

# Sexual reproduction and larval biology



## Animals are life cycles

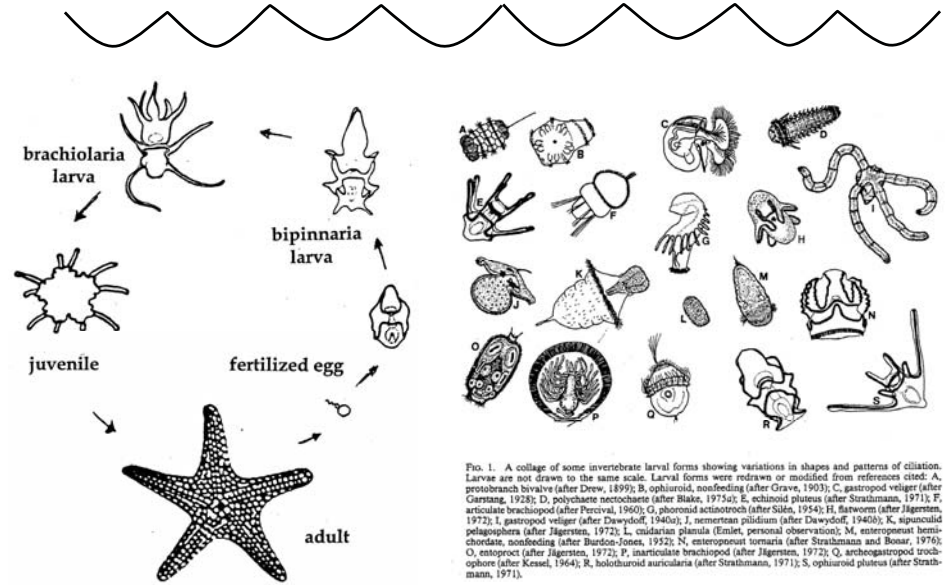


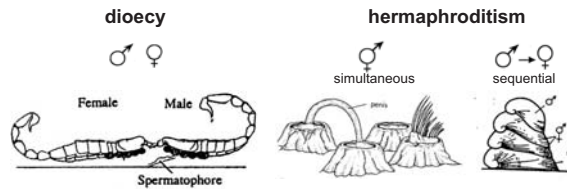
FIG. 1. A collage of some invertebrate larval forms showing variations in shapes and patterns of ciliation. Larvae are not drawn to the same scale. Larval forms were redrawn or modified from references cited: A, protobranch bivalve (after Dewe, 1899); B, ophiuroid, nonfeeding (after Grave, 1903); C, gastropod veliger (after Garstang, 1928); D, polychaete neotrochae (after Blake, 1975a); E, echinoid pluteus (after Strathmann, 1971); F, articulate brachiopod (after Percival, 1960); G, phoronid actinotroch (after Sölen, 1954); H, flatworm (after Jägersten, 1972); I, gastropod veliger (after Deweyhoff, 1940a); J, nemertean pilidium (after Deweyhoff, 1940b); K, sipunculid pelagosphera (after Jägersten, 1972); L, cnidarian planula (Emlert, personal observation); M, enteropneust hemichordate, nonfeeding (after Burdon-Jones, 1932); N, enteropneust tornaria (after Strathmann and Bonar, 1976); O, entoproct (after Jägersten, 1972); P, inarticulate brachiopod (after Jägersten, 1972); Q, archegastropod trochophore (after Kessel, 1964); R, holothurid auricularia (after Strathmann, 1971); S, ophiuroid pluteus (after Strathmann, 1971).

### Modes of Sexual Reproduction

	Sexes <sup>1</sup>	Broadcast Spawn?	Brood? <sup>2</sup>
Porifera	d, H	Yes <sup>3</sup>	+++
Cnidaria	D, h	Yes <sup>3</sup>	+++
Ctenophora	d, h	Yes	+
Platyhelminthes	d, h	C	+
Nemertea	D, h	Yes	+
Nematoda	D, h	C	++
Annel. Polychaeta	D, h	Yes	++
Sipuncula	D, h	Yes	++
Mollusca	D, H	Yes	++
Arthro. Crustacea	D, H	C <sup>4</sup>	+++
Hexapoda	D, h	C	+++
Phoronida	d, H	Yes <sup>3</sup>	+++
Bryozoa	d, H	Yes <sup>3</sup>	+++
Brachiopoda	D, h	Yes <sup>3</sup>	++
Echinod.	D, h	Yes	++
Hemichordata	D	Yes	-
Urochordata	D, h	Yes	++

<sup>1</sup> Sexes: D = dioecious, H = hermaphrodite, lower case = rare.  
<sup>2</sup> Brooding: embryo development encapsulated or on adult body.  
<sup>3</sup> Typically or often only male spawns.  
<sup>4</sup> C = copulation (or other direct gamete exchange)  
<sup>5</sup> All cephalopods, most gastropods.

### Modes of sexuality



### Modes of fertilization

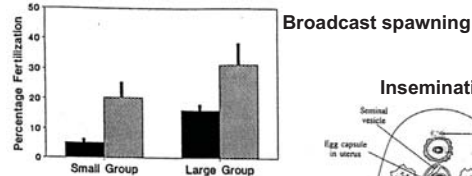
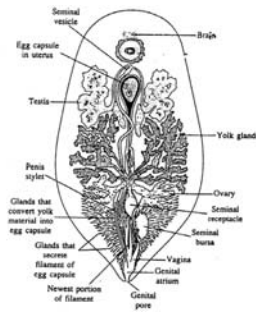
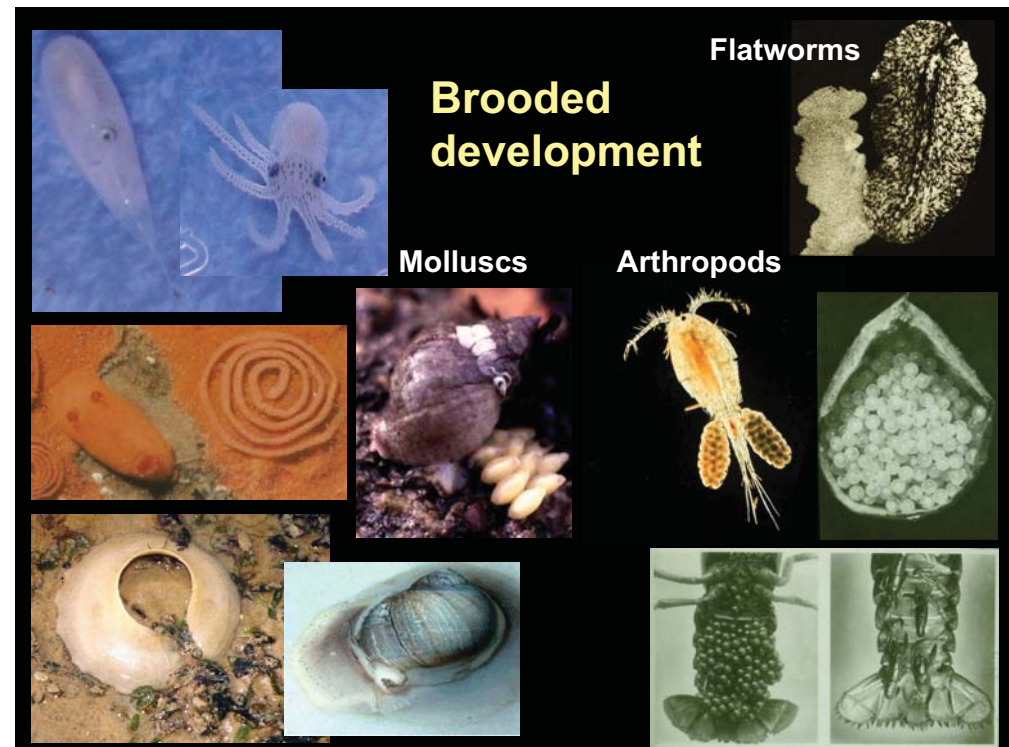
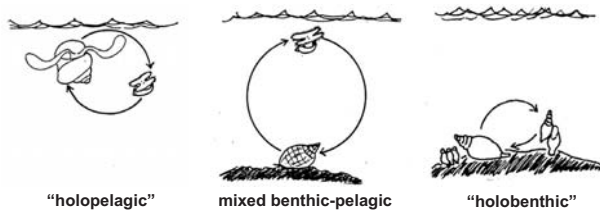


FIG. 4. Percentage of eggs fertilized as a function of spawning-group size and degree of aggregation. Solid bars are dispersed treatments; hatched bars are aggregated treatments.

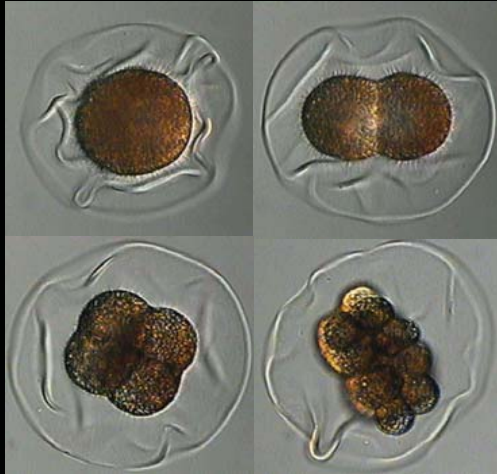
### Insemination



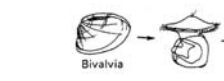
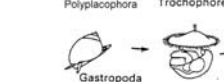
### Modes of habitat use



# Early development in...bryozoans

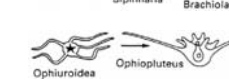
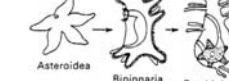
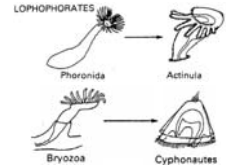
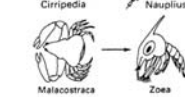
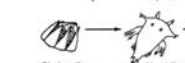
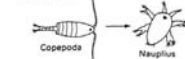


## Presence of metamorphosis and typical larval forms



	Metamorphosis?	Typical larva
Porifera	Yes	amphiblastula
Cnidaria	Yes	planula
Ctenophora	Yes	cydippid
Platyhelminthes	Yes	Müller's, cercariae
Nemertea	Yes	plidium
Nematoda	No	gordoid
Nematomorpha	Yes	acanthor
Acanthocephala	Yes	
Rotifera	Yes	
Annel. Polychaeta	Yes	trochophore
Sipuncula	Yes	trochophore, veliger
Mollusca	Yes	nauplius, zoea
Arthro. Crustacea	Yes	caterpillar, grub, maggot
Hexapoda	Yes	articulate larva
Phoronida	Yes	
Bryozoa	Yes	cyphonautes, coronate
Brachiopoda	Yes	articulate larva
Kamptozoa	Yes	
Echinod. Oph, Ech	Yes	pluteus
Ast, Hol	Yes	bipinnaria, auricularia
Hemichordata	Yes	tomaria
Urochordata	Yes	tadpole
<i>Chaetognatha</i>	No	
<i>Onychophora</i>	No	
<i>Gastrotricha</i>	No	
<i>Kinorhyncha</i>	No	
<i>Loricifera</i>	Yes	Higgins
<i>Tardigrada</i>	No	
<i>Priapulida</i>	Yes	Lorica

### CRUSTACEA

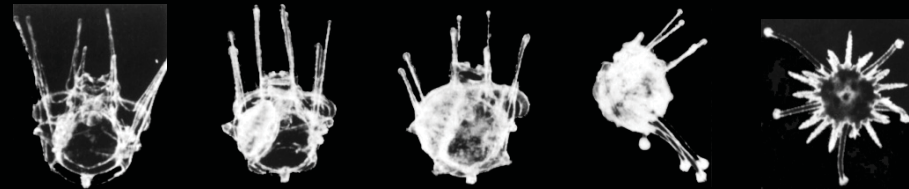


## Metamorphosis in three echinoderm classes

Ophiuroid *pluteus*

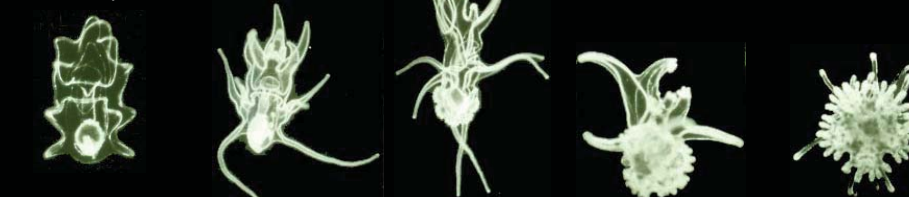
JUVENILE

Echinoid *pluteus*



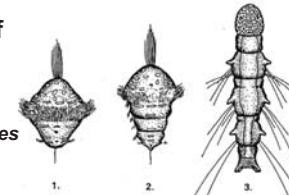
Asteroid *bipinnaria*

*brachiolaria*

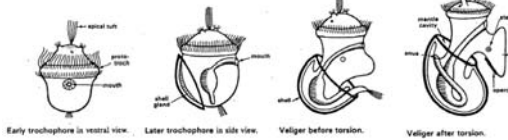


## Some examples of metamorphosis

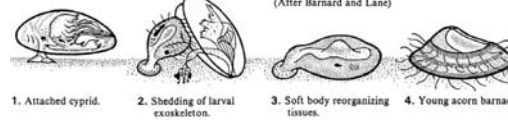
polychaetes



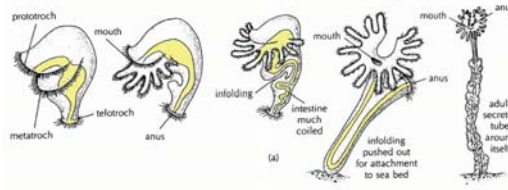
gastropods



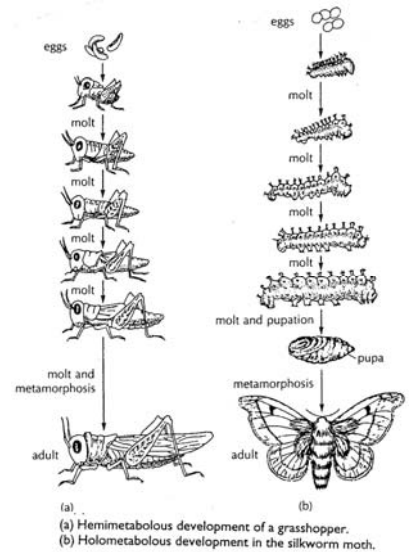
barnacles



phoronids



## Direct and indirect development in terrestrial insects



(a) Hemimetabolous development of a grasshopper. (b) Holometabolous development in the silkworm moth.





Who wants to be a larval biologist?



Who wants to be a larval biologist?

"bipinnaria"

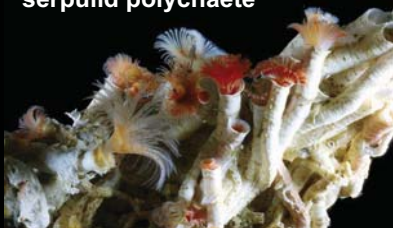


Who wants to be a larval biologist?

"trochophore"



serpulid polychaete



Who wants to be a larval biologist?

"veliger"

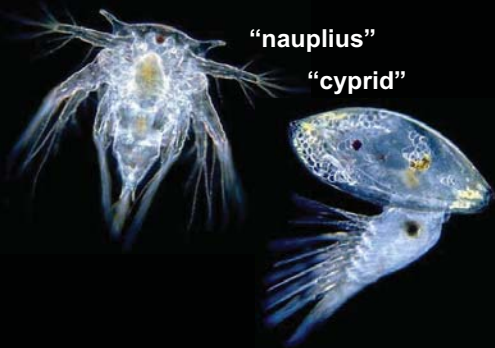


gastropod

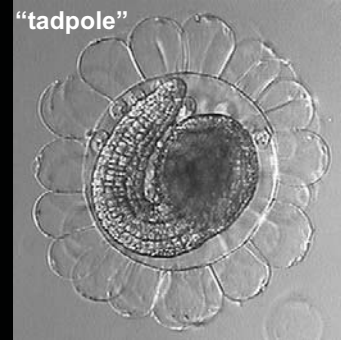




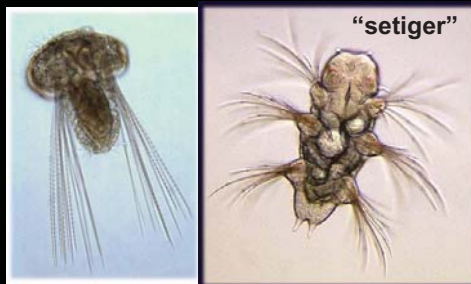
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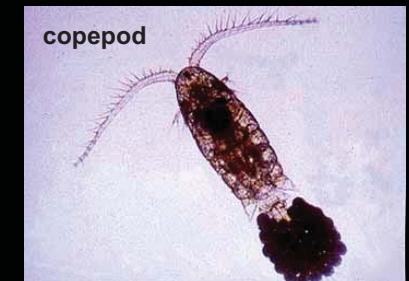
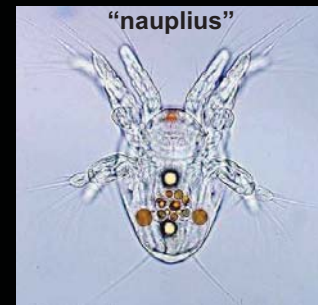
# Who wants to be a larval biologist?



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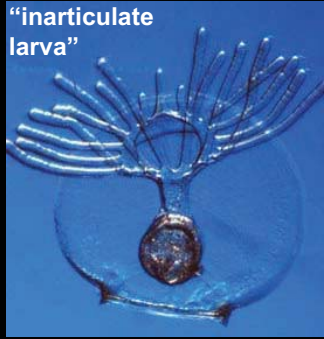


# Who wants to be a larval biologist?





# Who wants to be a larval biologist?



brachiopod



# Who wants to be a larval biologist?



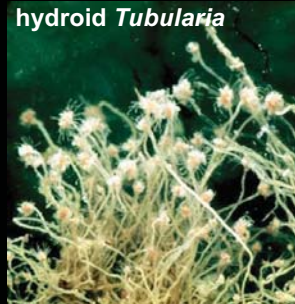
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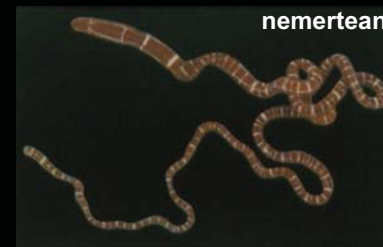
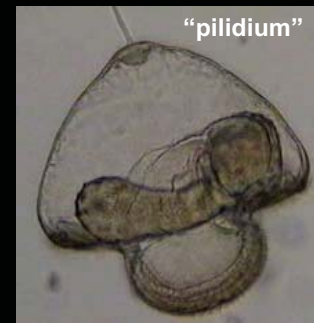
"actinula"



hydroid *Tubularia*



# Who wants to be a larval biologist?



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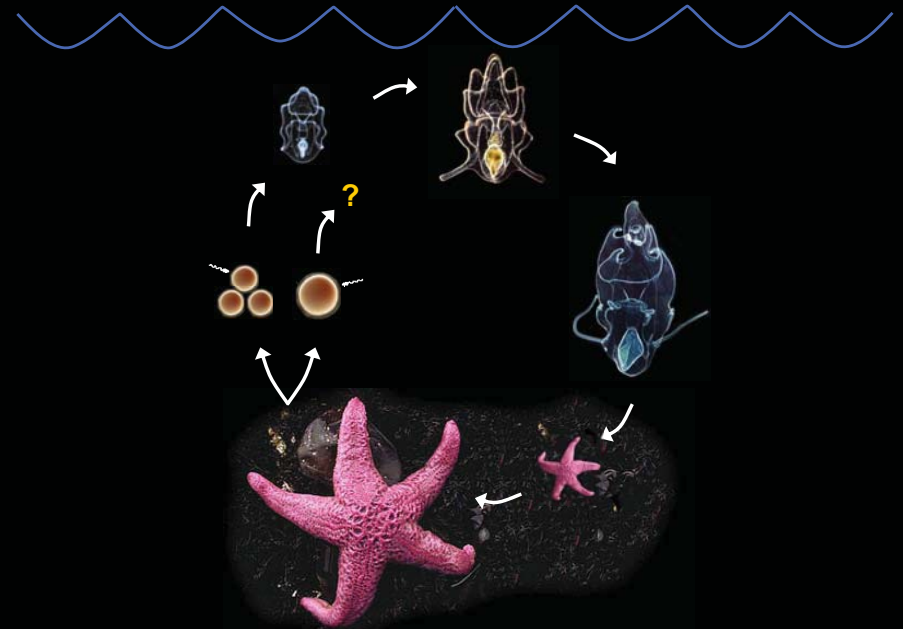


"tornaria"



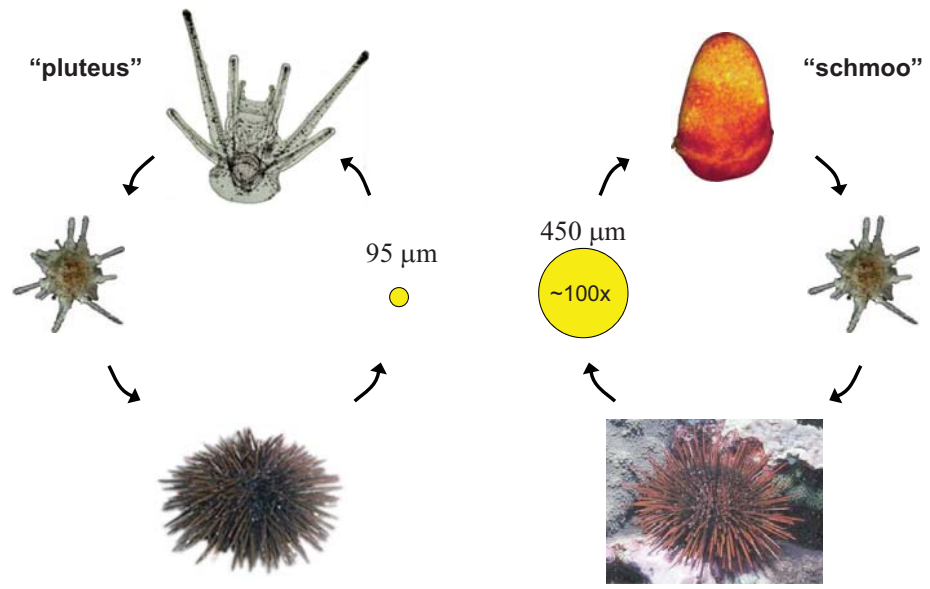
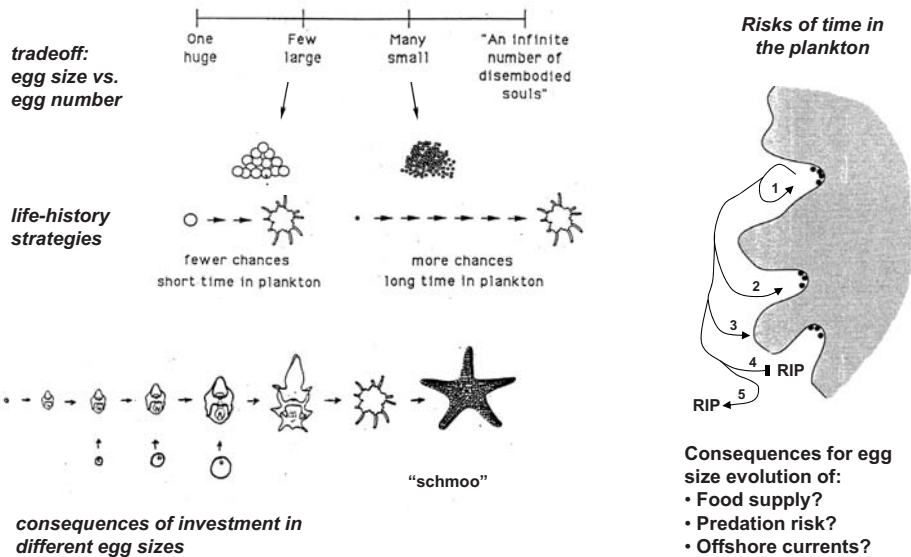
hemichordate

# Animals are life cycles



## Life-history evolution of marine invertebrates

### the "time-fecundity model"



*Heliocidaris tuberculata*

*H. erythrogramma*