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## Arthropod Life History

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### Definition

The changes undergone by an arthropod during its lifetime.

### Introduction

Arthropods account for over 80% of the species on earth. As such, the diversity of life histories of arthropods practically spans that of all life. Arthropods are born, grow to sexual maturity, reproduce, and die; discovering variation and patterns of these major life events is to study life history of arthropods (Stearns 1992).

There are four major groups of extant arthropods. Chelicerates (>100,000 species) include animals like spiders, mites, harvestmen, and the four extant species of horseshoe crab; Crustaceans (>70,000 species) include groups like crabs, shrimp, barnacles, woodlice, and brine shrimp; Myriapods (>16,000 species) include centipedes and millipedes. The most speciose group, insects (>2 million, and perhaps as many as 30 million), includes beetles, butterflies, flies, and bees,

among many others. Extant arthropods range in size from the crustacean giants to maxillopod miniatures. The Japanese spider crab is the largest of all arthropods with a 2.8 m leg span and the American lobster is the heaviest, weighing over 20 kg. Coconut crabs are the world's largest terrestrial arthropods, weighing over 4 kg, and with a 1 m leg span. Tantulocarida – highly specialized parasitic crustaceans – includes the smallest arthropod species, measuring only 85  $\mu\text{m}$ . This vast richness of life presents a variety of life histories, which are discussed below.

### Reproduction

Most arthropods reproduce sexually in a bisexual population. Like all things in arthropod life history, however, there are interesting exceptions. Some species (e.g., most barnacles) are hermaphroditic, such that a single individual has both male and female sexual organs (Charnov 1987). These species often mate with other individuals, but self-fertilization can also occur (Yusa et al. 2011). Other species are parthenogenic (e.g., some bees and scorpions), where unfertilized ova develop without sperm.

Nevertheless, most arthropod species need to find a mate and transfer sperm to reproduce. Arthropods can have internal or external fertilization, depending on the species. Aquatic arthropods may release gametes into the water column, where sex occurs externally. All terrestrial

arthropods, and many aquatic species, engage in internal fertilization, where sperm are inserted into the reproductive tract of the female by some mechanism. The most common mechanism for internal fertilization is the spermatophore, a packet of sperm deposited by the male and retrieved by the female (Proctor 1998). The simplest form of spermatophore deposition occurs when males leave spermatophores in the environment for females to find. Alternatively, courtship rituals can be used to direct females to the spermatophore, which may be deposited on sclerotized (hardened cuticle) stalks (Weygoldt 2000). Further, spermatophores may be deposited directly into the female via a variety of organs, including pene and gonopores (Macías-Ordóñez et al. 2010). Females of many species have mechanisms to store sperm for multiple clutches, or divert it away from eggs to avoid fertilization from an unsuitable male (Andersson 1994). Spermatophores can include nutrients to support offspring survival, or hormones to change female behavior (Gillott 2003; Vahed 1998).

Arthropods may be semelparous or iteroparous (one vs. multiple reproductive events). Some species produce a single clutch of eggs before senescence, while others produce multiple clutches in a season, year, or across multiple years. Arthropods can produce very few to thousands of offspring per reproductive event. According to life history theory, arthropods, like all organisms, should maximize reproductive fitness by optimizing the relationship between the quality and quantity of offspring. Some arthropods, like Theraphosid spiders, produce hundreds of tiny offspring, of which only a small fraction survive to adulthood. Still other arthropods, however, produce very few young (e.g., some tsetse flies produce only a single egg; Tobe and Langley 1978). Variation in offspring number and size is also in part explained by environmental variation, with substantial variation occurring within species (Fox and Czesak 2000).

## Parental Care and Sociality

The level of parental investment varies in arthropods more than any other group. Forms of postzygotic parental care include nest and burrow building, territoriality, caring for eggs, caring for young after hatching, and provisioning young with food, even after offspring are independent (Clutton-Brock 1991; Trumbo 2012). Notable behaviors include exclusive paternal care seen in many harvestmen (Opiliones) – only the male contributes postzygotic resources (Tallamy 2000; Pinto-da-Rocha et al. 2007). Many arthropod species engage in matrophagy (>3000 species; Ostrovsky et al. 2016), where offspring consume a parent (usually the female) to increase offspring survivorship, and presumably, parent inclusive fitness (Ostrovsky et al. 2016). Most scorpions carry offspring on their dorsum for protection, and may even provide food to young (Polis 1990).

Parental care is one of the two evolutionary routes to sociality (Bourke 2011). In the most basic sense, an offspring receiving care from one or both parents is a social group. Social groups lasting longer than this initial period have evolved in many Arthropod groups. Groups made up of relatives are termed fraternal groups, while groups made up of nonrelatives are termed egalitarian groups (Bourke 2011). Fraternal groups include the social bees, wasps, and ants (of the order Hymenoptera), termites, and some species of beetle, true bugs, and thrips, all of which form large colonies with one or a few reproductive individuals. This reduction in reproductive individuals insures genetic relatedness among colony mates. Some species of spider form large fraternal groups, but, unlike social Hymenoptera, have little skew in reproduction across individuals of a colony. Instead, colonies maintain high relatedness by inbreeding (Bilde et al. 2005; Agnarsson et al. 2006). As mentioned, egalitarian groups are social groups composed of nonrelatives. Examples include arthropods that group around a resource like spiny lobsters, harvestmen, or amblypygids that aggregate around high-quality microhabitat (Zimmer-Faust and Spanier 1987; Machado 2002; Chapin 2014).

## Birth and Growth

All arthropods are born from eggs, although ovoviviparity, in which eggs hatch inside the mother, which then gives birth to free-living young, occurs in some species (scorpions, in particular). Eggs can be deposited into the environment (water column, on vegetation), in a built structure (burrows, silk chambers), or are carried by the female.

Arthropods grow by molting a sclerotized exoskeleton (Gilbert and Frieden 1981). Many arthropods have a series of molts, the last of which results in sexual maturity, and, in the case of insects, wings. Thus, arthropods not only increase their size with successive molts, but also change morphologically as they develop into adult forms. These growth patterns are often binned into three categories, based on the level of change that occurs during development: ametaboly, hemimetaboly, and holometaboly. Ametabolous (sometimes termed direct development) arthropods maintain general morphology from hatchlings to adulthood. All myriapods, bristletails, and silverfish, for example, exhibit this form of development. Many arthropods engage in hemimetabolous development (sometimes termed simple or incomplete metamorphosis), which has three stages (egg, nymph, and adult) and more minor changes in morphology than complete metamorphosis. Examples include insects like true bugs, crickets, and cockroaches, which have young that generally resemble adults, but without wings or reproductive organs.

The most complex form of metamorphosis is holometaboly, also called complete metamorphosis. Holometabolous arthropods exhibit four developmental stages: egg, larva, pupa, and adult. Eggs hatch and the larva (e.g., caterpillars, maggots, and grubs) undergo several molts before entering the pupa stage, during which the arthropod is usually inactive. After some time, the adult molts from the pupa, usually with notable morphological differences from the juvenile form. Holometabolous arthropods include butterflies, beetles, and flies. An estimated 45–60% of all living species are holometabolous insects (Hammond 1992). Some arthropods, like

Amblypygi and female Theraphosid spiders, have postultimate (after-maturity) molts (Chapin and Hebets 2016). These species also tend to have extended lifespans, and multiple reproductive events.

## Conclusion

Arthropods make up the majority of Animalia and, thus, represent the enormous variation in life histories. Adapted life histories range from living hours to decades, producing a few to thousands of offspring, and providing little to huge offspring benefits. The diversity that Arthropoda captures is exceptional, and so is the life history of animals in the world's largest phylum.

## Cross-References

- ▶ [Arthropod Cognition](#)
- ▶ [Arthropod Sensory Systems](#)
- ▶ [Insect Cognition](#)
- ▶ [Insect Sensory Systems](#)

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