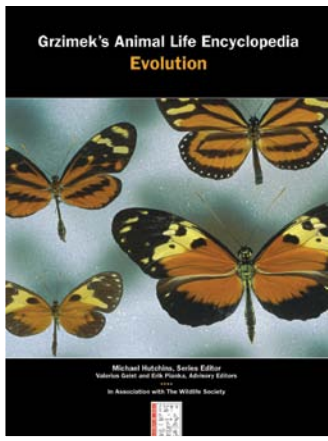


NEW TITLE



Grzimek's Animal Life Encyclopedia: Evolution

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Grzimek's Animal Life Encyclopedia: Evolution

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FULL COLOR

Convergent evolution and ecological equivalence

Discovered by the German zoologist Fritz Müller (1821-1897), Müllerian mimicry by contrast occurs when two species, both distasteful or dangerous, mimic one another. Both bees and wasps, for example, are usually banded with bright yellow and black. Because potential predators encounter several species of Müllerian mimics more frequently than just a single species, they learn to avoid these bees, and the relationship is actually beneficial to both prey species. The resemblance need not be as precise as it must be under Batesian mimicry because another species actually deceives the predator, rather, each only reminds the predator of its danger or distasteful properties. Müllerian mimicry is beneficial to all parties, including the predator, because mimics merely remind predators that they are distasteful or poisonous; they can be equally abundant and, in contrast to Batesian mimicry, they are rarely polymorphic.

Convergent evolution of eyes and intelligence

Other examples of convergence involve the development of similar characteristics to solve similar problems of adaptation.



Müllerian mimicry occurs when two species, both distasteful or dangerous, mimic one another. Both bees and wasps, for example, are usually banded with bright yellow and black. © Justin W. 2010/istockphoto.com

For example, anatomically remarkably similar eyes have evolved independently in cephalopods (cuttlefish, squid, and octopus) and vertebrates, although the positioning of light-sensitive cells in the retina is different—photoreceptors face the pupil in cephalopods but are on the back side of the retina in vertebrates. (Eyes in these mollusks are actually better developed than those of vertebrates.) Intelligence has arisen, multiple times, most notably in cephalopods and marine invertebrates, as well as in birds and mammals (especially in cetaceans and primates).

Arid regions of South Africa support a wide variety of euphorbia-like plants, some of which are strikingly close to American ones phylogenetically. They are halophyte succulents, protected by sharp spines, presumably adaptations to reduce water loss and predation in arid environments. Similarly, evergreen sclerophyll shrubs shrubs have evolved convergently under Mediterranean climates in several different geographical regions with winter rain and prolonged summer droughts (Mooney and Dunn 1976). Spines, used in defense, have evolved in several different mammalian lineages, including New World and African porcupines, the thorns of Madagascarian and the Canary Islands, African and European hedgehogs, and Australian and New Guinean echidnas (monotremes).

Convergence sometimes occurs under unusual conditions where selective forces for the achievement of a particular mode of existence are particularly strong. Presumably in response to thick-skinned prey, two fossil saber-tooth carnivores, the South American marsupial "cat" *Thylacynus* and the North American placental saber-toothed tiger *Homotherium*, evolved long, knife-like canine teeth independently (though these two species were not contemporary). Many other marsupial mammals have undergone convergent evolution with placental mammals, including wolf-like (marsupial) dingo, moles (marsupial) quoll, and diabolical (marsupial) kangaroo (Carter 1976). Carter also emphasizes that "mars" and "tam" have evolved repeatedly among many different mammalian lineages.

Still another example of convergent evolution is seen in the similar shape and coloration of fish and cetaceans, both of which have adapted to the marine environment by developing a fusiform body (one tapering at both ends) and neutral buoyancy. They are also counterintuitive, with a light underbelly and a darker upper surface, which makes them less visible from both below and above. Counterbalancing is actually the role among both cephalopods and vertebrates, however, so it is presumably an ancestral trait that has been retained throughout the evolution of both groups. Counterbalancing is important for predators as in a prey species, as it makes both harder to detect.

Convergent evolution of molecules

Even molecules can evolve convergently, especially when parasites mimic molecular messages that signal "self" to immune responses of hosts, which allows the parasite to elude its host's defenses. Molecular convergence could also take place when a particular metabolic function requires similar or identical molecular structures (Doolittle 1996). Some gene circuits and gene networks appear to have undergone convergent evolution by single-gene duplications in higher

Evolution

Evolution



The counterbalancing on a killer whale (*Orcinus orca*) is important for the predator, as it makes it harder to detect in the water. © Brandon D. Gray/Corbis

evaporates (Antonovics et al. 2004; Conant and Wagner 2003). Convergence in DNA nucleotide sequences would lead to erroneous phylogenetic conclusions, which would be problematic for molecular systematic studies.

Ecological equivalence

Evolutionary convergence involving unrelated organisms living in similar environments but in different places (known as allopatry) can also occur in another way. This usually takes place in relatively simple communities in which biotic interactions are highly predictable and the resulting number of different ways of exploiting the environment is limited. Similar environments pose similar challenges to survival and reproduction, and those traits that enhance Darwinian fitness are selected for in each environment. Such organisms that fill similar ecological roles in different, independently evolved biotas are termed "ecological equivalents" (Huxford 1924; Hubbell 2000).

Examples are legion. For instance, wings and winglike structures have evolved independently several times, in insects, reptiles (parrots and birds) and in mammals (bats) (Dryden 2007). Flight first evolved in insects about 330 million years ago (mya), second in pterosaurs (about 225 mya),

later in birds (about 130 mya), and still later in bats (50-60 mya). Some frogs, lizards, and mammals have also evolved the ability to glide, presumably a precursor to flight. In order to land safely, such long gliders must time their fall precisely at the right moment and place.

For many years, avian systematics classified Old World and New World vultures as close relatives, both thought to be allied to raptors (birds) and owls. DNA evidence indicates, however, that, although Old World vultures are indeed related to raptors, New World vultures are not and are instead descendants of common ancestors to birds and cranes. Morphological convergence was strong enough to actually mislead students of bird classification. Interestingly, a behavioral trait was conserved in the evolution of New World vultures: When least stressed, vultures defecate onto their own legs to dissipate excess heat. New World vultures do this, whereas Old World vultures do not.

A brown bird of some African prairies and grasslands, the African yellow-bellied longbill (*Macropygia tenuirostris*), a monophyletic, has a yellow breast with a black chevron. "V." This colorful bird acts so much like an American roadrunner (*Streptopelia megala*) in several, that a competent bird watcher might mistake them for the same species, yet they belong to different avian families. Another example is the North American

Vivid color images complement in-depth, accessible text.

Evolution

Adaptation and evolutionary change



The desert iguana (*Dipsosaurus dorsalis*) has adapted to extreme temperatures and practices behavioral thermoregulation. © Gert Hochmuth. Image from iStockPhoto.com.

adaptation as well, by flying low in open spaces and more in vegetation, where it is harder for bats to detect them via echolocation (Lewis, Puffard, and Merrill 1993). Interestingly, human engineers have mimicked sonar and the echolocation function of bats and dolphins in robots. The objective of this work was to evaluate the value of sound waves in lieu of vision for habitat exploration. Sound waves allow for an immense amount of detail to be detected (Kuc 1997).

Adaptations to extreme environments

While echolocation serves as an excellent adaptation for nocturnal hunting, organisms that live in extreme temperatures also have a unique set of adaptations to survive. Musk oxen (*Ovibos moschatus*) are large, hooved mammals that live in Arctic regions. They have adapted to severe winter temperatures that fall well below freezing, via several adaptations. These include practicing energy conservation during the extreme winter months, gaining the ability to digest low-quality forage, retaining high body fat, and having a very thick, warm coat that is comprised of two layers (Raybould, Wilson, and Klein 2002). The outercoat is comprised of long, tough, water-resistant guard hairs, which grow for several years and are never shed. The undercoat, or qiviut, is

comprised of down and serves as insulation during the winter but can be shed each spring (Dowell et al. 2001).

Animals that do not have fur coats have adapted to frigid habitats in other ways. Some species have evolved antifreeze glycoproteins as an adaptation to cold environments. In fact, several Antarctic monacanthid fishes, as well as northern cod, have converged on the same solution to freezing water temperatures by making these unique antifreeze proteins, even though these fishes are not at all closely related and are found in different orders and superorders. The antifreeze glycoproteins that these fishes synthesize are very similar to one another and are encoded by a family of polyprotein genes. Each gene produces multiple glycoprotein molecules in tandem (Chen, DeVries, and Cheng 1997). The gene sequences and structures of the proteins, however, demonstrate that they have evolved independently in the different fishes (Chen, DeVries, and Cheng 1997). Thus, these unrelated fishes have evolved the same adaptation that allows for survival in a harsh ecological environment. When relatively unrelated organisms independently evolve the same, or very similar, adaptations to a particular circumstance, this is called convergent evolution.

In stark contrast, many plants and animals have adapted to the extreme temperatures, the high variance in hot and

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