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# Background Information *Artemia franciscana*

## Taxonomy

Phylum: Arthropoda

Subphylum: Crustacea

Class: Branchiopoda (includes fairy shrimp, brine shrimp, daphnia, clam shrimp, tadpole shrimp)

Order: Anostraca (brine shrimp and fairy shrimp)

Genus and species: *Artemia franciscana* (the North American version of *Artemia salina*)

## Reproduction

Typically, sexes are separate and adults are sexually dimorphic. Males have large graspers (modified second antennae) which easily distinguish them from females. In some species and populations of *Artemia* (for example, Europe), males may be rare and females reproduce by parthenogenesis.

During mating, males deposit sperm in the female ovisac where eggs are fertilized and covered with a shell. Eggs are then deposited and stored in a brood sac near the posterior end of the thorax (Figure M on page 8). Once fertilized, eggs quickly undergo cleavage and development through the gastrula stage (Figures A–E). After one or a few days, eggs are then released by the female (oviposition). Multiple batches of eggs may be released at intervals every few days by the same female.

Two types of eggs may be laid—(1) thin-shelled "summer eggs" that continue developing and hatch quickly, or (2) thick-shelled, brown "winter eggs" in which development is arrested at about early gastrula stage. Such "winter eggs," in their dried and encysted form, survive in a metabolically inactive state (termed cryptobiosis) for up to 10 or more years while still retaining the ability to survive severe environmental conditions. For example, *Artemia* eggs may remain viable after heating to 80 °C for 1 hour, cooling to –190 °C for 24 hours, or reducing air pressure to 0.000001 mm mercury for 6 months!

## Embryology

Cleavage of the developing egg is total and yolk is equally distributed among blastomeres. While within the female brood sac, egg development proceeds rapidly through cleavage and blastula stages (Figures A–C). Eggs are then deposited in the environment where they may remain encysted, with embryonic development arrested at about early gastrula stage (Figures D–E). At this time, there are about 4,000 cells in the embryo and these are highly organized, but no organs are discernible.

When encysted eggs are exposed to more favorable conditions (rehydration), the eggs swell and rapid development of the embryo resumes, resulting in completion of the nauplius stage (Figures F-G). Hatching occurs in about 1–2 days, depending on temperature. For the first few hours, the nauplius stays within a hatching membrane that hangs beneath the cyst shell. This is also called the "umbrella stage" in which development of the nauplius is completed.

## Larval stages and growth

Larval development of *Artemia* has been described in detail by several authors. Although basic interpretations of development are similar, there are differences among authors regarding the numbering of molts and the naming of various instar stages.

At hatching, the nauplius larva (instar #1) emerges as a free-swimming stage (Figure H). This stage is about 0.4–0.5 mm in length and brownish-orange in color, due to the presence of yolk material. In a sense, the body of the nauplius larva consists mainly of a head. It has three pairs of "head" appendages—a pair of small first antennae (antennules), a pair of well-developed second antennae, and a pair of mandibles. There is a large lip-like structure (labrum) covering a ventral mouth. A nauplius eye is present but it is not easily distinguished at this stage.

The posterior end of the nauplius consists of the future trunk—it is short, undifferentiated, and unsegmented (Figure H). The nauplius larva does not have a complete digestive tract and does not immediately feed. It relies on stored yolk as an energy source. Depending on temperature, it swims weakly for about 12–20 hours and then molts into the metanauplius larva (second instar).

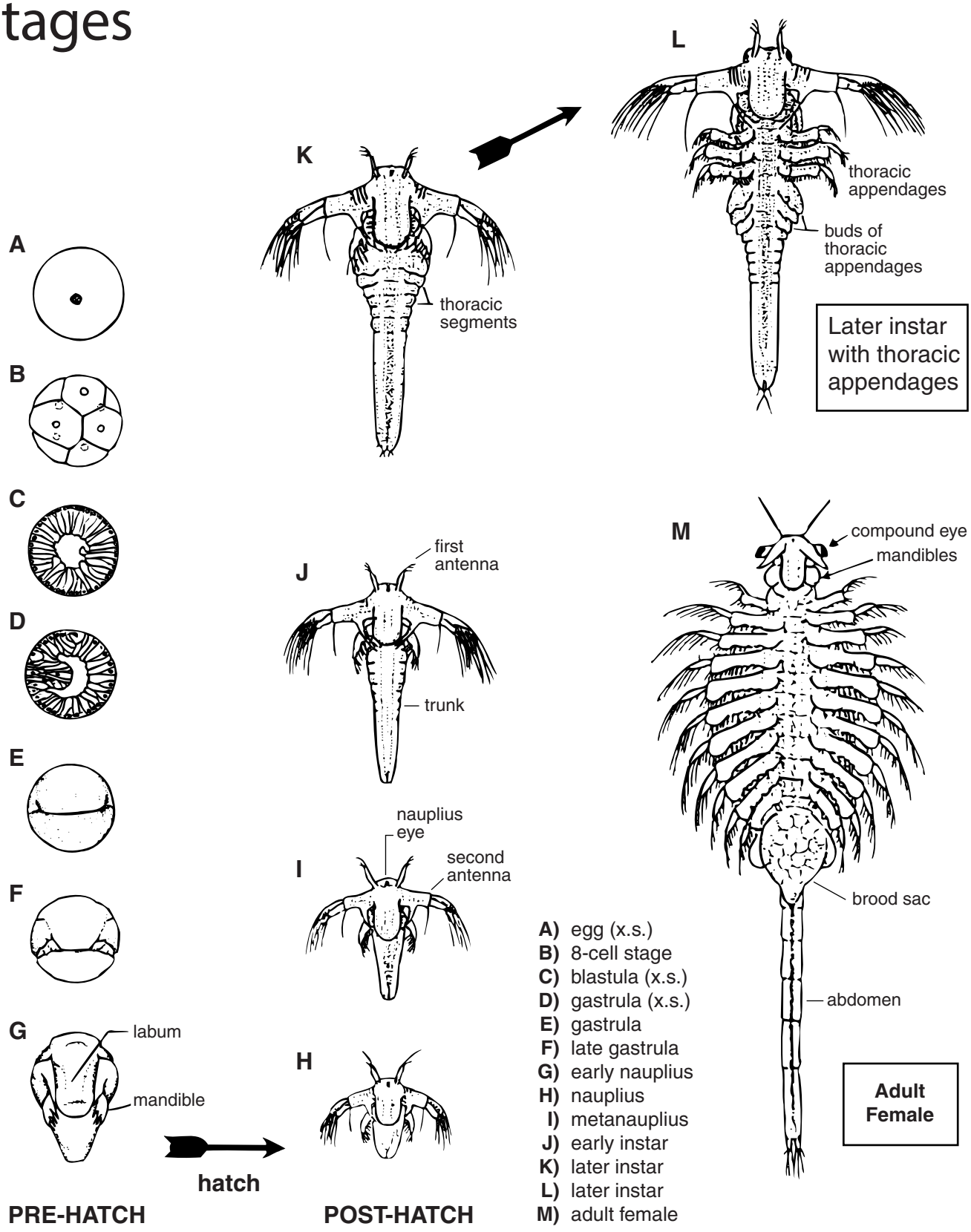
The metanauplius larva is translucent in color and about 0.6 mm in length (Figure I). Its trunk region is noticeably longer, and this region continues to lengthen and differentiate through the next series of molts. The metanauplius swims vigorously using its second antennae which are now better developed. At this stage it starts filter-feeding. Its food consists mainly of microalgae, bacteria, and detritus.

The next three stages (each terminated by a molt) are also classified as developmental stages. Examples are shown in Figures J–K. Some metanauplius trends during these later stages include more developed mouth part appendages (maxillules and maxillae) and a longer thoracic region, with some definition of thoracic segments.

Next, there are seven postnaupliar stages—one example is shown in Figure L. During these stages, the antennae begin to undergo a reduction in size and paired thoracic appendages begin forming. With each stage, these appendages become more numerous, larger, and functional. In addition, the compound eyes become more fully developed, the labrum is reduced in size, and abdominal segments become defined.

Then, there are a series of five postlarval stages (not illustrated) involving further reduction in the antennae, multiplication of ommatidial facets in the compound eyes, lengthening of the eyestalks, and formation of sexual organs.

# *Artemia* Development from Egg to Adult Stages




**A)** egg (x.s.)
**B)** 8-cell stage
**C)** blastula (x.s.)
**D)** gastrula (x.s.)
**E)** gastrula
**F)** late gastrula
**G)** early nauplius
**H)** nauplius
**I)** metanauplius
**J)** early instar
**K)** later instar
**L)** later instar
**M)** adult female

# Transparency Strips