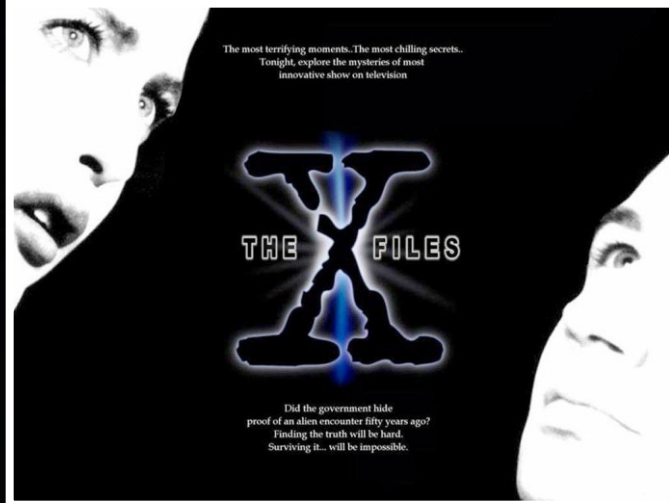
Bdellovibrio
Desulfovibrio
Desulfonema



Myxococcus xanthus a *Stigmatella aurantiaca*



- **Intenzivní studium tajemství
mezibuněčné komunikace a následné
diferenciace**

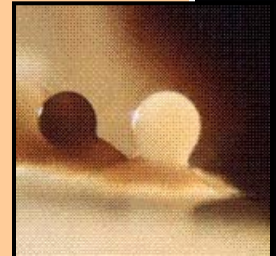


gliding motility

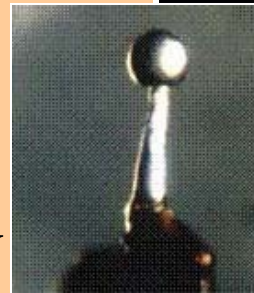
- Následkem klouzavého pohybu roste v koloniích podobných **tenkých filmům**
- Hladovění: **kooperativní morfogeneze**
 - shluk veg.buněk tvoří **plodnice**
 - plodnice – 50-500 μm , viditelné
- Zráním plodnice: diferenciací vedoucí k tvorbě **myxospor z veg. buněk**
- Myxospory – krátké refraktilní buňky, s obsahem tuku, rezistentní k vysychání, UV
přežívání prokázáno 10 let



*Stigmatella
aurantiaca*



*Myxococcus
fulvus*



*Myxococcus
stipitatus*

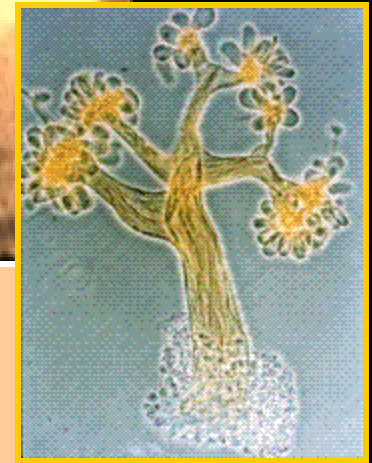
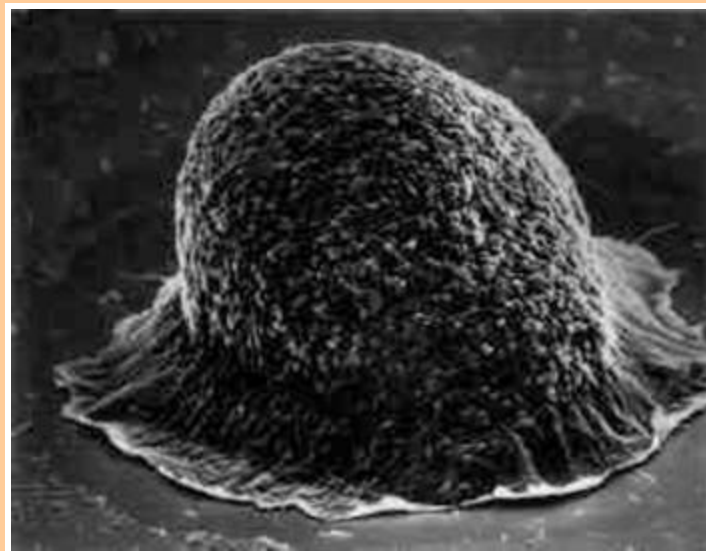
Růst a vývoj

- Souborem interakcí mezi buňkami
- "social bacteria"
- Genom: 9 454 – 9 870 kbp

Mycoplasma
577 to 590 kbp

*Chondromyces
crocatus*

Studium
genetiky
diferenciace
prokaryot,
fágů,
myxofágů



Výskyt

**Mikropredátoři, saprofágové.
Rozkládají buněčný materiál kvasinek,
Bakterií, celulózu.
Tlející kůra, listí, exkrementy býložravců.**

Substrate	Myxobacterial species typically found ^b
Soil	<i>Nannocystis exedens</i> , ⁵ <i>Sorangium cellulosum</i> , ⁴ <i>Archangium serpens</i> , ⁴ <i>Corallococcus coralloides</i> , ⁴ <i>Polyangium</i> spp., ³ <i>Cystobacter</i> spp., ³ <i>Melittangium</i> spp., ³ <i>Myxococcus fulvus</i> , ² <i>Mx. virescens</i> , ² and <i>Mx. stipitatus</i> ²
Dung of herbivores	<i>Myxococcus fulvus</i> , ⁵ <i>Corallococcus coralloides</i> , ⁵ <i>Mx. virescens</i> , ⁴ <i>Cystobacter fuscus</i> , ⁴ <i>Cb. ferrugineus</i> , ⁴ <i>Archangium serpens</i> , ⁴ <i>Nannocystis exedens</i> , ³ <i>Cb. violaceus</i> , ³ <i>Polyangium</i> spp., ³ <i>Stigmatella erecta</i> , ² <i>Mx. xanthus</i> , ² <i>Melittangium</i> spp., ² and <i>Cb. velatus</i> ¹
Bark and rotting wood	<i>Stigmatella aurantiaca</i> , ⁴ <i>Chondromyces apiculatus</i> , ⁴ <i>Sorangium cellulosum</i> , ⁴ <i>Corallococcus coralloides</i> , ⁴ <i>Myxococcus fulvus</i> , ³ <i>Cm. pediculatus</i> , ² and <i>Haploangium</i> spp. ²

^a The frequency of myxobacteria on a specific substrate may vary substantially in different environments. Furthermore, some species may be underestimated from a particular source because the isolation technique usually applied may not result in the isolation of a particular organism.

^b Frequency of the encountered species: ⁵, ubiquitous; ⁴, very frequent; ³, moderately frequent; ², relatively rare; and ¹, rare.

Taxonomie

Order: Myxococcales

Families and genera:

Myxococcaceae

Myxococcus

Corallococcus (formerly *Chondrococcus*)²

Pyxicoccus nov. gen.^b

Cystobacteraceae

Archangium

Cystobacter

Melittangium

Stigmatella

Hyalangium nov. gen.^b

Families and genera:

Polyangiaceae

Sorangium

Polyangium

Haploangium

Chondromyces

Byssophaga nov. gen.^b

Jahnia nov. gen.^b

Families and genera

Nannocystaceae

Nannocystis

Kofleriaceae

Kofleria nov. gen.^b



Haliangium nov. gen.^b

Nově: *Haliangiaceae*
Kofleriaceae

^a Three recently described and unusual genera, *Anaeromyxobacter* (<citeref rid="sanford2002">Sanford et al., 2002</citeref>), *Enhygromyxa* (<citeref rid="iizuka2003b">Iizuka et al. 2003b</citeref>), and *Plestiocystis* (<citeref rid="iizuka2003a">Iizuka et al., 2003a</citeref>), are missing from Table 3 and the illustrated key (Fig. 15) because they have not yet been characterized thoroughly enough to accurately place them in this taxonomic scheme.

^b These novel genera are validly described in <citeref rid="reichenbach2004">Reichenbach (2004)</citeref>.

Morfologie myxobakterií

- **Vegetativní buňky** – 0,5–1 μm x 3-8 μm
 - štíhlé se špičatými konci (*Cystobacterinae*) 
 - robustní s kulatými konci (*Soranginae*) 
- **Plodnice** – 50 – 500 μm
 - často pestře zbarvené – karotenoidní pigmenty
 - různého tvaru a složitosti
- **Spory** – zkrácené ztlustělé buňky



Cystobacterinae

Soranginae

*Myxospory
Cystobacter*

*Myxospory
Myxococcus*

Fig. 1. Various types of myxobacterial cells. (a to d) Vegetative cells. (a and b) The Cystobacterinae type: (a) *Cystobacter ferrugineus*, cells from a liquid culture. (b) *Stigmatella aurantiaca*, cells in situ on agar surface in a chamber culture. (c and d) The Soranginae type. (c) *Chondromyces crocatus* in a chamber culture. (d) *Sorangium compositum* in a chamber culture. (e to h) Myxospores of members of the Cystobacterinae. (e) Myxospores of *Cystobacter ferrugineus*, from a crushed, degenerated, *Archangium*-like, fruiting body; under oil immersion, the high optical refractility of the myxospores is not apparent. (f) Myxospores of *Cystobacter velatus* from a crushed fruiting body sporangiole; oil immersion. (g) Experimentally induced myxospores of *Stigmatella aurantiaca* on the agar surface in a chamber culture; under the 40 \times dry objective, the high optical refractility of the myxospores becomes very conspicuous. (h) Myxospores from a *Myxococcus xanthus* fruiting body; the optical refractility of these spherical myxospores is so high that it is recognizable even under oil immersion. All photographs are in phase contrast. Bars = 10 μ m.

Životní cyklus myxobakterií

- **Vegetativní buňky** – sliz, klouzavý pohyb, binární dělení, tvorba shluků a koordinovaný pohyb
 - pohyb za novým zdrojem živin – slizové cestičky
 - „They look like schmoos that are pulled along by their heads. How they are able to glide is a mystery.“ (Miyata, M., Ryu, W.S., and Berg, H.C. (2002): Force and velocity of *Mycoplasma mobile* gliding." *J. Bacteriol.* 184, 1827-1831)
- **Tvorba plodnic** – shlukování a diferenciacce
 - Impuls: vyčerpání živin, laboratoř: 0,5M glycerol
- **Tvorba myxospor** z někt. veg. buněk uvnitř plodnic
 - indukce – chemicky
 - primárně – v plodnicích – uzavřeny ve sporangiolech, zkrácené ztluštěné buňky

TVORBA PLODNIC MYXOBAKTERIÍ

Plodnice: několik mm.

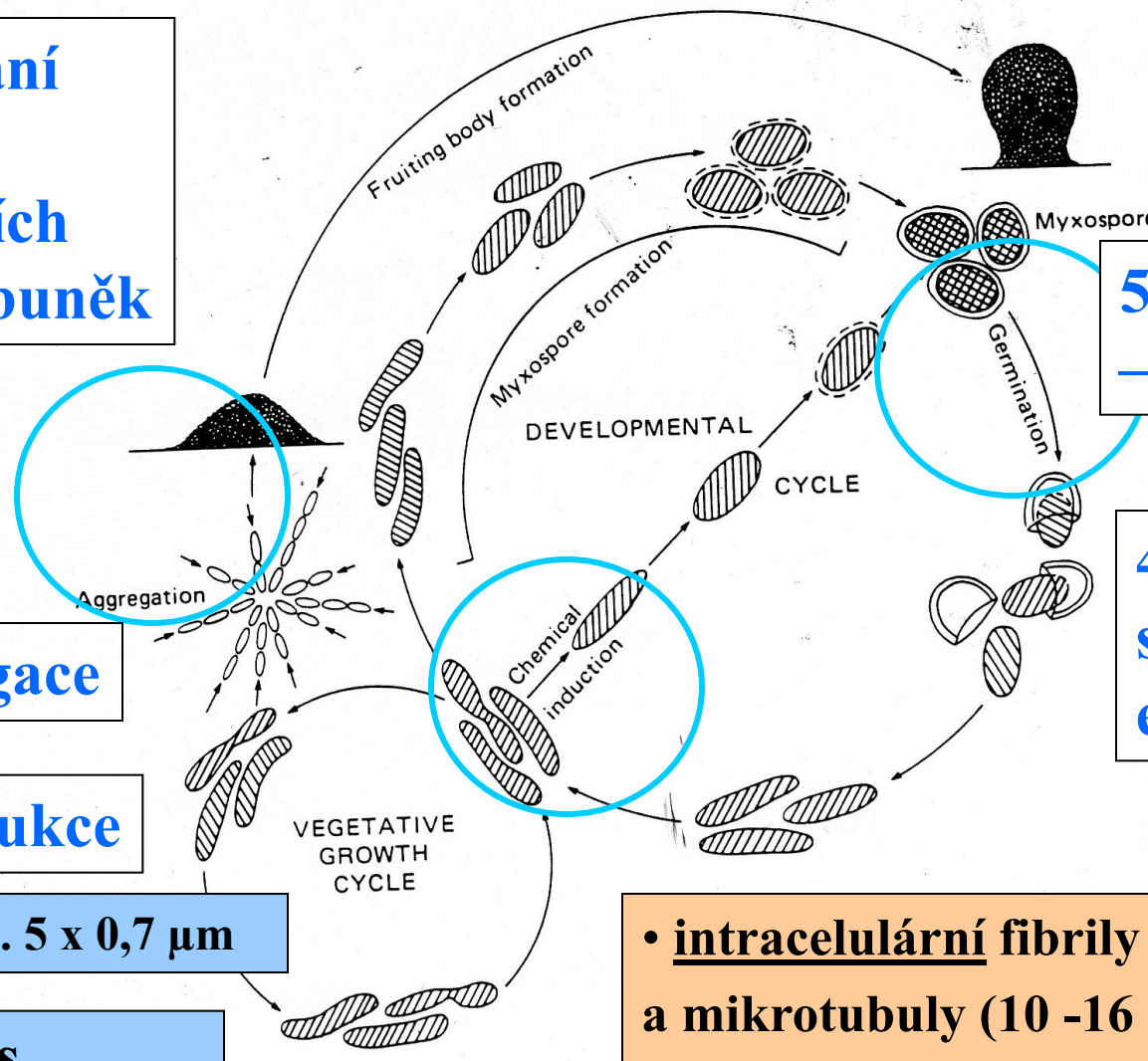
3. vylučování
molekul
umožňujících
propojení buněk

2. agregace

1. indukce

veg.b. 5 x 0,7 μm

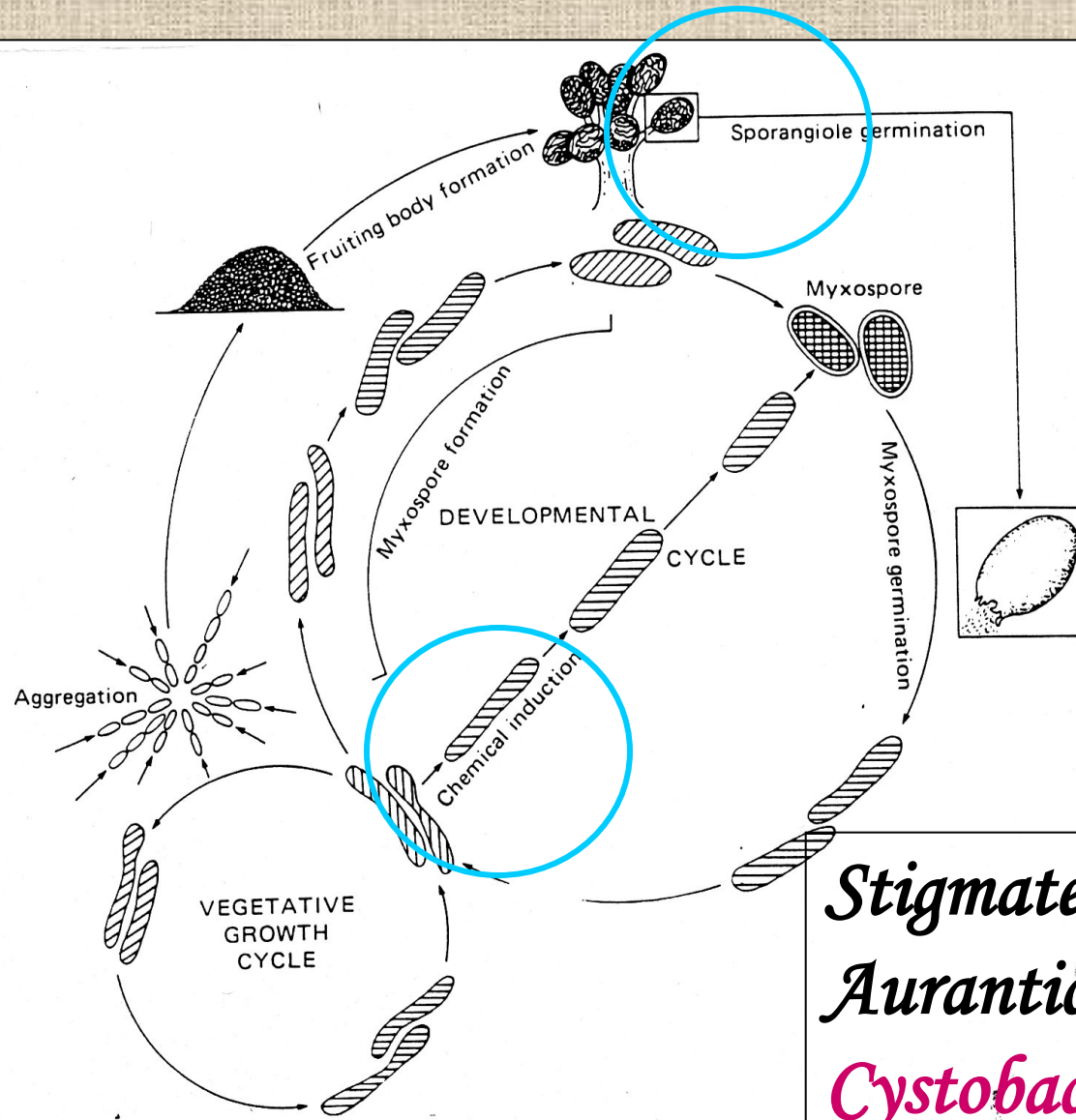
Život.cyklus
Myxococcus xanthus
Myxococcaceae



5. maturace
– myxospory

4. speciální
strukturní
elementy

- intracelulární fibrily (4 – 6 nm) a mikrotubuly (10 -16 nm)
- spirálovité pásy na povrchu buňky
- slizovité materiály - fibrily



Stigmatella
Aurantica
Cystobacteraceae

Fig. 27. Diagram of the life cycle of *Stigmatella aurantiaca*. (From Dworkin, 1985.)

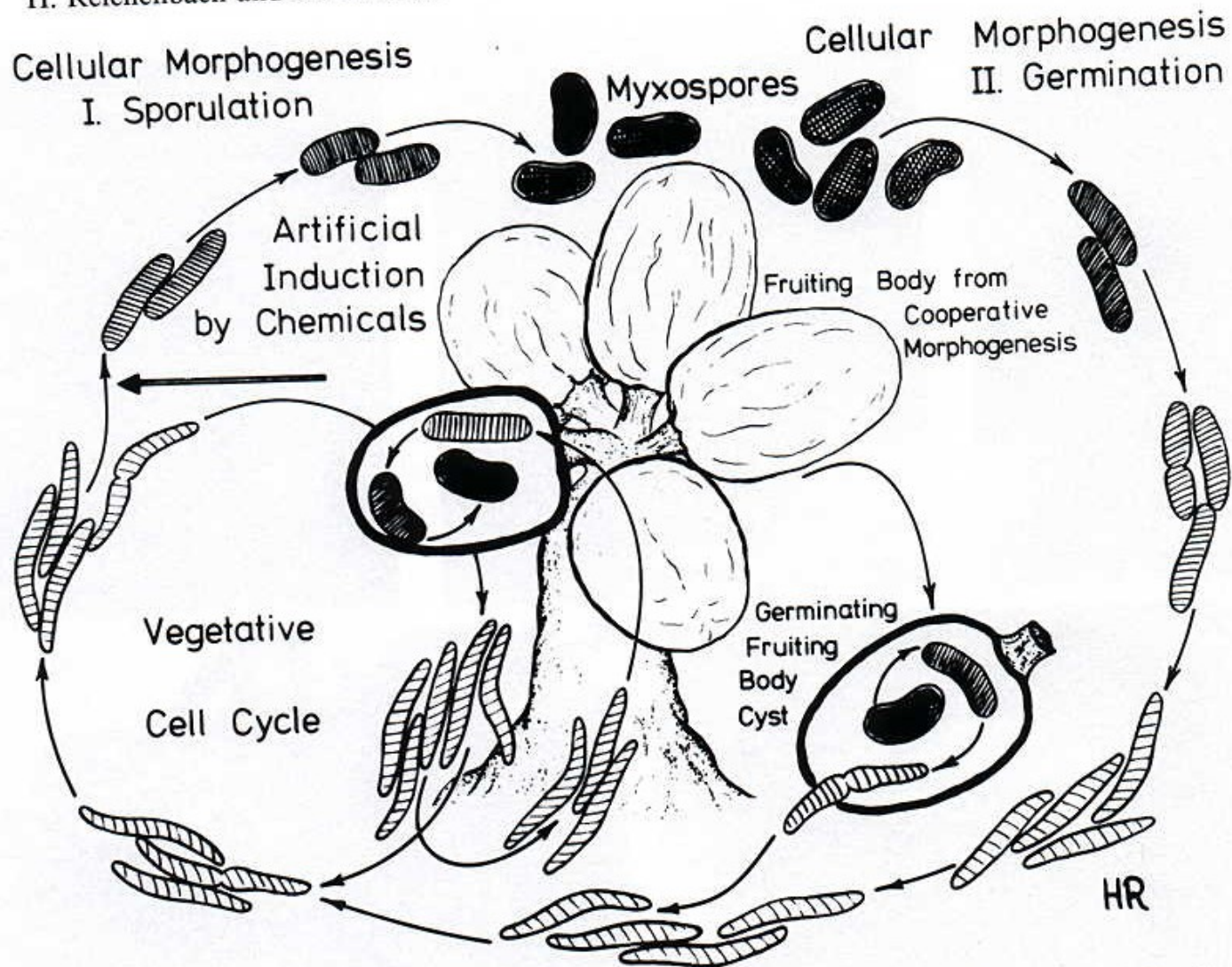
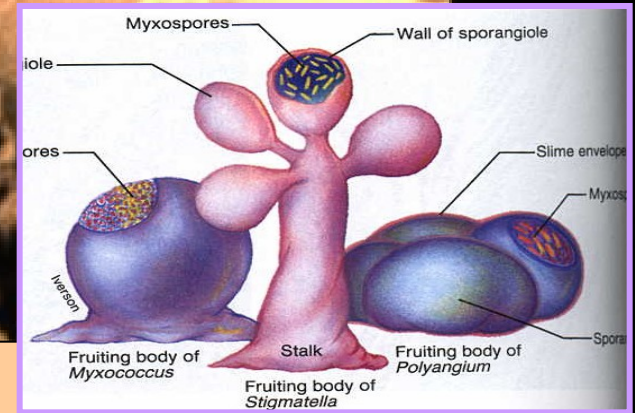


Fig. 3. Cellular morphogenesis in myxobacteria, shown with *Stigmatella aurantiaca* as an example. Fruiting body and cells are not drawn to scale. (From Gerth and Reichenbach, 1978.)

Plodnice

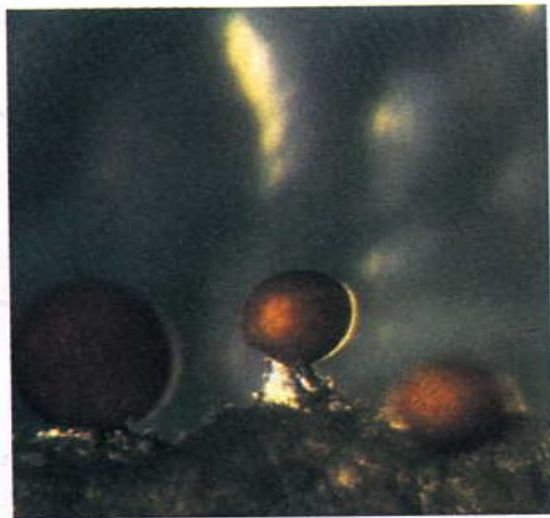
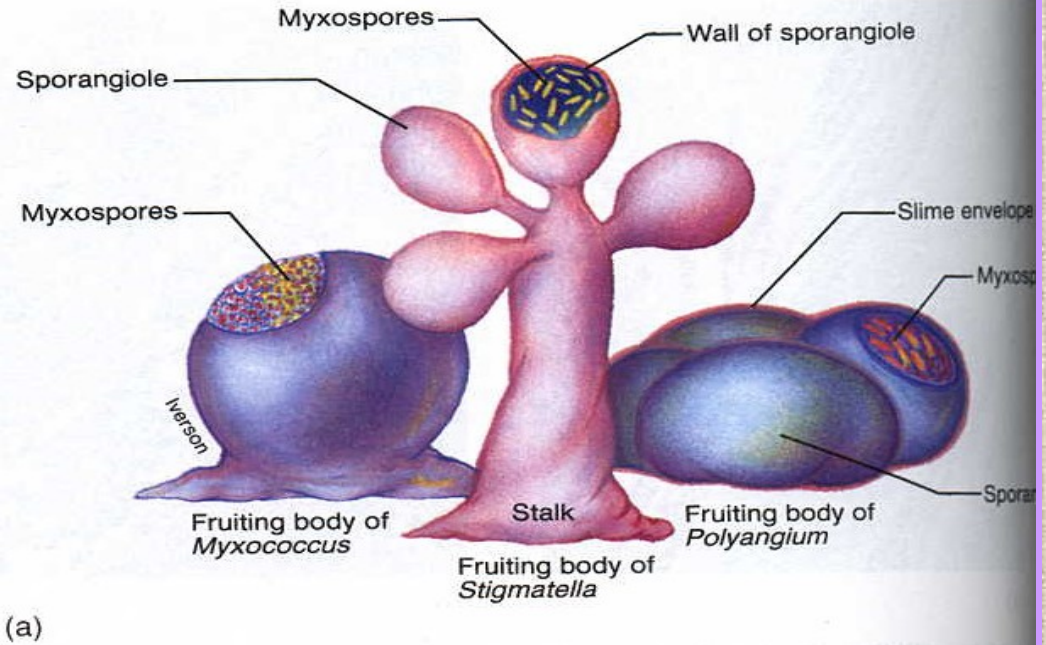


tvoreny

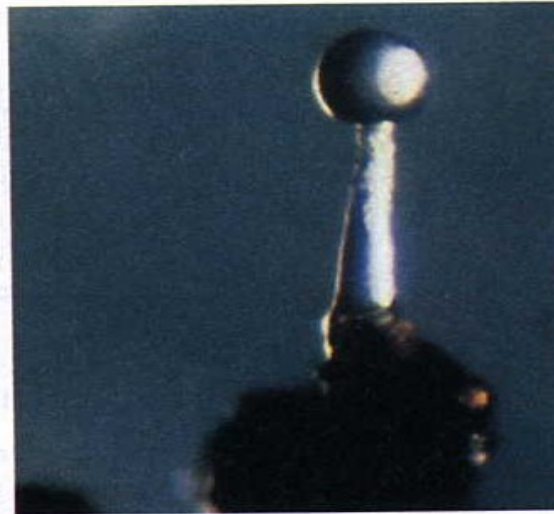
- A. měkkou sliz. strukturou - *Archangium*
 - B. tuhou slizovitou strukturou - *Cystobacter*
- Sporangioly - 1 nebo shluky
- 1. rostou přímo na substrátu
 - 2. vybavené stopkou

Figure 22.28 Myxobacterial Fruiting Bodies.
 (a) An illustration of typical fruiting body structure.
 (b) *Myxococcus fulvus*. Fruiting bodies are about 150–400 μm high.
 (c) *Myxococcus stipitatus*. The stalk is as tall as 200 μm .
 (d) *Chondromyces crocatus* viewed with the SEM. The stalk may reach 700 μm or more in height.

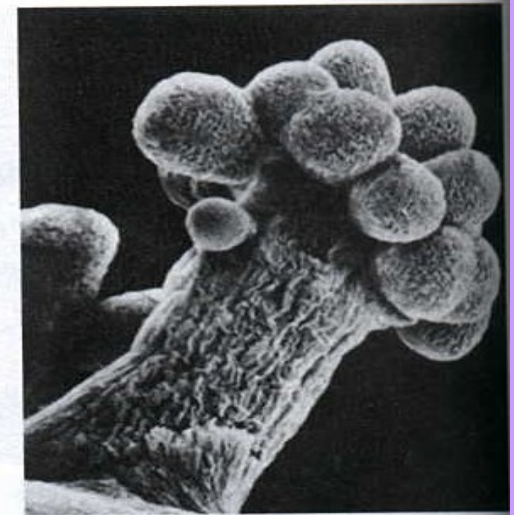
Plodnice a jejich struktura



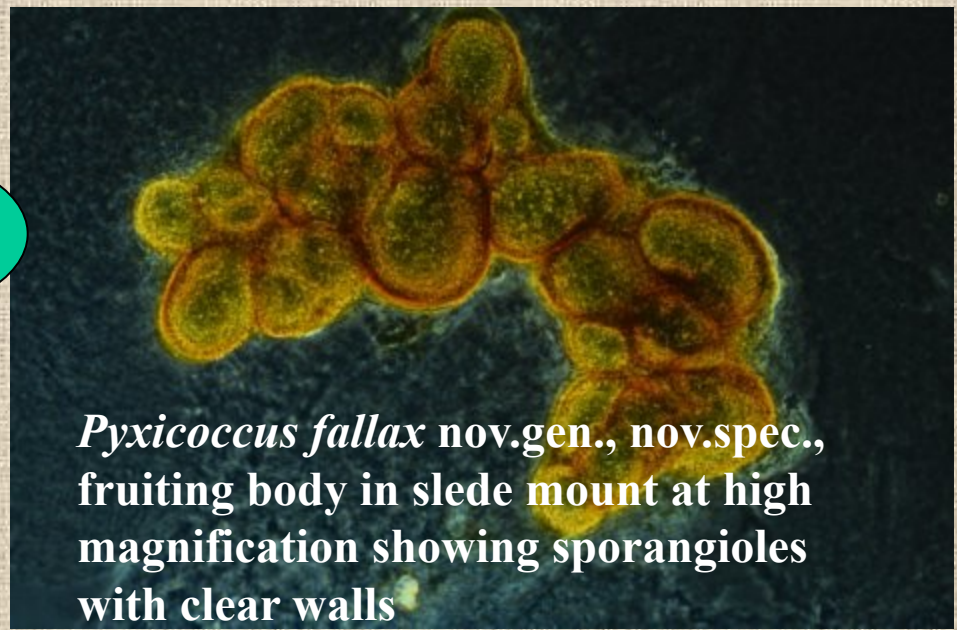
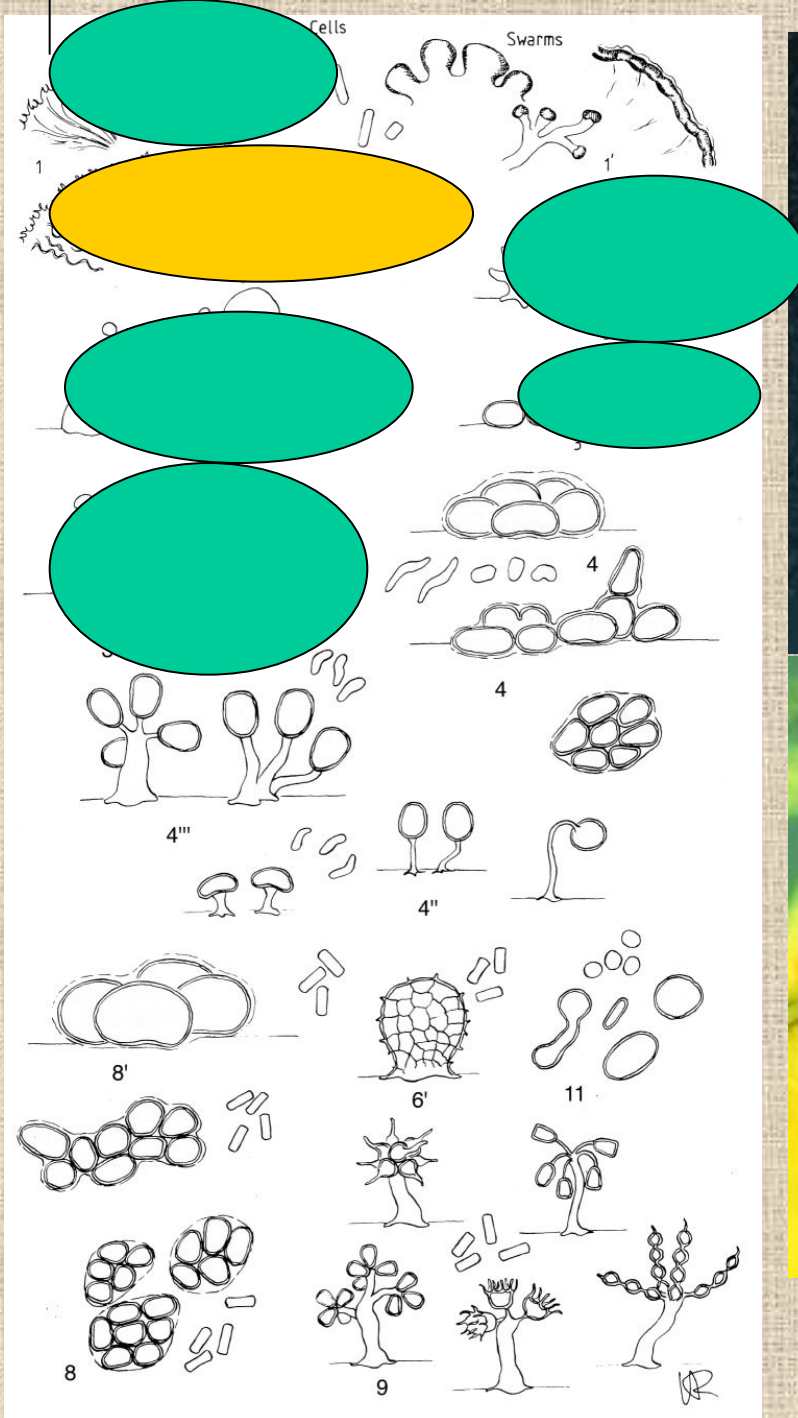
(b)



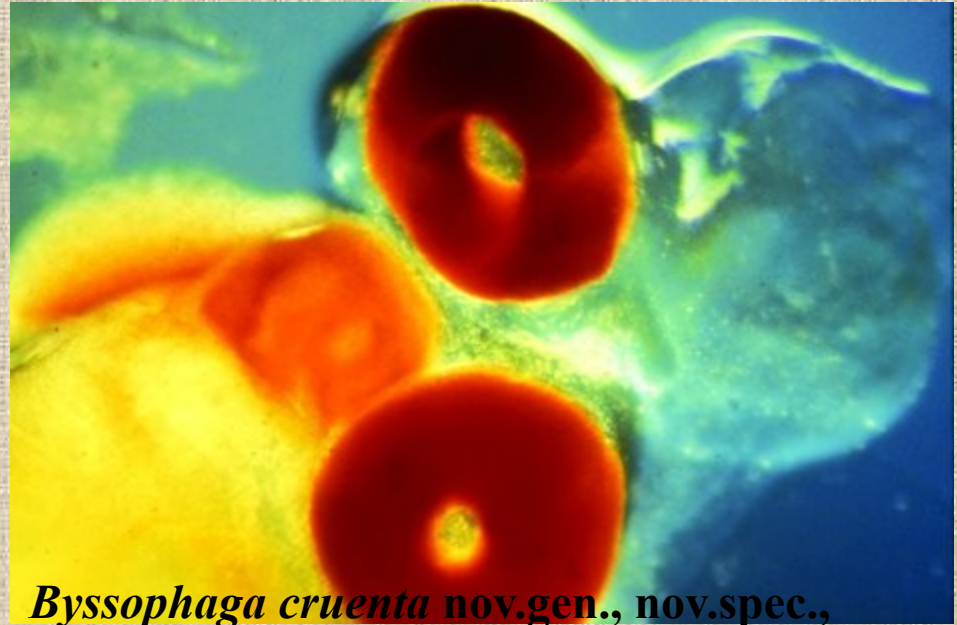
(c)



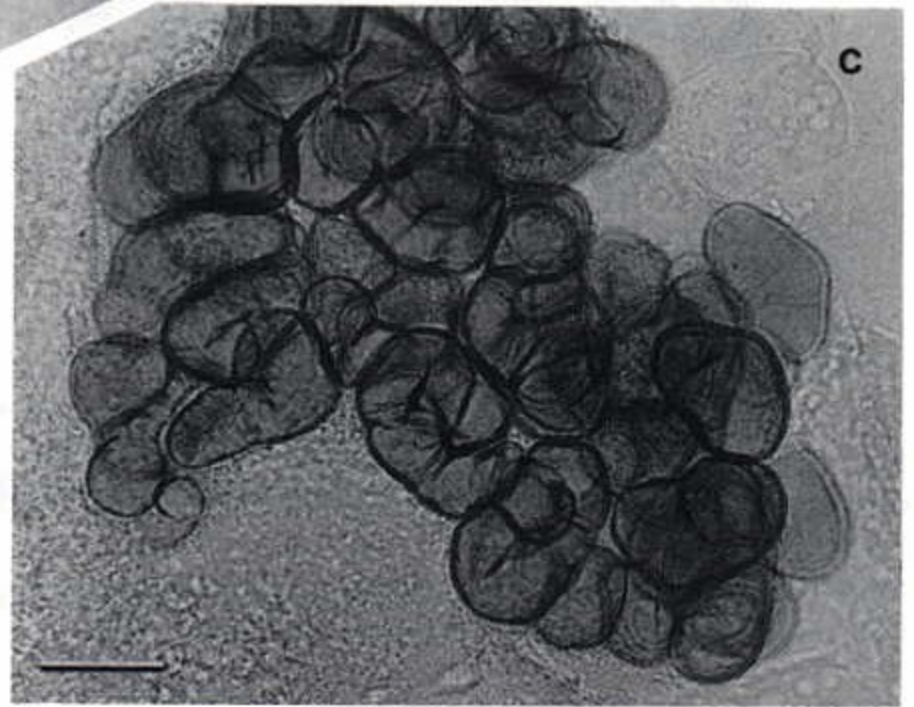
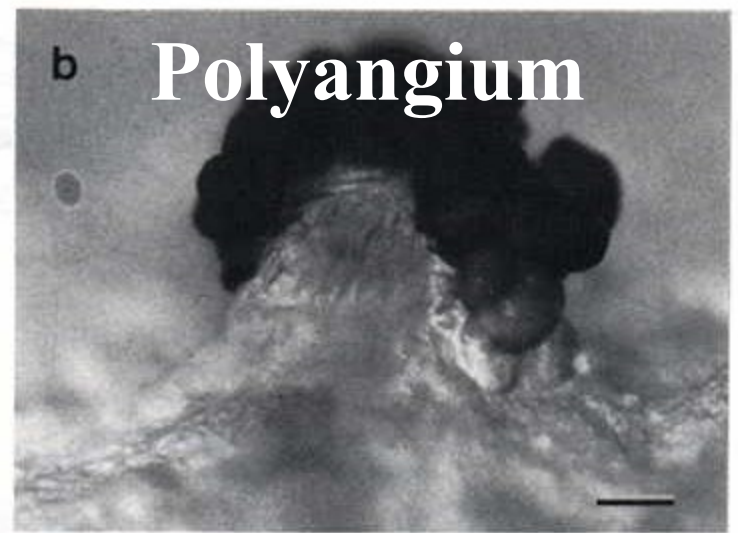
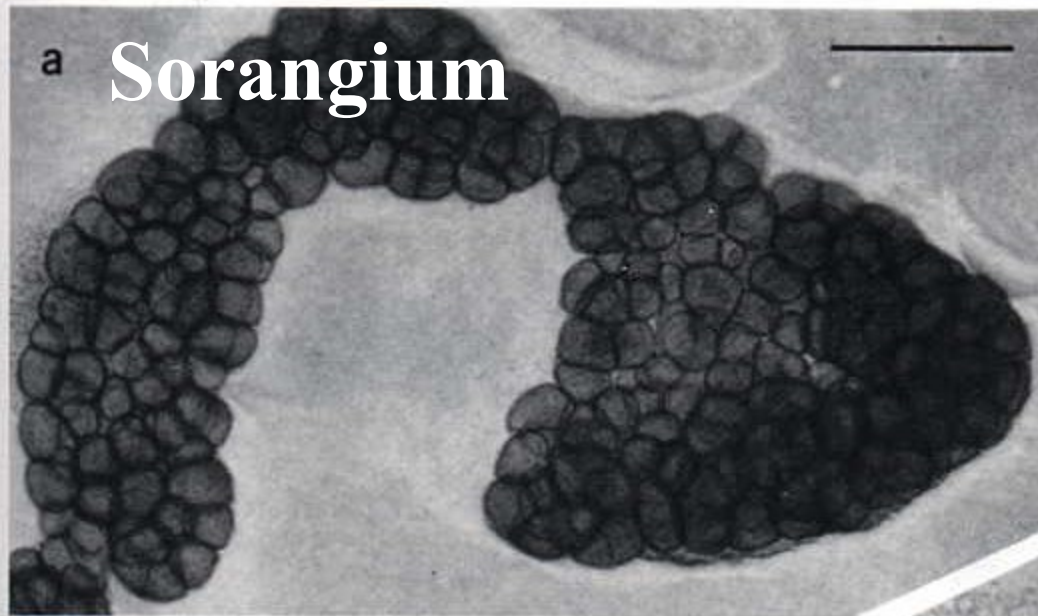
(d)

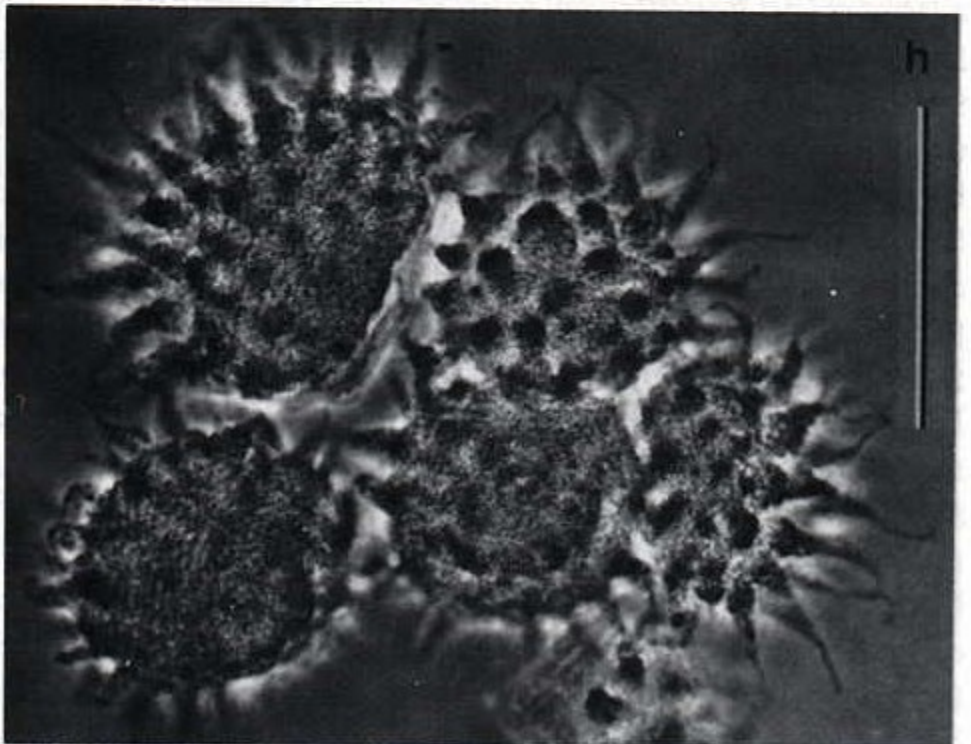
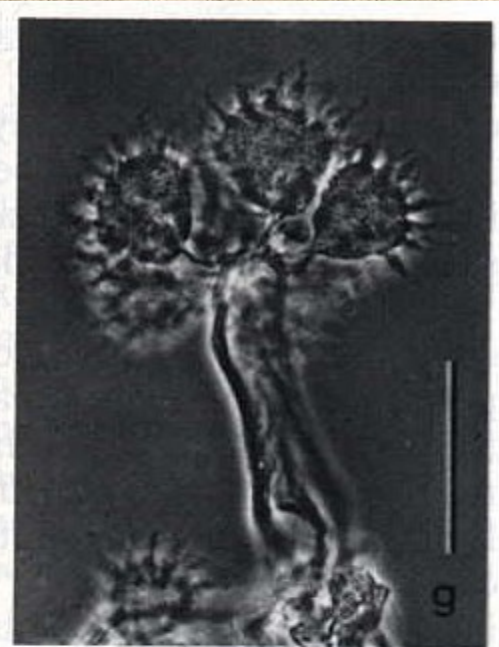


Pyxicoccus fallax nov.gen., nov.spec.,
fruiting body in slide mount at high
magnification showing sporangioles
with clear walls



Byssophaga cruenta nov.gen., nov.spec.,
strain By c2 (type strain), cells assembled
in massive rings on the agar surface





Chondromyces

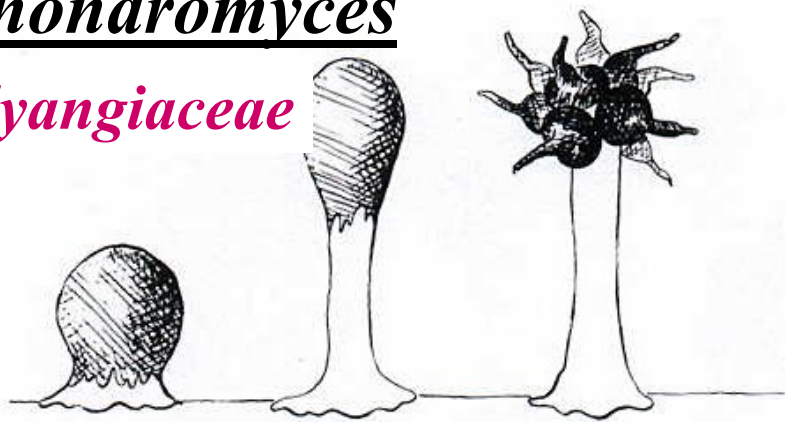
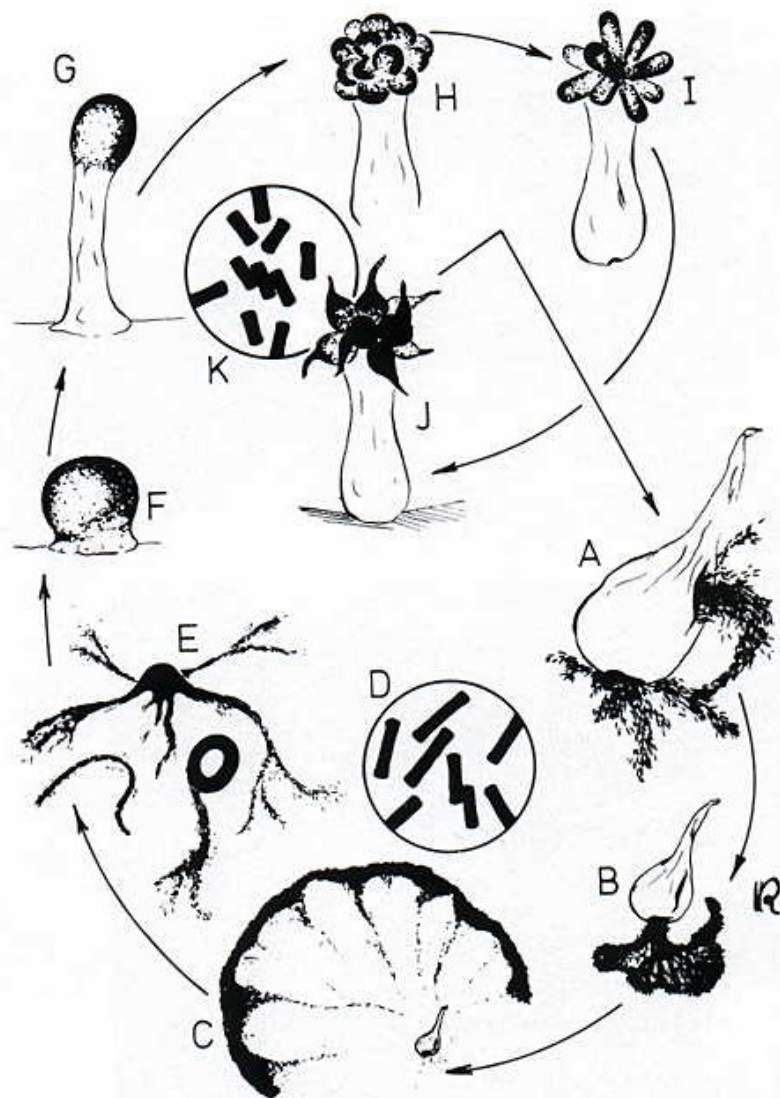
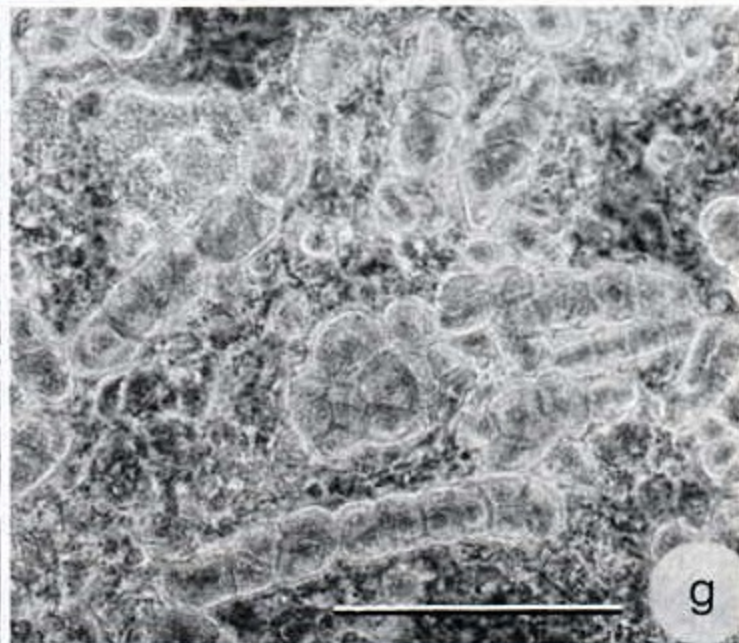
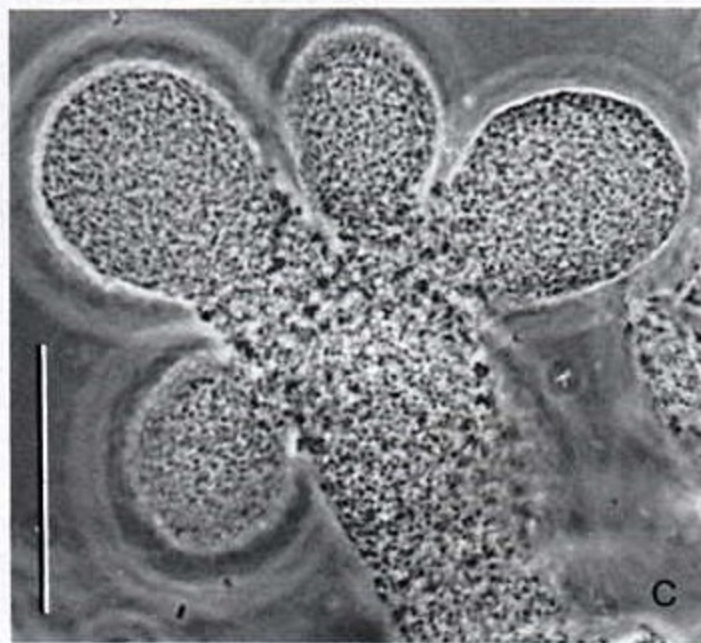
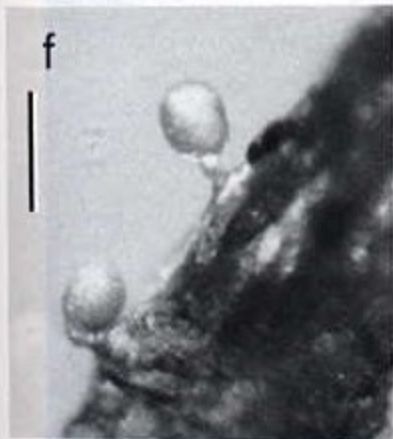
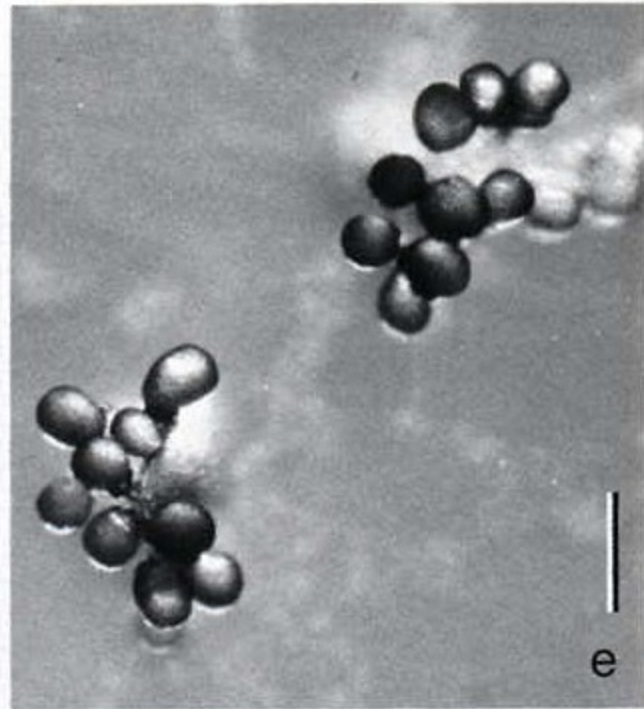
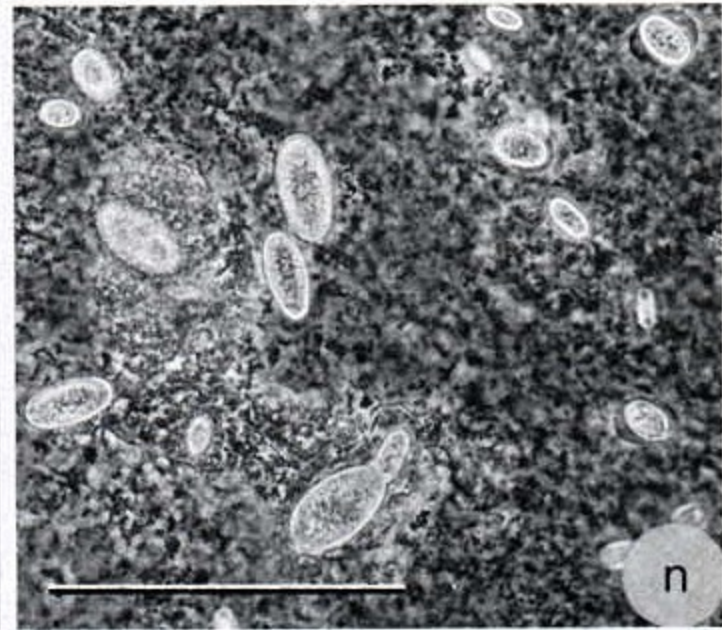
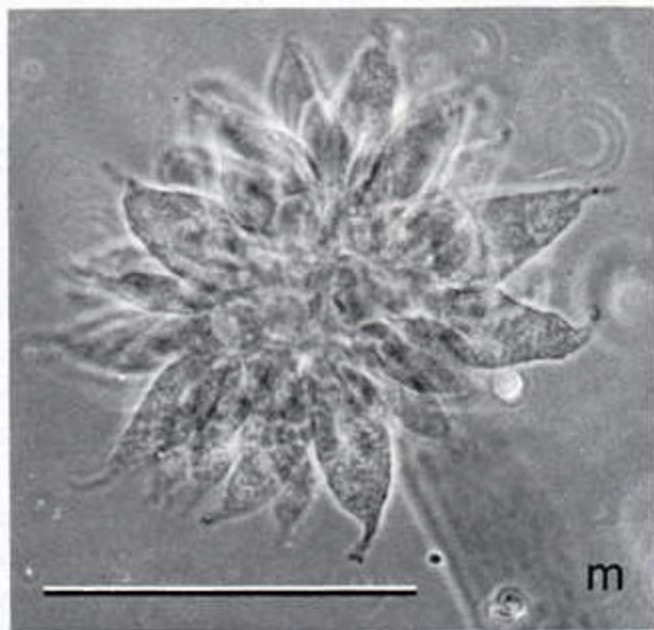
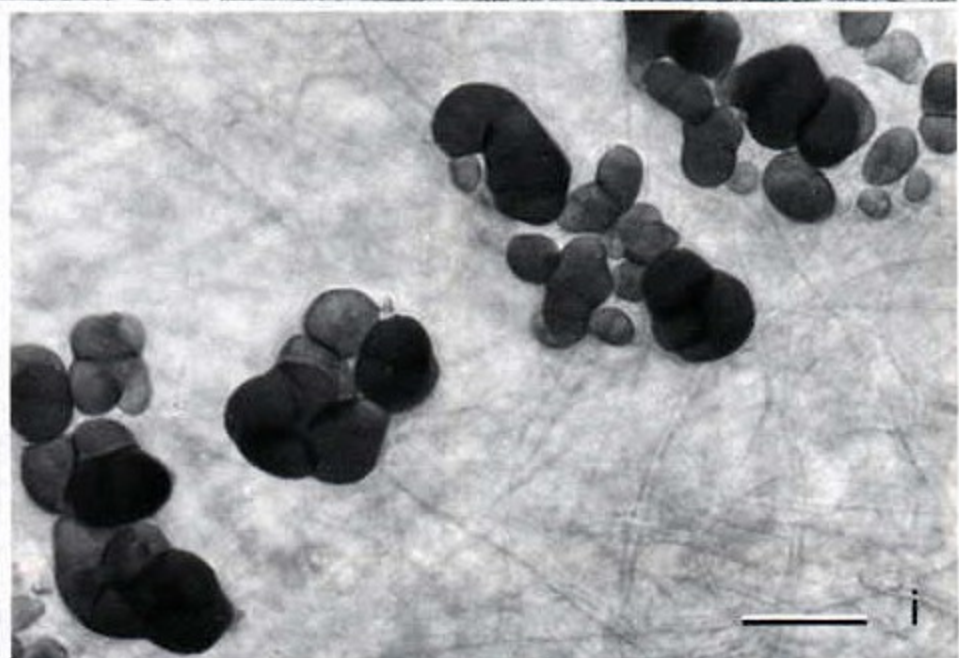
*Chondromyces**Polyangiaceae**Stigmatella**Cystobacteraceae*

Fig. 12. Similar fruiting body shapes may be reached in different ways, as shown here for *Chondromyces apiculatus* (above) and *Stigmatella aurantiaca* (below), two organisms formerly thought to be closely related. The hatched areas indicate where the cells are located at the various stages.







Gliding motility

- **Bez aparátu pohybu, cestičky**
- **geneticky prokázány 2 systémy**
- **A**
 - pohyb individuální buňky
 - 33 genů
 - pravděpodobně souvisí s transportem biopolymerů
- **S**
 - social (skupinový)
 - plodnice
 - fimbrie typu IV

Cestičky na agaru vznikající klouzavým pohybem

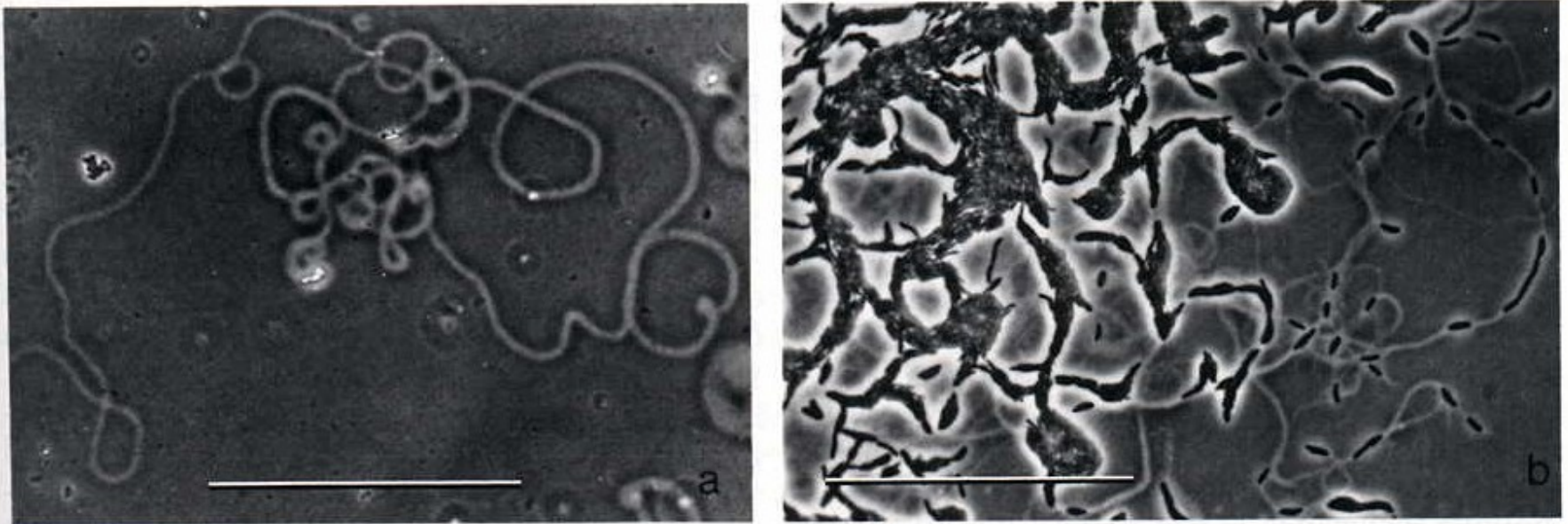
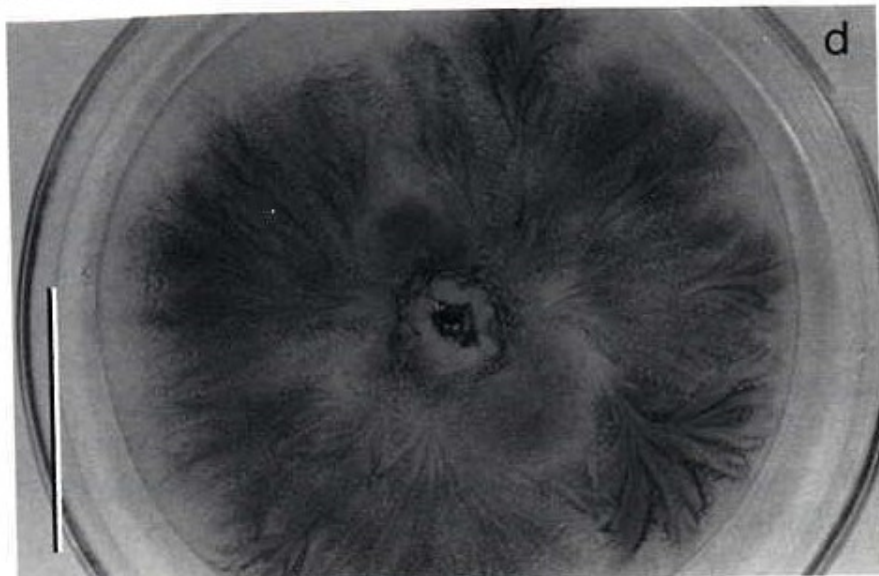
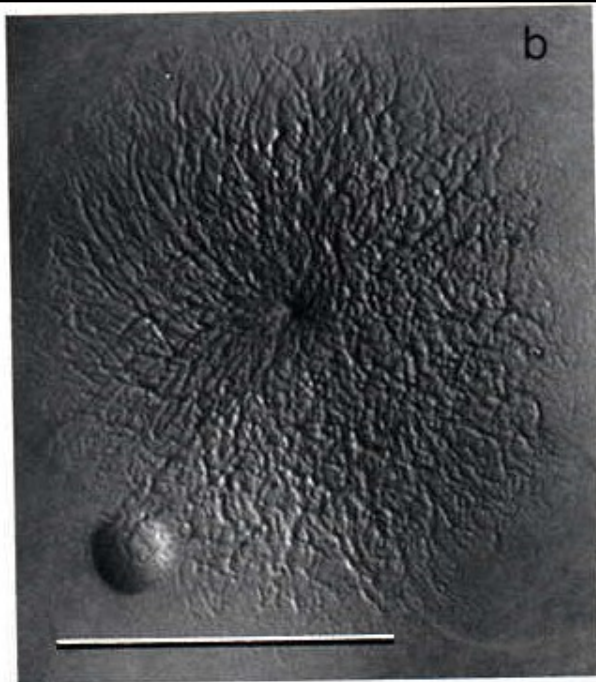
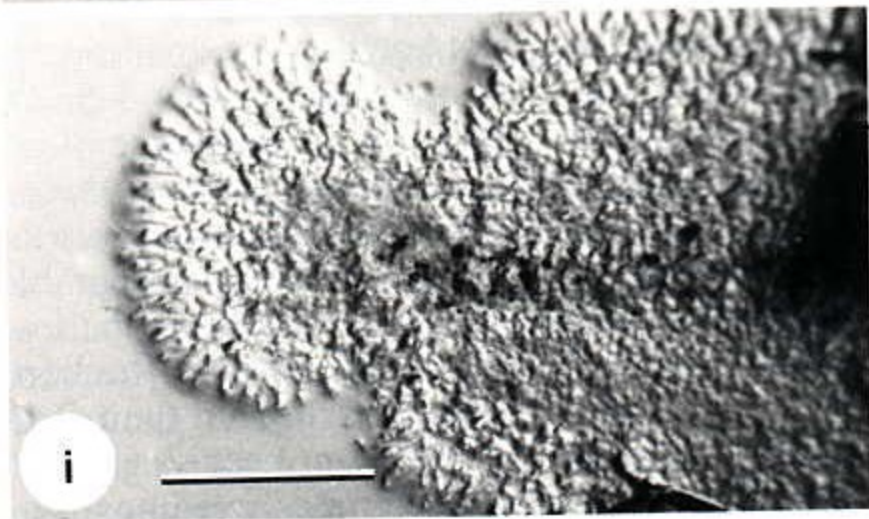
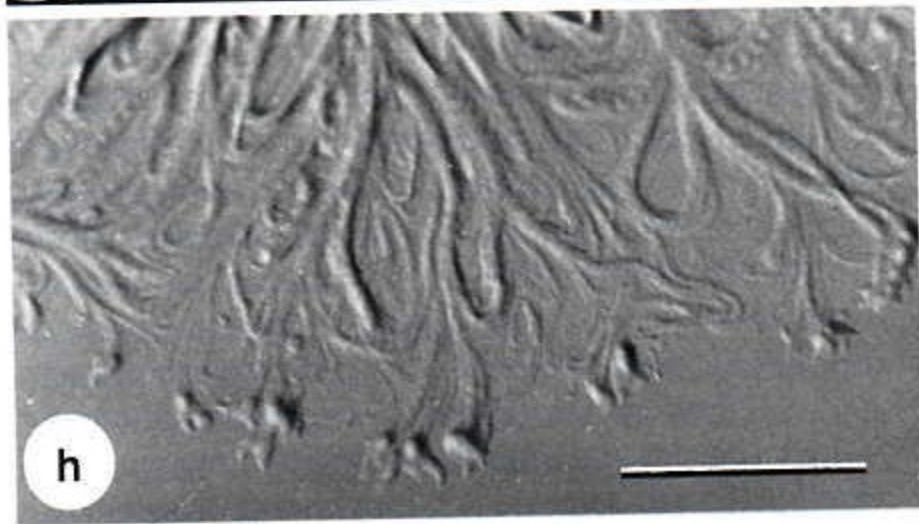
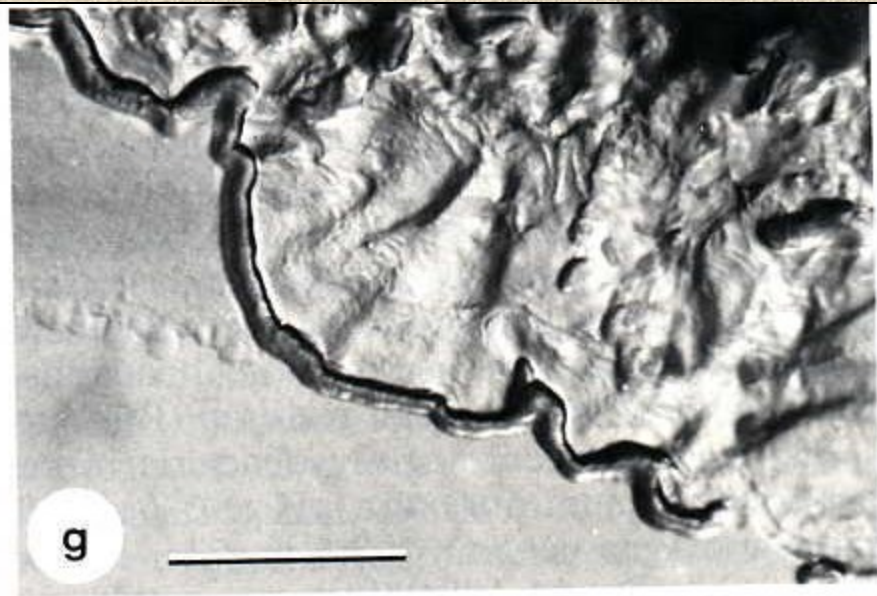
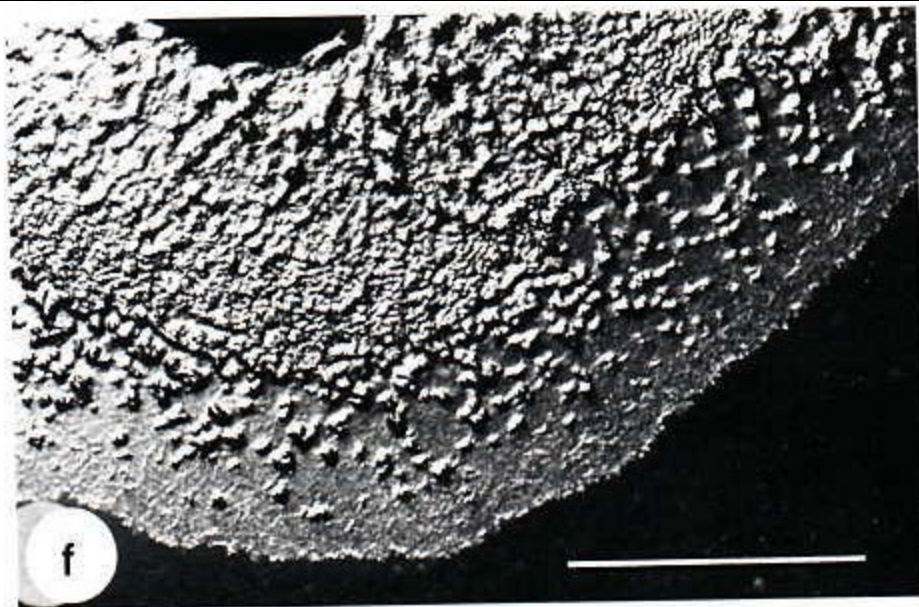
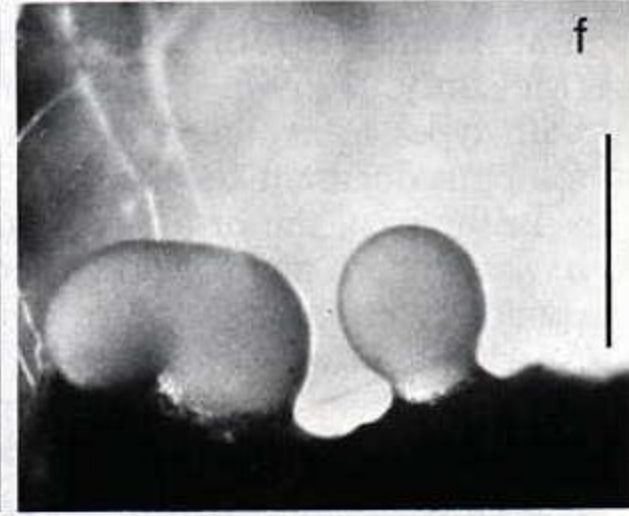
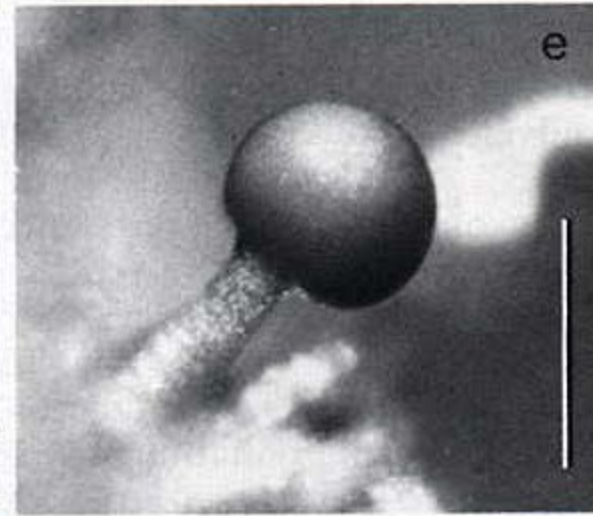
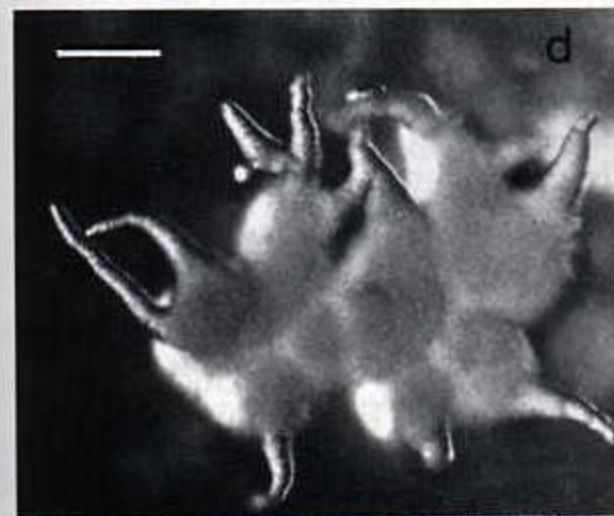
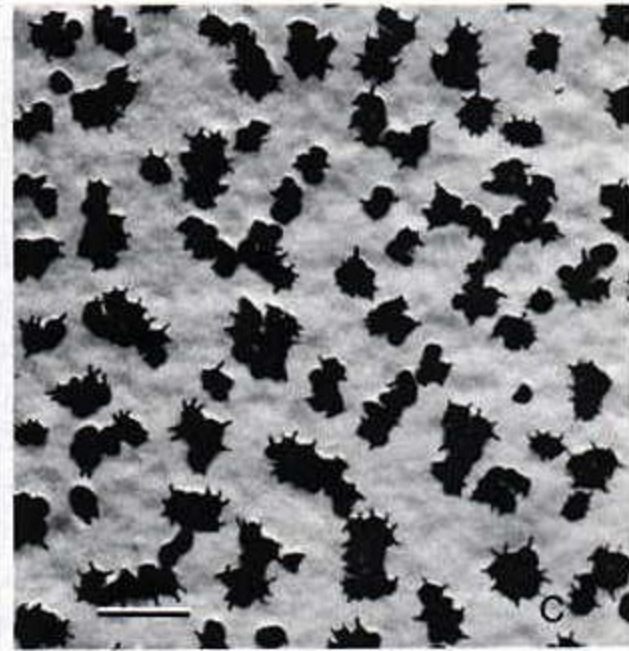
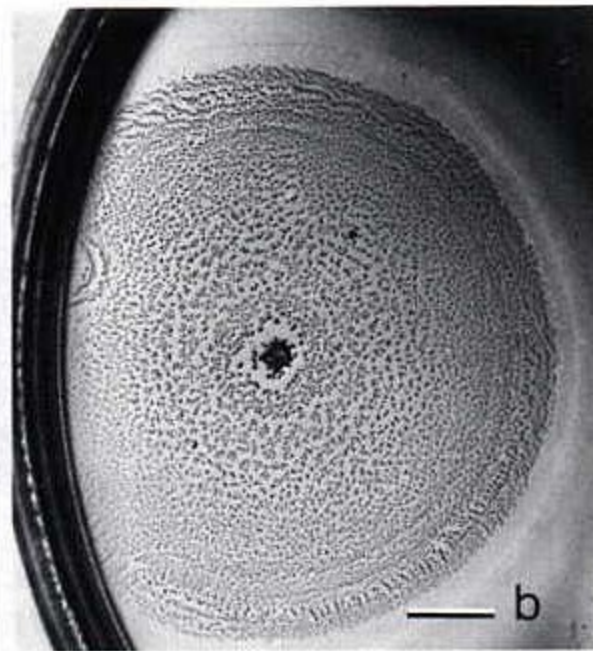
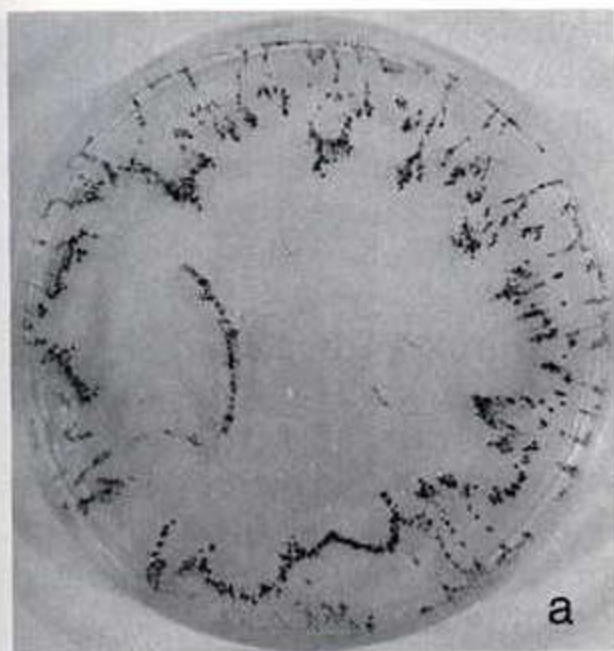


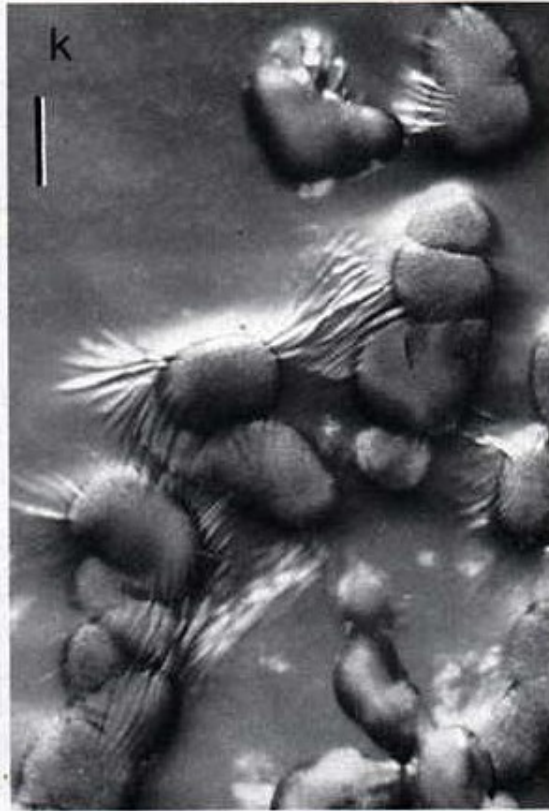
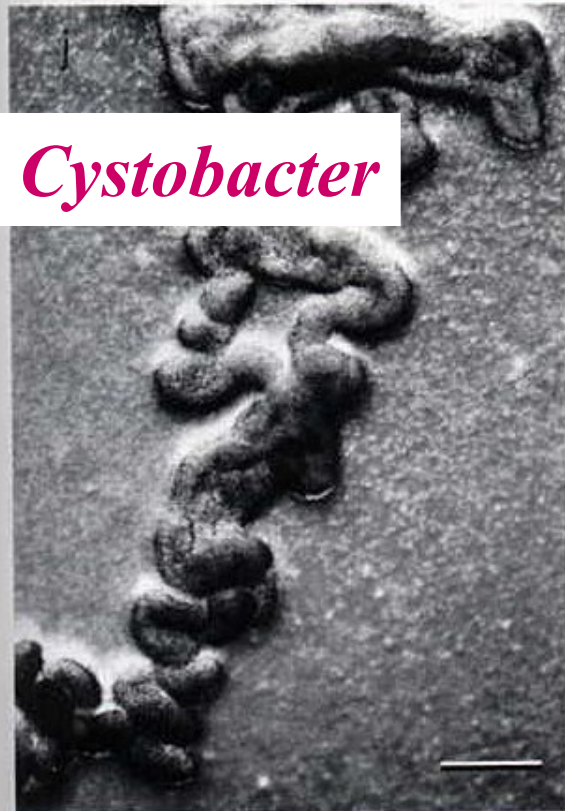
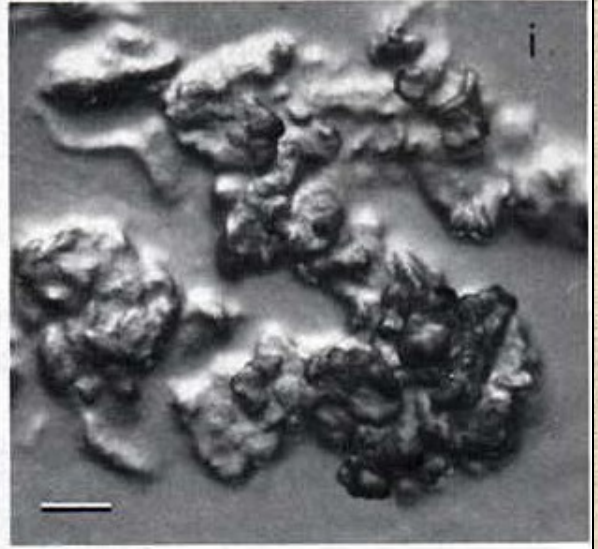
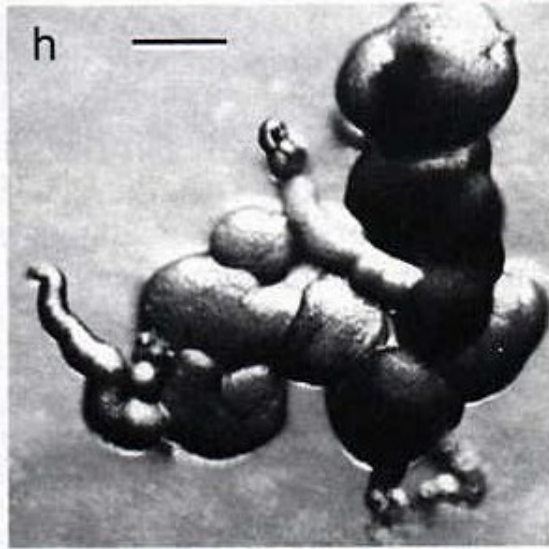
Fig. 5. Slime tracks as seen on thin agar layers in chamber cultures. (a) *Nannocystis exedens*. (b) *Myxococcus fulvus*; the spots seen on the left are cell clusters, not single cells. Bar = 100 μm . Phase contrast.

**Plazivé
kolonie**









D. Strídání jednobuněčného a vláknitého nebo mnohobuněčného stádia

- ***Flexibacter filiformis* – vláknitá, klouzavá bakterie**
- **1. stádium – dlouhá vlákna**
- **2. stádium – krátké, kulovité buňky vyplněné tukem**
 - přechod do 2. stádia – se vstupem do stacionární fáze nebo s přechodem do vyšší teploty (35°C)

- **McBride, M.J. P. Hartzell and D.R. Zusman. 1993 Motility and tactic behavior of *Myxococcus xanthus*. p285-306. in Myxobacteria II M. Dworkin and D. Kaiser (eds) American Society for Microbiology Press**
- **Hartzell, P.L. and P. Youderian 1995 Genetics of gliding motility and development in *Myxococcus xanthus*. Arch. Microbiol. 164:309-323.**
- **Freese, A., H. Reichenbach and H. Lünsdorf. 1997 Further characterization and in situ localization of chain-like aggregates of the gliding bacteria *Myxococcus fulvus* and *Myxococcus xanthus*. J. Bacteriol. 179:1246-1252.**
- **Shimkets, L.J. 1993 The myxobacterial genome p.85-108 in Myxobacteria II M. Dworkin and D. Kaiser (eds) American Society for Microbiology Press**
- **Shimkets, L.J. (1999): Intercellular signaling during fruiting-body development of *Myxococcus xanthus*. Annu Rev Microbiol. 53:525-49.**

- **White, D. 1993 Myxospore and fruiting body morphogenesis. p.307-346 in Myxobacteria II M. Dworkin and D. Kaiser (eds) American Society for Microbiology Press**
- **Kaiser, D. and L. Kroos 1993 Intercellular signaling p.257-284 in Myxobacteria II M. Dworkin and D. Kaiser (eds) American Society for Microbiology Press**
- **Dworkin, M. 1996 Recent advances in the social and developmental biology of the myxobacteria. Microbiol. Rev. 60: 70-102.**
- **Reichenbach, H. 1993 Biology of the myxobacteria: Ecology and Taxonomy. p.13-62 in Myxobacteria II M. Dworkin and D. Kaiser (eds) American Society for Microbiology Press**



Děkuji za Vaši pozornost