The "Backwards" March of Evolution: The Destruction of Self to Ensure the Future

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Imagine for a moment that you are on a relaxing vacation in a small yacht, spending your time idly watching the horizon, taking comfort in the endless seas of water before you. To help pass the time, you decide to go fishing, hoping to catch a monstrous fish that will surely be the stuff of legends. After a few moments, you feel a sharp tug and you pull excitedly. However, what comes out is anything but prize-worthy. A hideous nightmare emerges from the other end: a misshapen blob full of spines and teeth stares back at you, almost daring you to even try to eat it. Small, indistinct, blobby growths jut out of its body, as if the fish were in the terminal stages of cancer. This eldritch horror is the deep sea angler, a disturbingly ugly fish that, since 2003, has been scaring children watching the heartwarming adventures of a clownfish looking for his son. Its unique characteristics arise from adaptations to living in the depths of the sea. For example, the small "cancers" described before are actually individual males that have permanently melded with the female, becoming little more than blood-sucking reproductive organs. Such events are known as degenerative events, characterized by the destruction or loss of certain physiological structures, and their evolution has long been the subject of debate.

While the basic concept of evolution, or descent with modification, has remained more or less constant during the intervening years since its inception, the concept of "why" has undergone significant changes. During the late 1800's, one offshoot of evolutionary theory rose to prominence: the concept of devolution, or backwards evolution. At this time, England was in the midst of the Victorian era, when the virtues of self-worth and self-sufficiency were heavily valued and appreciated (Brown, 2007). Strong work ethics, combined with beliefs that social barriers could be overcome if one worked hard enough, allowed for increases in social mobility for lower class citizens. Consequently, those perceived as "paupers" were despised due to the perception that their poverty was due to an unwillingness to make an honest living. Simultaneously, Europe's imperialistic policies and aggressive colonization of other continents contributed to a sense of European superiority over all other beings. In 1877, American anthropologist Lewis H. Morgan published his treatise titled Ancient Society: or Researches in the Lines of Human Progress from Savagery, through Barbarism to Civilization, where he promised to guide the reader along the path of human progression, "bring[ing] forward additional evidence of the rudeness of the early condition of mankind, of the gradual evolution of their mental and moral powers through experience, and of their protracted struggle with opposing obstacles while winning their way to civilization."

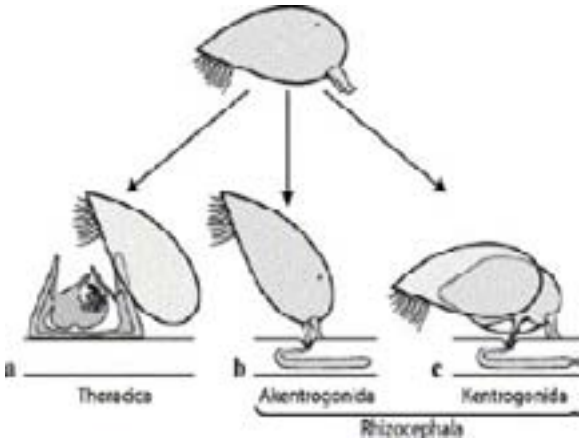

Figure 1. Barnacle Attachment and Maturation. Thoracica are typical barnacles that grow on secure surfaces. Rhizocephala are the parasitic barnacles that utilize specialized stylets to inject cells into the crab host.

The dichotomy between primitive and civilized states would bleed its way through all aspects of society, biology not excluded. By this point, Charles Darwin's then controversial book, *On the Origin of Species,* had largely become accepted in the biological community. However, misconceptions still abounded. Late 19th century society was categorized into varying hierarchies based on superiority, and biology was to be no exception. During this time period, one model of evolution rose to prominence and has since been characterized as being similar to a Christmas tree (Zimmer, 2000). In this model, all living things were ranked in an ascending ladder of life, with the most primitive of protozoans occupying the bottom rungs while humanity was at its apex. In 1883, devout Christian Henry Drummond declared that as an organism, "thou shalt evolve, thou shalt develop all

thy faculties to the full, thou shalt attain to the highest conceivable perfection of thy race—and so perfect thy race—this is the first and greatest commandment of nature." The mixing of the Victorian values of self-worth and self-determination, as well as European hubris, resulted in some organisms being "condemned" for their unwillingness to conform to these basic natural laws. As a result, certain organisms have acquired an undeserved stigma that carries on to this very day. Parasites were by far the most maligned because of their reliance on their host for food and Drummond absolutely despised them. A parasite "[disobeys] the fundamental law of its own being, and taxes the innocent to contribute to its disgrace" (Drummond, 1883). Biologists such as Sir E. Ray Lankester offered no voice of dissent and instead warned that once the parasitic life cycle was secured, "away go legs, jaws, eyes, and ears." Degeneracy, in this case the loss of physiological structures, was a form of punishment bestowed upon the sloths of the world. In fact, biology merged with history as people began attributing ancient Roman and Mayan decline to overindulgence and idleness that resulted from owning the riches of the world (Zimmer, 2000). Curiously, both Lankester and Drummond harped upon one organism in particular: the parasitic barnacle.

At first glance, barnacles would already seem to be fairly simplistic, degenerate organisms. Often seen encrusting the surfaces of ships or the gentle giants of the sea, the barnacle has been described as "nothing more than little shrimp-like animal, standing on its head in a limestone house and kicking food into its mouth" by Louis Agassiz in the early 1800s. Barnacles are curious creatures because their life cycles can be divided into two phases: a free-swimming larval stage and an immobile adult stage. Typically, the larvae will find a suitable surface and perform a headstand, secreting a cement–like mixture that will permanently attach them to this new surface. At this point, the parasitic barnacles diverge from their typical cousins. Instead of building impenetrable fortresses, parasitic barnacles shrink away and become even less significant. The adult morphologies of these barnacles do not resemble tiny limestone fortresses at all; instead, they resemble fleshy bumps that dot the surface of their crab host (Walker, 2001). Worse yet, upon closer inspection, these structures seem to have only one purpose: sexual reproduction (Walker, 2001). Gone are any traces of food acquisition. Gone are the intricate castles that a barnacle will typically spend a lifetime creating and maintaining. Lankester and Drummond were especially critical of these organisms because they seemed to lack ambition; whilst all other organisms wanted to constantly improve themselves, here was evidence of an organism that was perfectly content to devolve into a formless blob and only engage in hedonistic pleasures. The fact that a free-living creature could devolve into such an abhorrent form went against a perfect plan of evolution. In his treatise Natural Law in the Spiritual World, Drummond outlined the life cycle as such:

> "After penetration into the crab host, the parasitic barnacle undergoes an even more astounding metamorphosis."

> For a time it leads an active and independent life, industriously securing its own food and escaping enemies by its own gallantry. But soon a change takes place. The hereditary taint of parasitism is in its blood, and it proceeds to adapt itself to the pauper habits of its race. […The] Sacculina sets out in search of a suitable host, and in an evil hour, by that fate which is always ready to accommodate the transgressor, is thrown into the company of the Hermit-crab. With its two filamentary processes—which afterward develop into the root-like organs—it penetrates the body; the sac-like form is gradually assumed; the whole of the swimming feet drop off—they will never be needed again—and the animal settles down for the rest of its life as a parasite. (1883)

In fact, Drummond probably would have been even more critical of these barnacles had he known of an intermediate step in the life cycle. Shortly after attachment, some parasitic barnacles will form needle-like apparatuses that will pierce through the crab's defenses to get at the nutrient rich hemolymph. Immediately afterwards, the needle everts, secreting a few cells into the body of the host (Glenner, 2006). At this point, aside from these few cells, everything else is superfluous and no longer needed to proceed to the next stage of the life cycle. Here is an organism that has descended from a complex multicellular organism to a small ball of cells with no discernable structure! With such a bizarre life cycle, it is no wonder that biologists such as Lankester would have been quick to denounce these organisms as unnatural.

In its heyday, evolutionary theory was difficult to distinguish from devolution, or the notion that organisms can trend to a more "primitive" form. Devolutionary theory seemed to account for those organisms that did not evolve towards the pinnacle of the evolutionary tree and could easily be applied to social problems as well. However, modern evolutionary theory has distanced itself from this distant predecessor and there is no longer any belief in "natural laws." The recent discovery of DNA and genes has greatly contributed to our understanding of how organisms can evolve over time. Genes are the very blueprints of life and from them, proteins and regulatory factors can be created that all come together to create a functioning organism. Occasionally, mistakes occur or are introduced into DNA that results in corresponding changes in the organism. The environment weeds out the deleterious variants of genes and retains only the variants belonging to those that can live long enough to pass on their genes. Not only do these organisms have to survive their environments, they must compete with one another to try to pass on their own unique blueprints. Life, as it turns out, is nowhere near as poetic as the version dreamt up by the aforementioned early biologists. Instead of an intrinsic desire to improve oneself and become the very best, evolution seems to rely as much on chance as it does on the efforts of the individual; a notion that would probably have disturbed those early evolutionists.

Figure 2. Representatives of Barnacle. From left to right: a goose barnacle (Thoracica, Lepadidae); an Indo-Pacific giant acorn barnacle (Thoracica, Balanidae); and the externa of a parasitic Sacculina (Rhizocephala) sitting under the abdomen of a crab.

Therefore, the question becomes, how could the parasitic barnacle's life cycle possibly be advantageous? In actuality, the unique morphology of these organisms is perfectly suited to survive within its host. After penetration into the crab host, the parasitic barnacle undergoes an even more astounding metamorphosis. Once inside the host, the ball of cells travels close to the gut where it begins to elongate and develop root-like tendrils that quickly spread throughout the entirety of the crab (Walker, 2001). These rootlets are designed to steal nutrients directly from crab and are so efficient that parasitized crabs lose the capacity to molt; all of the energy that a crab usually utilizes to molt is sapped away by these barnacles to live (Zimmer, 2000). The parasite may intentionally prevent this molting because the molting would redirect energy that would otherwise feed the parasite into "non-beneficial" processes that do not directly benefit the parasite itself (Zimmer, 2000). Not only that, but many parasitic barnacles have carried this step further to completely castrate their host, thereby ensuring the crab does not "waste" energy that the parasite could use (Ritchie, 1981). To add insult to injury, these barnacles will now trick the crab into believing it is pregnant by laying barnacle eggs inside the crab's brooding chamber, manipulating the crab into caring for a whole new generation of parasite young (Zimmer, 2000). Curiously, male crabs are not immune to this manipulation. In fact, parasitic barnacles somehow feminize the males so that they develop pseudopouches with which they will use to care for the parasite's eggs, ventilating and grooming the "eggs" just like a brooding female (Ritchie, 1981). The mysterious bumps that form on the crab's surface are actually receptacles formed by the female barnacle to house males. These serve as a convenient way to find potential mates and to ensure a never ending supply of sperm to fertilize the female's eggs (Walker, 2001). The parasitic barnacle is not a degenerate; it is just as well adapted to its environment as any other organism on Earth. In fact, its ability to manipulate and control its host is nothing short of awe-inspiring and is most certainly not a punishment.

We still do not understand how these parasitic barnacles evolved. Phylogenetic tree analyses that rely on comparing DNA sequences have suggested that these parasitic barnacles originated from a single filter-feeding ancestor that somehow evolved a way to feed on the hemolymph of ancient hermit crabs and lobsters (Glenner, 2010). How this may have evolved and why this may have evolved

are two questions that are not fully understood, but a few hypotheses exist. Researchers have observed that crabs of the species Petrolisthes cabrilloi have a set of grooming behaviors that seem to have been specifically adapted to ward off parasitic barnacle colonization (Ritchie, 1981). These crabs pay particular care to groom their branchial chambers, which are one of the weakest points in the crab's armored defenses and thus one of the most common entry points for these barnacles (Ritchie, 1981). Ritchie hypothesized that these grooming behaviors served as an important selective factor for the evolution of parasitic barnacles. A purely ectoparasitic barnacle (a parasite that does not invade its host) would be at a disadvantage because the crab could easily remove it during its routine grooming habits. However, Ritchie argues that the internal phase of the barnacle's life cycle could have plausibly evolved as a defense against this aggressive grooming because it helped the barnacles to anchor themselves into the host and make it more difficult to be dislodged. Over time, the parasite adapted to a more endoparasitic life cycle. In fact, one of the strongest pieces of evidence for this hypothesis is the fact that the parasitic barnacles that devolve into balls of cells are found only in crabs with exhibited grooming behaviors. Parasitic barnacles that parasitize crabs without grooming behaviors have a slightly different method for entry (Ritchie, 1981). Ritchie proposes that this dramatic metamorphosis is the result of the intense selective pressures presented by the cleaning defenses of their crustacean host.

Figure 3. Female anglerfish with recently attached males. Sexual dimorphism between the two sexes is so extreme that the males fuse with the female's body, becoming permanently attached.

Today, the term "biological degeneration" refers only to the loss of a structure, usually due to functional degeneracy. A structure can be lost if it is no longer essential to an organism's survival in a given environment. Since these structures are no longer under heavy selective pressures, mutations can accumulate that eventually result in loss of function, and, in extreme cases, loss of the structure itself. Vestigial structures are often pointed to as traits that are undergoing this form of degeneration. For example, in many endosymbionts, microbes that can only live inside their host, genome reduction, or loss of whole sections of DNA, is fairly commonplace and excruciatingly tiny genomes have been discovered. These endosymbionts can afford to have such small genomes because they derive most of their nutrients from the host and have no need to synthesize their own.

The decline of the theory of devolution is closely related to the decline of social Darwinism and the eugenics movements that followed afterwards. With the onset of WWII and the blatant racism that occurred, categorizing different races or civilizations as being more civilized or degenerate was no longer considered acceptable. However, while the concept of "primitive" and "advanced" organisms is no longer considered true, it is still fairly common to see references to "primitive" microbes and "sophisticated" animals. In the end, much care must be made to avoid the anthropomorphizing biological concepts to suit the prevailing social thoughts or beliefs of that given era. Evolution does not and has never produced the perfect being; it has only ever produced an organism that has adapted well enough to survive in its environment. And in the end, isn't this enough?

References

Brown, Debra. (2007, June 07). The Development of Victorian Morality - Were the Victorians Backward?. Retrieved from http://www.goodreads.com/story/show/271751-the-development-of-victorian-morality

Drummond, Henry. (1883). Natural Law in the Spiritual World. Retrieved from http://www.gutenberg.org/files/23334/23334-h/23334-h.htm#Page_237

Glenner, H. and M. B. Hebsgaard (2006). "Phylogeny and evolution of life history strategies of the Parasitic Barnacles (Crustacea, Cirripedia, Rhizocephala)." Molecular Phylogenetics and Evolution 41(3): 528-538.

Glenner, H., J. T. Høeg, et al. (2010). "The monophyletic origin of a remarkable sexual system in akentrogonid rhizocephalan parasites: A molecular and larval structural study." Experimental Parasitology 125(1): 3-12.

Morgan, Lewis H. (1877). Ancient Society: or Researches in the Lines of Human Progress from Savagery, through Barbarism to Civilization. Retrieved from http://www.marxists.org/reference/archive/morgan-lewis/ancient-society/

Ritchie, L. E. and J. T. Høeg (1981). "The Life History of Lernaeodiscus porcellanae (Cirripedia: Rhizocephala) and Co-Evolution with Its Porcellanid Host." Journal of Crustacean Biology 1(3): 334-347.

Walker, G. (2001). "Introduction to the Rhizocephala (Crustacea: Cirripedia)." Journal of Morphology 249(1): 1-8.

Zimmer, C. (2000). Parasite rex: Inside the bizarre world of nature's most dangerous creatures. New York: Free Press.

Images Sources

Glenner, H. and M. B. Hebsgaard (2006). "Phylogeny and evolution of life history strategies of the Parasitic Barnacles (Crustacea, Cirripedia, Rhizocephala)." Molecular Phylogenetics and Evolution 41(3): 528-538.

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http://animalworld.tumblr.com/post/3206165165/anglerfish-reproduction-reblogged-for-mandrak. Retrieved 4/1/12