Asexual reproduction and modular growth

unitary

modular

Why?

Benefits of asexual replication

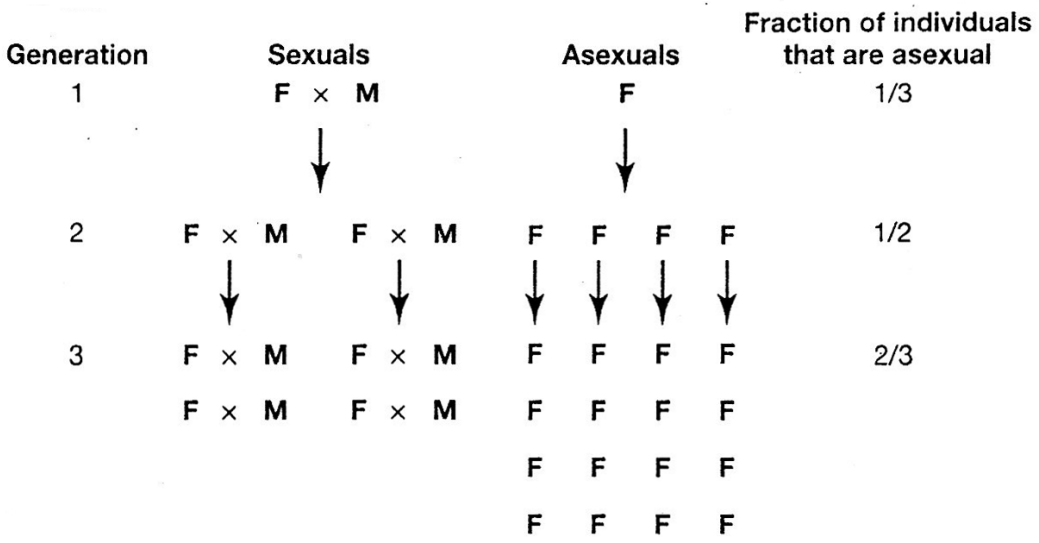
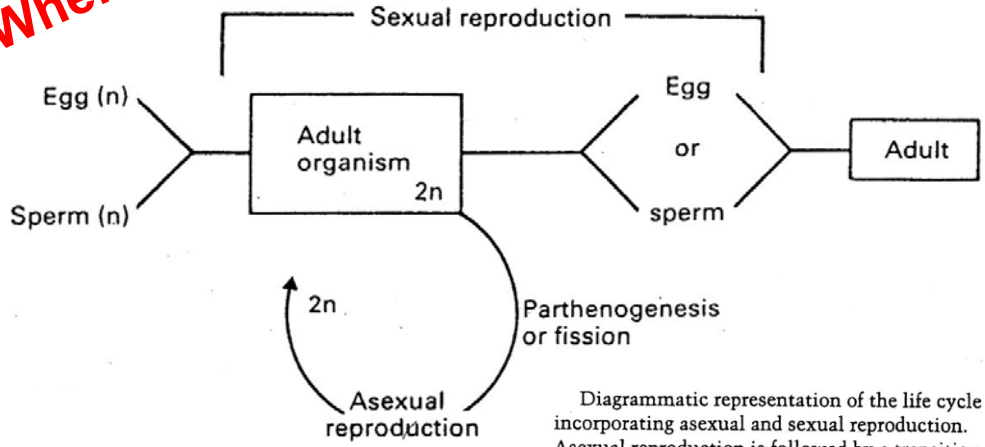


Figure 6.6 **The reproductive advantage of asexual females** Imagine a population founded by three individuals: a sexual female, a sexual male, and an asexual female. Every generation each female produces four offspring, after which the parents die. All offspring survive to reproduce. Half the offspring of sexual females are female; the other half are male. All the offspring of asexual females are, of course, female. Under these simple assumptions, the fraction of individuals in the population that are asexual females increases every generation.

When?



Diagrammatic representation of the life cycle incorporating asexual and sexual reproduction. Asexual reproduction is followed by a transition to sexual reproduction and all fragments which have reproduced in this way die.

Who?

Distribution of reproductive modes

		Reproductive mode *Sexual*	Reproductive mode *Asexual*	Modular growth?
Porifera		+	+	body
Cnidaria	Scy, Cub	+	+	
	Hydrozoa	+	+	colony
	Anthozoa	+	+	colony
Ctenophora		+		
Platyh.	Turbellaria	+	+	
Nemertea		+	+	
Nematoda		+	+	
Annelida	Polychaeta	+	+	
	Hirudinea	+		
Sipuncula		+		
Mollusca		+		
Arthr.	Crustacea	+	+	
	Hexapoda	+	+	
	Myriapoda	+		
Phoronida		+	+	
Bryozoa		+	+	colony
Brachiopoda		+		
Echinod.	Ast, Oph	+	+	
	Ech, Hol, Crin	+		
Hemich.	Enteropnuest	+	+	
	Pterobranch	+	+	colony
Urochord.	Larvacea	+		
	Ascideacea	+	+	colony
	Thaliacea	+	+	colony

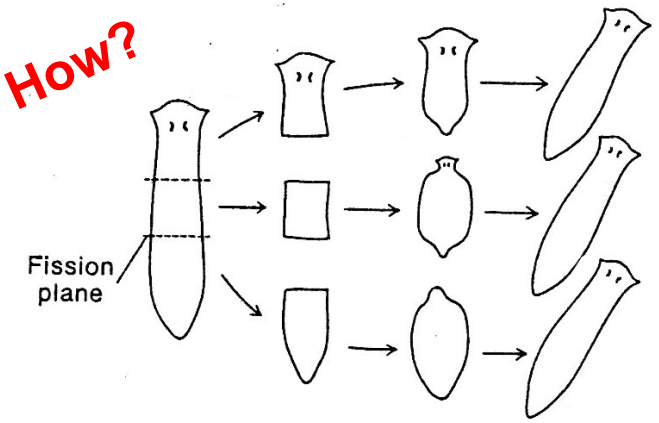
How?

Two types of asexual reproduction

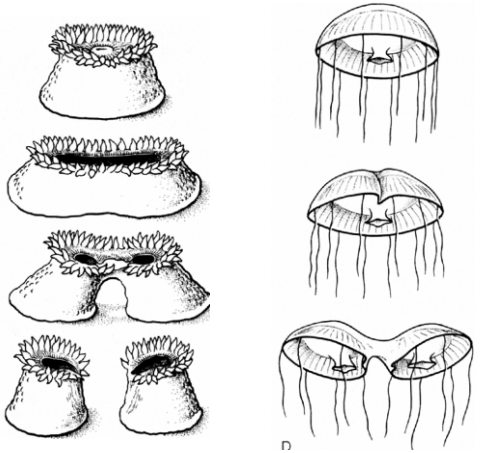
Comet formation and regeneration in *Linckia*

Parthenogenesis in *Daphnia* (Branchiopoda)

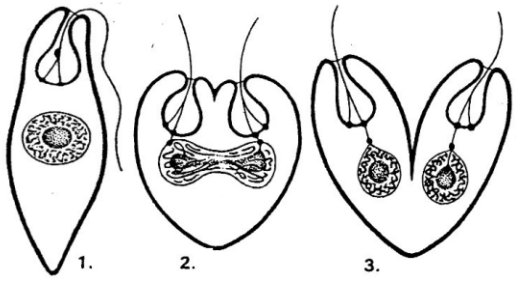
How?

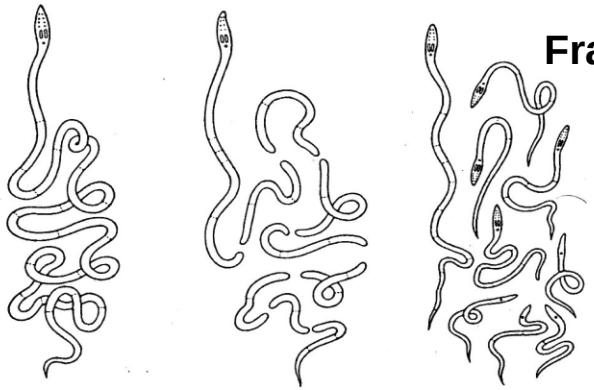


Fission
(flatworms, cnidarians)

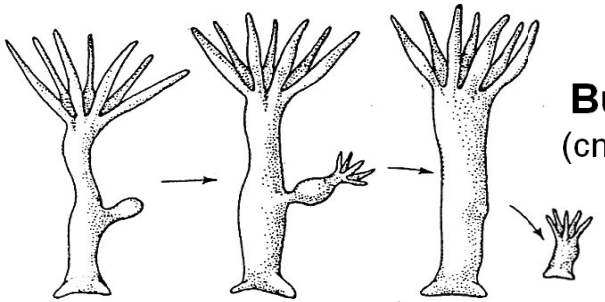


Binary fission
(protozoans)

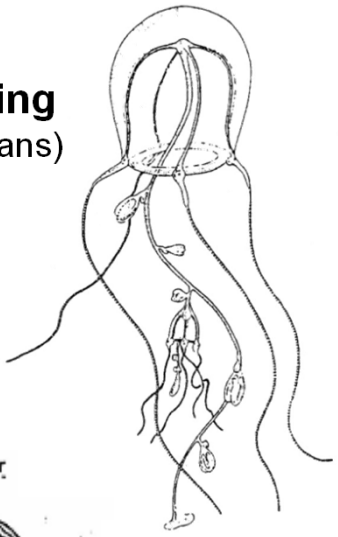


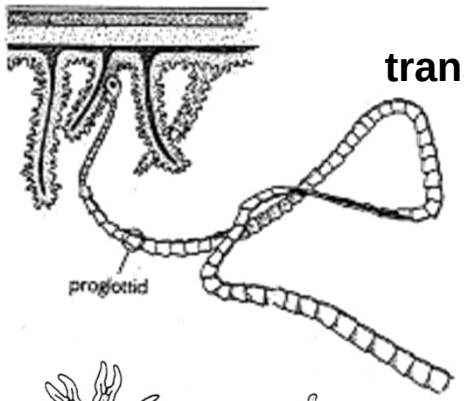


Fragmentation
(nemerteans)



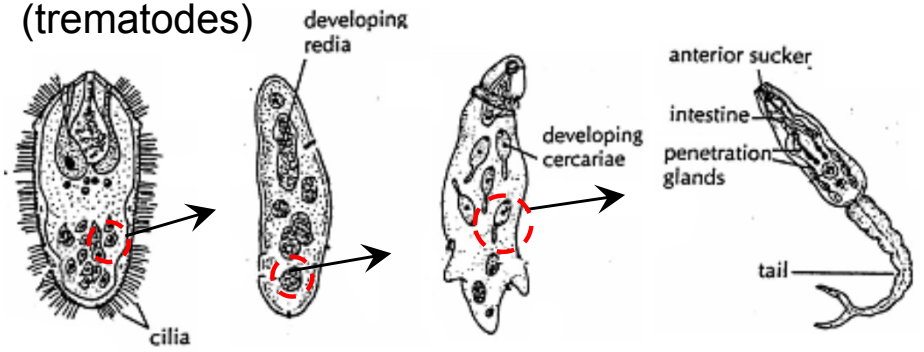
Budding
(cnidarians)

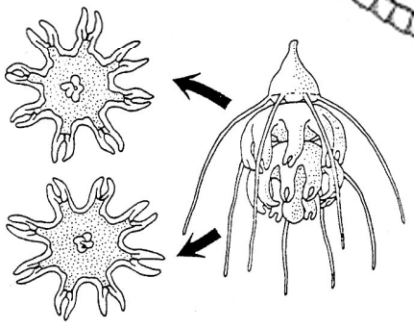




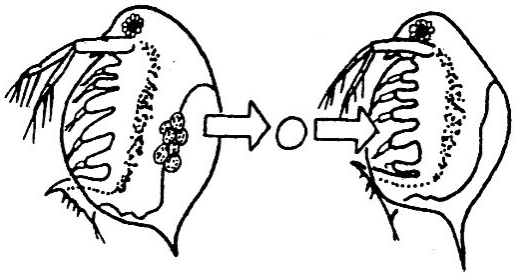
transverse division
(cestodes)

“amplification”
(trematodes)





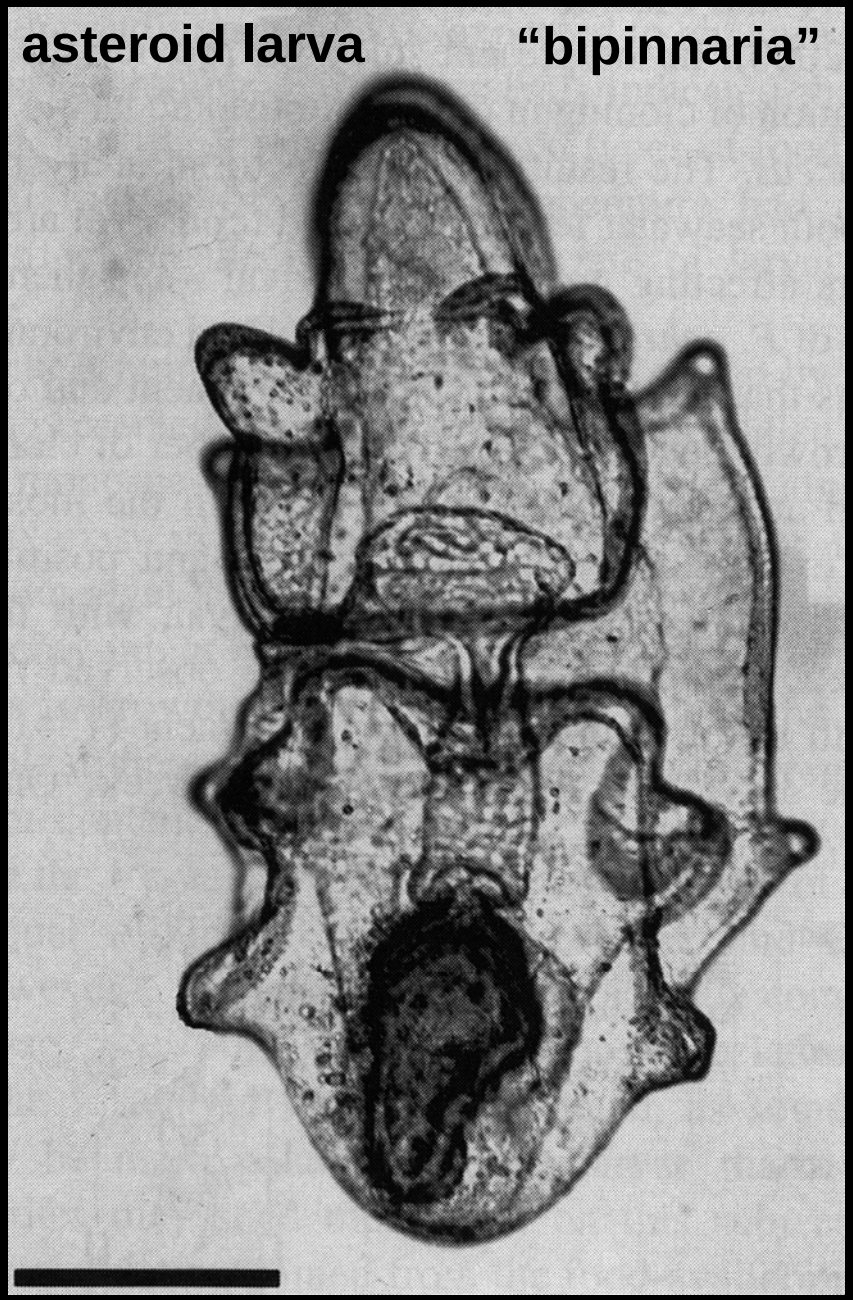
strobilation
(scyphozoans)

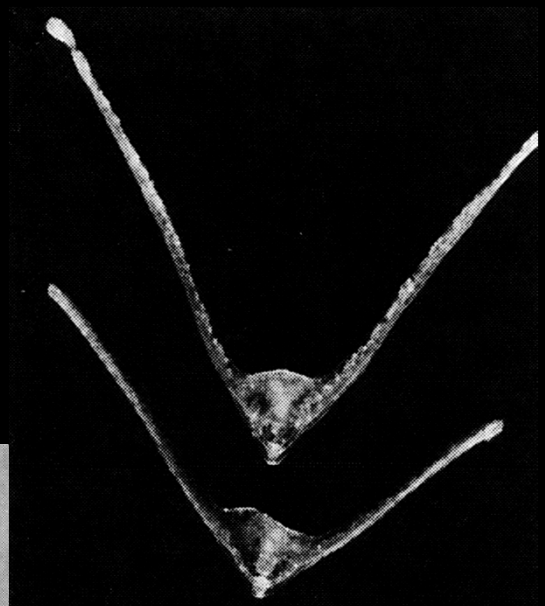


Parthenogenesis
(arthropods, rotifers, vertebrates)

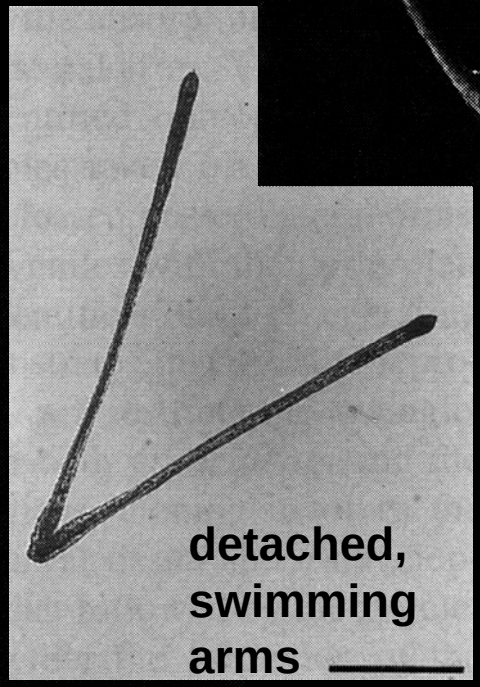
How?

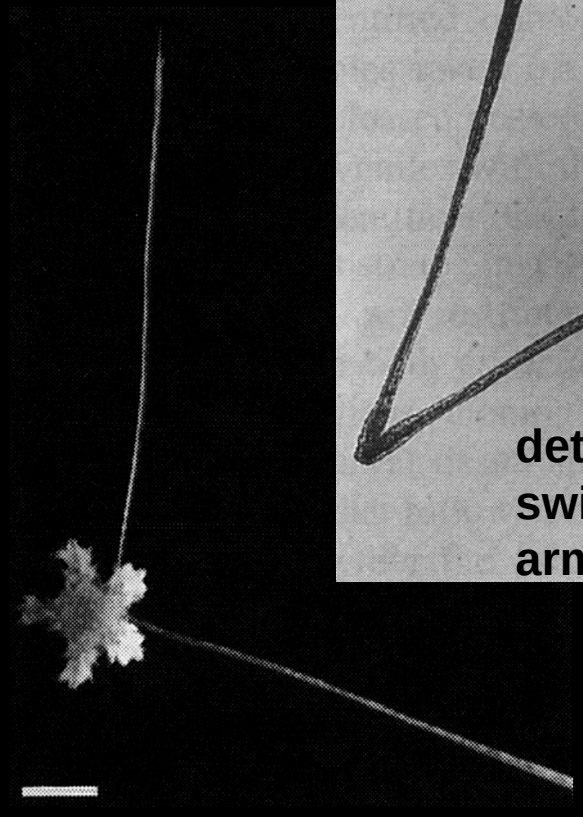
Asexual reproduction by echinoderm… larvae!





regenerated larvae!

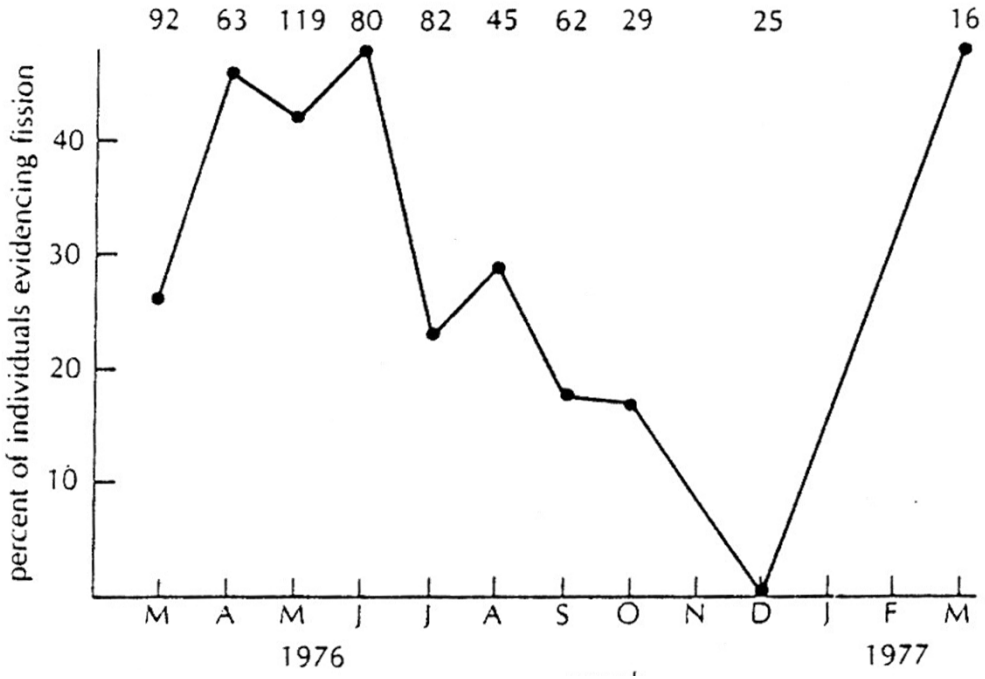




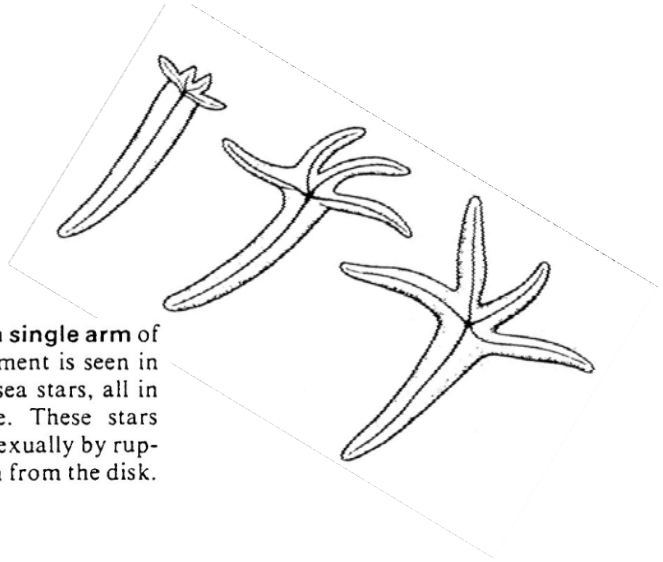
ophiuroid metamorph

When?

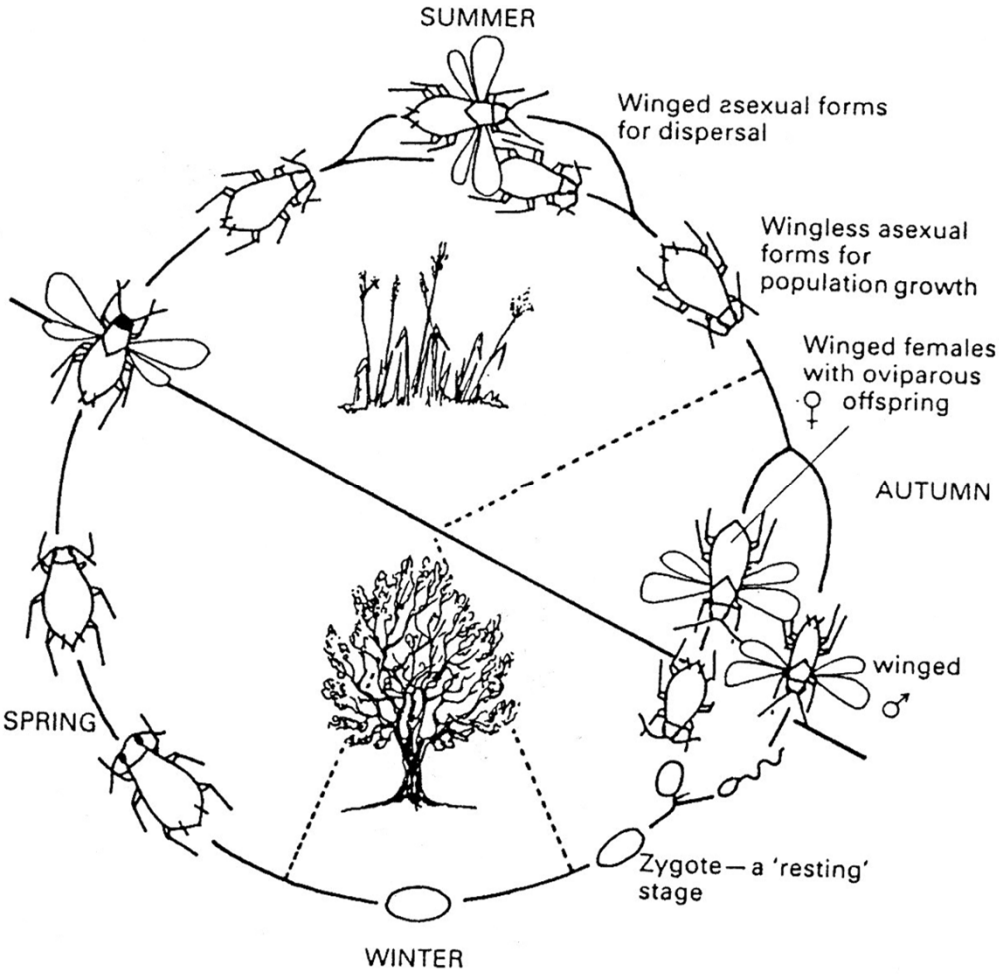
Seasonality of asexual and sexual reproduction



Asexual reproduction in the asteroid *Nepanthia belcheri*. Percent frequency of fission varied between 0% and nearly 50% of the population over the course of one year. The number of individuals examined each month is shown at the top of the graph.



Regeneration from a single arm of *Linckia*. Such replacement is seen in only a few species of sea stars, all in the family Linckiidae. These stars regularly reproduce asexually by rupturing an arm a few cm from the disk.



General patterns of reproduction

asexual ↑ **during periods of resource abundance**

sexual ↑ **during periods of environmental uncertainty**

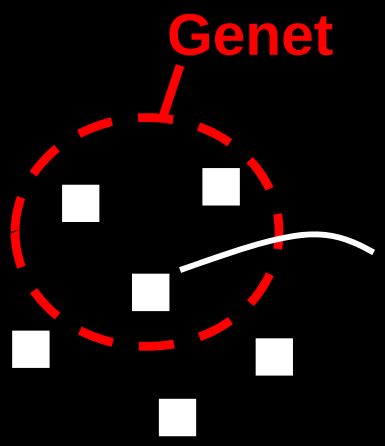
Asexual reproduction and the concept of "individuality"

Ramet

The "ecological" individual:
the countable, independent unit

Genet

The "evolutionary" individual:
the collection of all ramets that arise from a single genotype



Ramet: individual or **colony**

Module

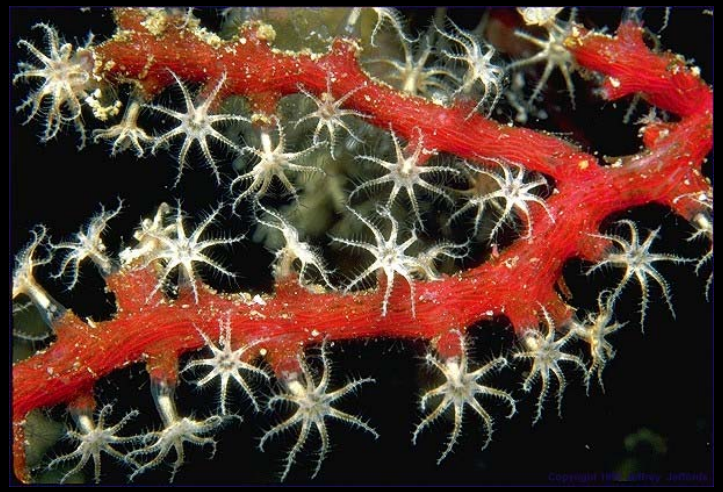
The fundamental unit of body construction
repeated to form a colony

Four phyla with modular, colonial growth

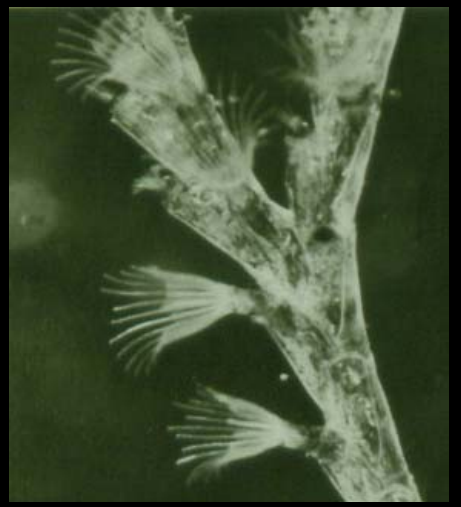
Cnidaria

Hydrozoa

Anthozoa



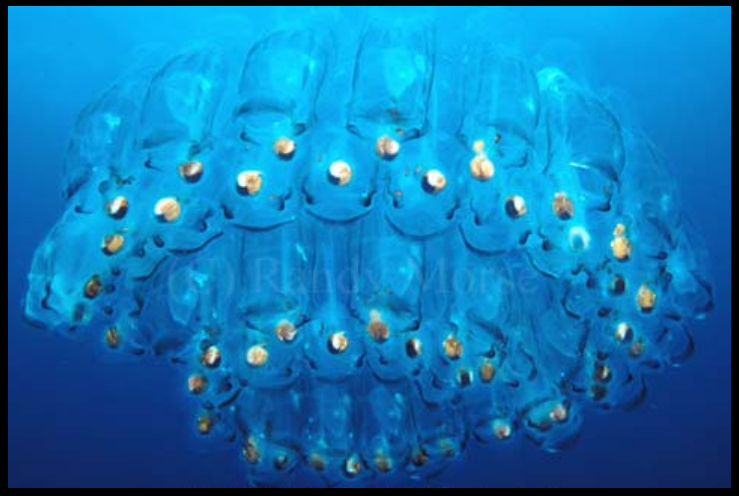
Bryozoa



Urochordata

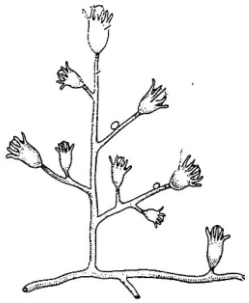
Ascideacea

Thaliacea

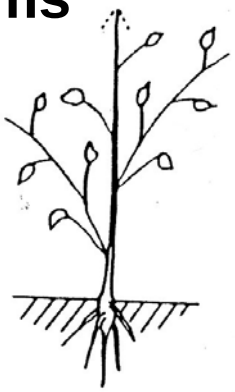


Hemichordata

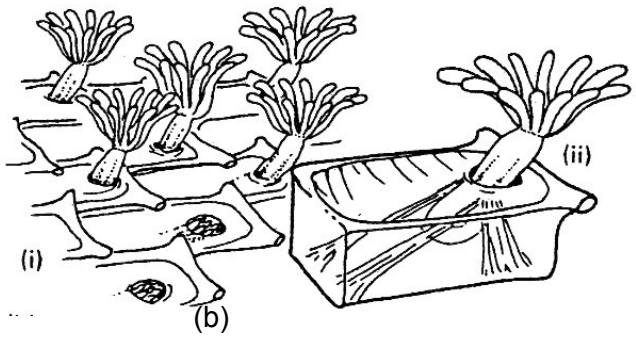
Two "modular" organisms

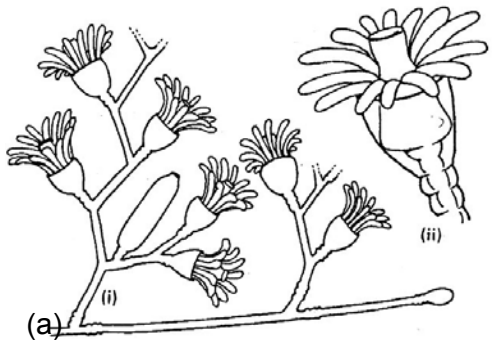


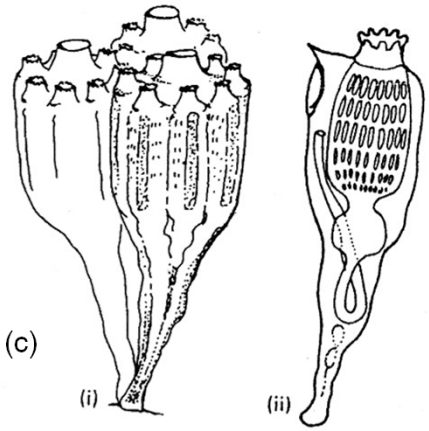
a hydroid



a plant







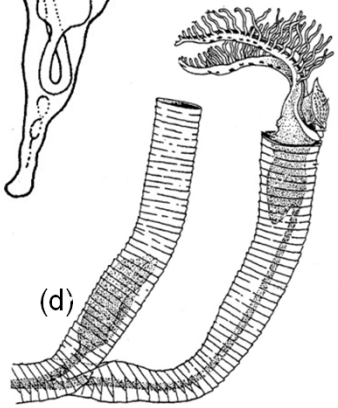
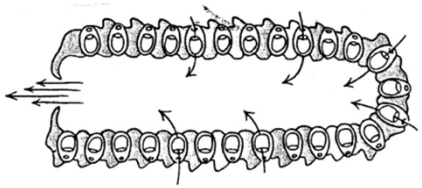


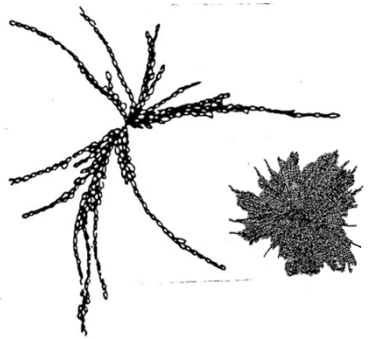
Fig. 14.4 Examples of colonial or 'modular' invertebrates: (a) the hydroid *Obelia*: (i) the branching colony, (ii) an individual polyp; (b) the bryozoan *Membranipara*: (i) part of the mat of zooids, (ii) an individual zooid; (c) the urochordate *Sydnium*: (i) three colonies showing individual inhalent siphons and a shared exhalent siphon, (ii) individual zooid; (d) colony of the pterobranch hemichordate *Rhabdopleura*.

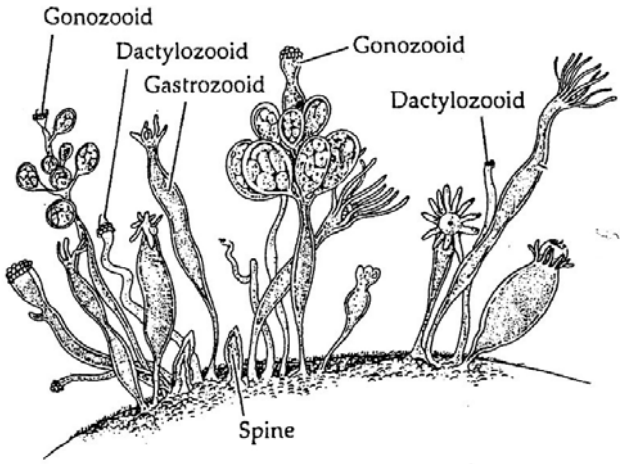
Benefits?



pyrosome colony

Colony Size (number of zooids)
1–2 (1)[a]
3–4 (4)
5–6 (4)
7–8 (4)
9–10 (2)
11–15 (5)
16–20 (7)
21–25 (2)
26–30 (3)
31–35 (5)
41–45 (5)
65–66 (3)

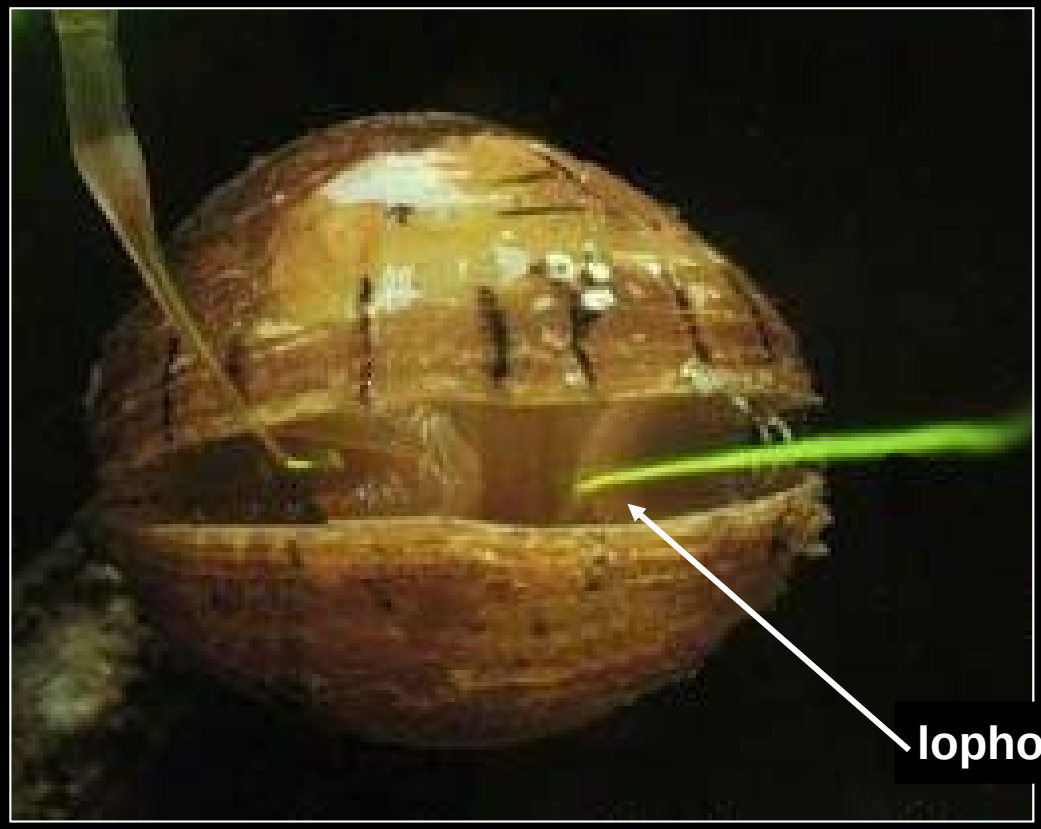


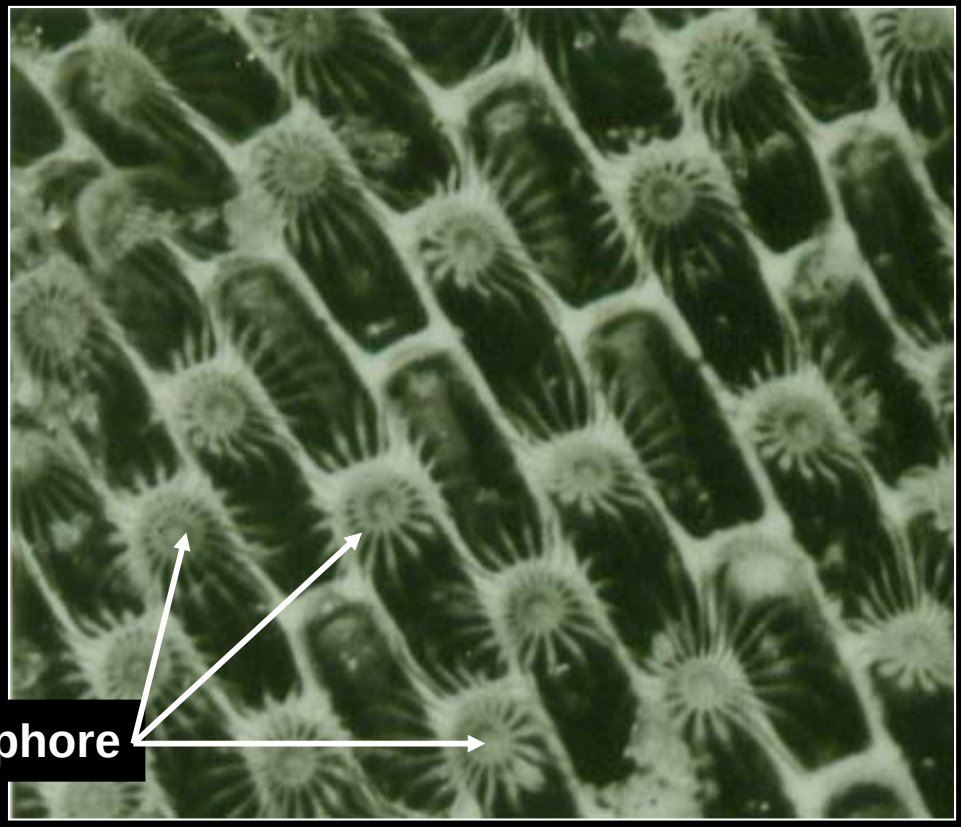


flexibility?

efficiency?

Is modular growth more efficient? (Are colonies more efficient?)

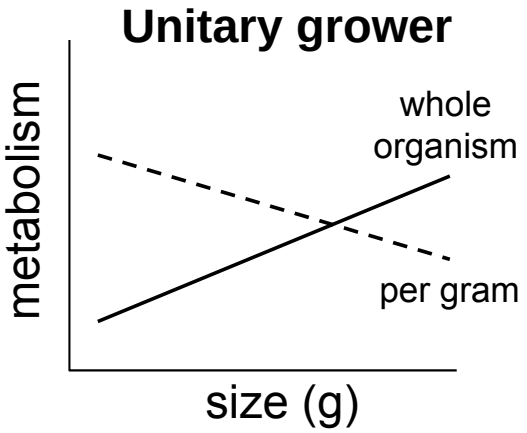


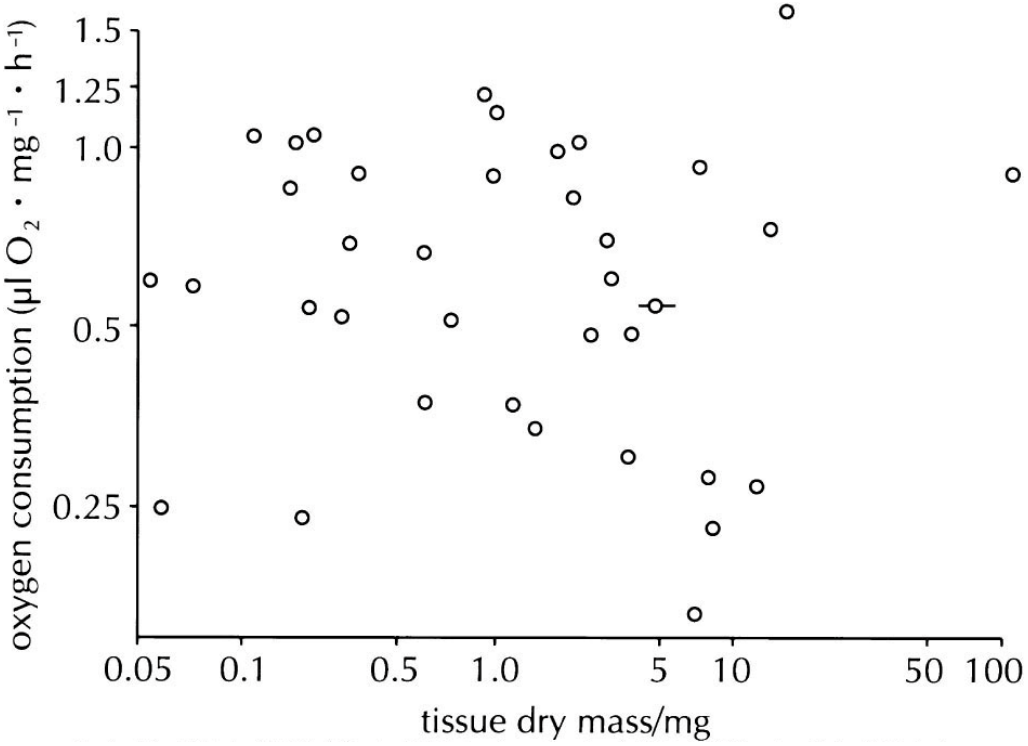


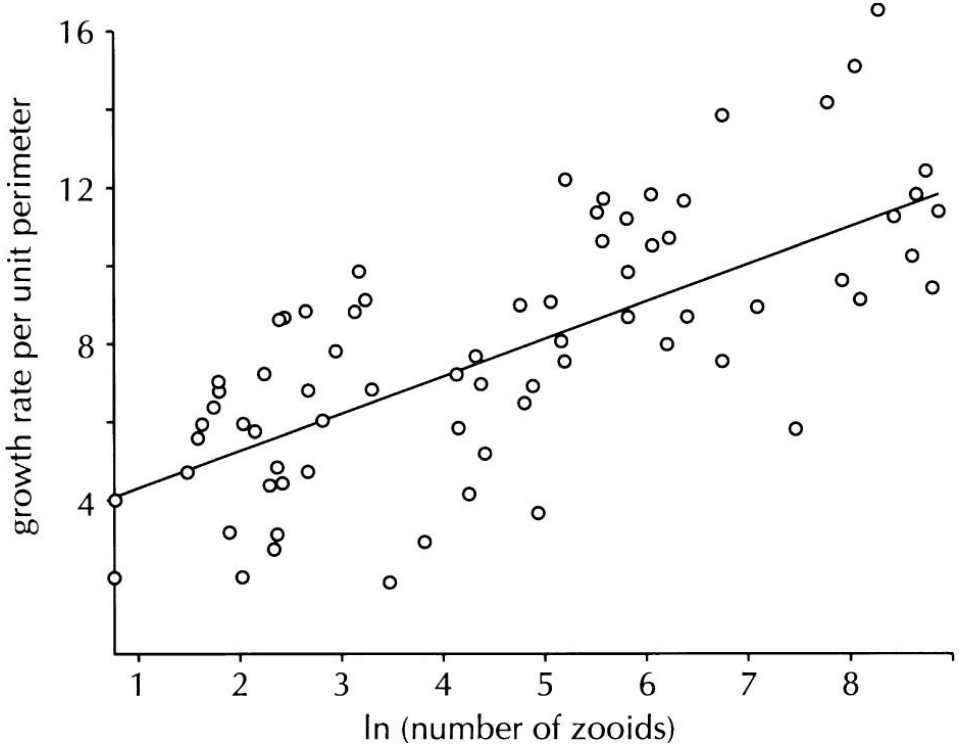
brachiopod

bryozoan

Is modular growth more efficient?
Metabolism in bryozoans

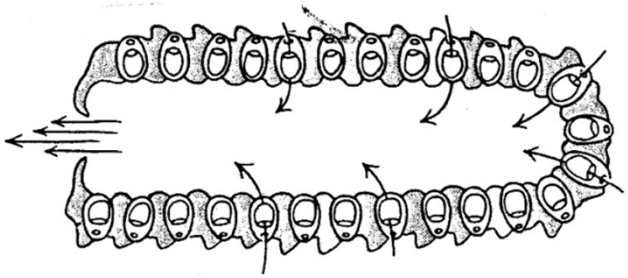




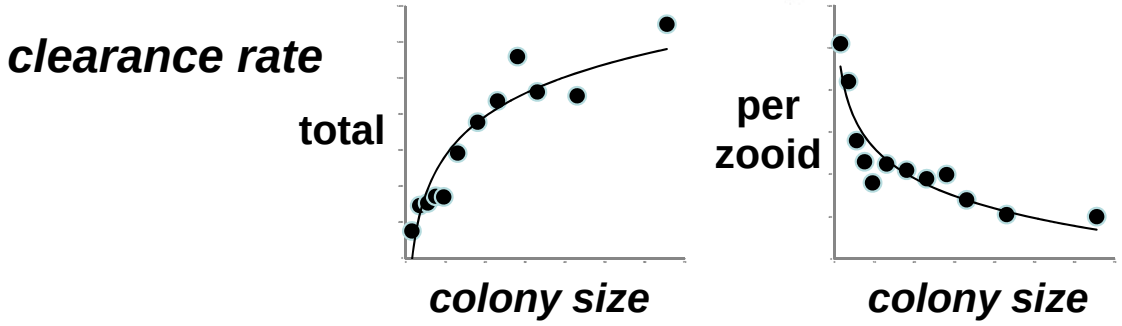


RFB 19.1, Hughes & Hughes 1986

Are colonies more efficient?
Feeding in pyrosomes

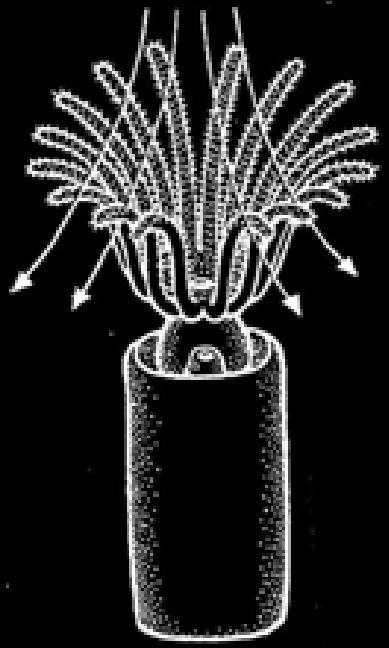


Colony Size (number of zooids)	Total clearance (microliter/min)	Clearance Rate (microliter/zooid/minute)
1–2 (1)[a]	153	102
3–4 (4)	294	84[b]
5–6 (4)	308	56
7–8 (4)	345	46
9–10 (2)	342	36
11–15 (5)	585	45
16–20 (7)	756	42
21–25 (2)	874	38
26–30 (3)	1120	40
31–35 (5)	924	28
41–45 (5)	903	21
65–66 (3)	1300	20

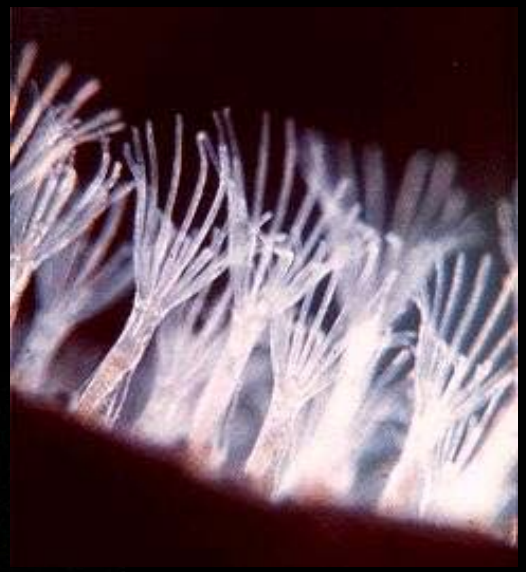


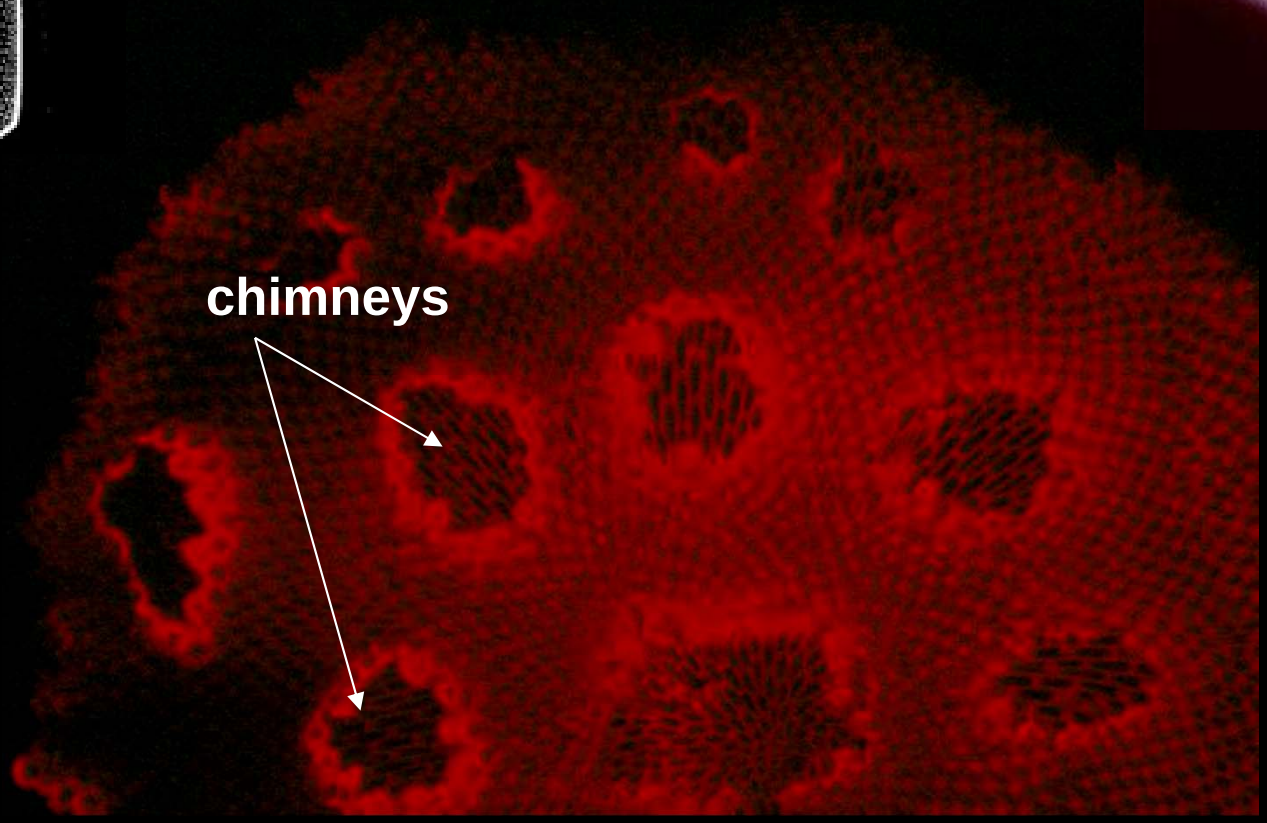
Are colonies more efficient?

Feeding in bryozoans



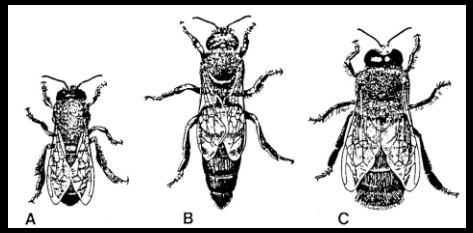
Scaling argument?



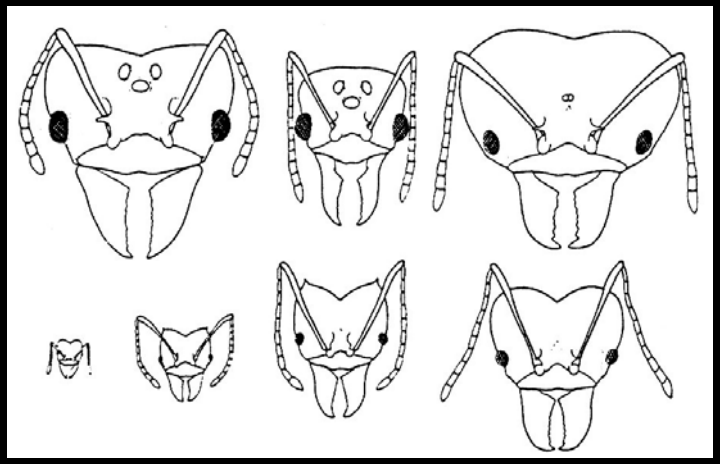


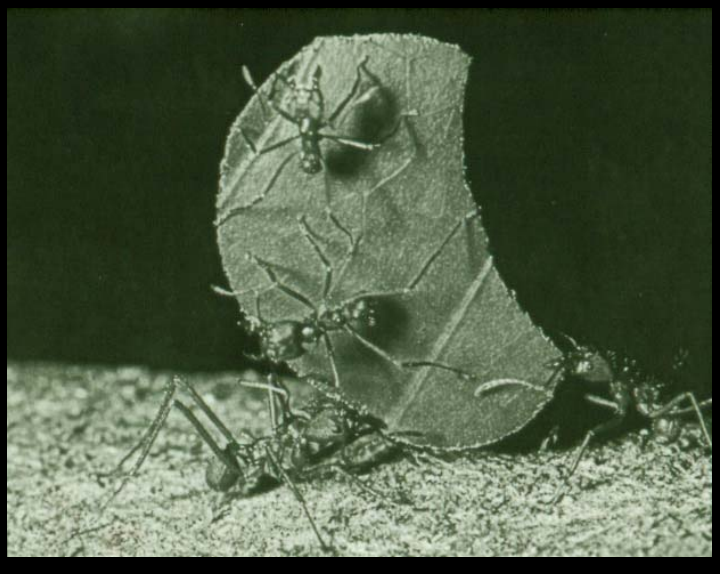
Eusocial insect colonies: modular, polymorphic "superorganisms"?

honeybee workers



minor worker guarding media worker
Atta leaf-cutter ants





"living-door" soldier
Camponotus truncatus