Shape of Life

The Next Segment
An Explosion of Life

What I like doing the most is actually getting out, getting down, getting dirty in the mud with the worms themselves. Getting out there whether it's pouring rain, whether it's a low tide at dawn, I don't care. I just like to be out there with the worms, seeing them in their own habitat.

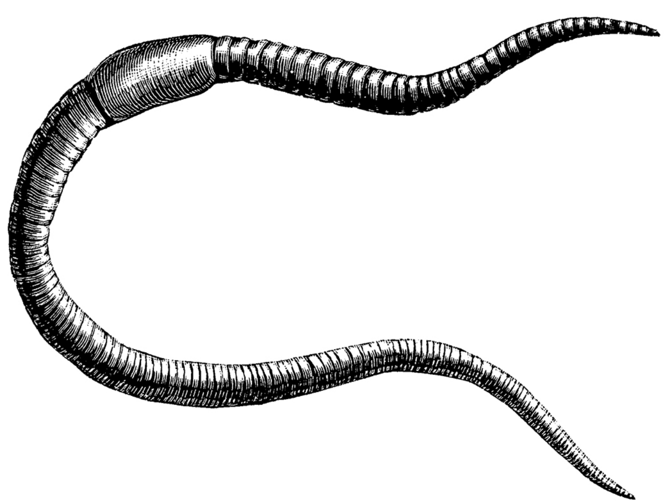
DAMNHAIT MCHUGH, BIOLOGIST

Imagine that you are on your hands and knees twenty feet from one of those prosaic struggles between a robin and an earthworm, celebrated in cartoons, homilies and the sketches of school children. The battle begins at dawn under an overcast sky. Hard rain threatens after a night of drizzle, a scene painted from a palate heavy with greens from the spring trees flashing their putty-colored undersides to the expanse of lawn in the building wind. It's so dark it seems almost black beneath the morning clouds. The robin attacks, landing first a foot from the prey it spotted from above, then nonchalantly sidling to the exposed nub of flesh in the grass where, like lightening, it strikes the earthworm. The assault carries the element of surprise and quickly, two inches of worm stretch from the ground to the robin's beak. Then, as though it summons courage, the earthworm fights back, actually tugging the robin's head to the grass. And then the worm is gone. The beaten robin hops away, then flies, quickly blending into the sky. As you watch you wonder, with a curiosity as simple as a child's: How can this be happening? How can an animal as big as that bird struggle so hard to pull a couple of inches of brown goo out of the ground? What does it mean that it can't? What does it mean that it can? What questions have you forgotten to ask?

That is science. Just that. Seeking the answers to questions--many of them obvious--about what we observe in the world. Charles Darwin, who is known to have studied earthworms during his epic life, might have experienced precisely that moment with a robin and a worm, too.

Segmented Worms

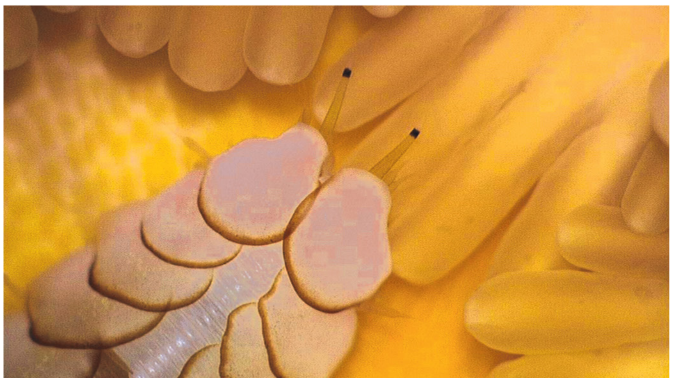
All members of each phylum exhibit anatomical traits similar enough to show a kinship of body architecture that binds the group together. Earthworms, like that tough little warrior on the lawn, for instance, belong to the phylum Annelida (their name comes from a Latin word meaning 'little ring'). All annelids are distinguished by ring-like external bands that coincide with internal partitions dividing the body into segments, each containing a repetition of nerves, muscles, and reproductive organs. With circulatory systems to



distribute blood and oxygen and one-way guts, their bodies are enormously more complex than modern flatworms. A gut that goes from one end of the body to the other was a major step in the evolution of animals. With such a gut, food can be continuously taken in by a mouth, processed as it passes through the body and released as waste at the other end. Not only could the early annelids continually digest their food, but also they could squirm, crawl and slither as they did it, thus not interrupting their movement whether hunting or fleeing.

A substantial body against which muscles could work to produce powerful movements was a great architectural breakthrough. The secret of the success of these new bodies was an internal cavity that not only provided room for large complex organ systems, but also proved essential for more complex ways of living. A worm is basically a hollow tube with the internal space fluid filled to create a hydrostatic skeleton. We have bones; an annelid's skeleton is made of fluid. These hydrostatic skeletons were pioneered by anemones that filled their stomachs with seawater to support their bodies. But an annelid could carry its hydrostatic skeleton with it all the time. While the earliest annelids lived in the ocean, this kind of permanent hydrostatic skeleton would be essential when the worms took up life on land. An elongated worm shape would also prove to be one of the most successful body designs. This shape is so common on our planet that if intelligent aliens capable of assuming any body plan to blend in were to land on earth, they would most likely transform themselves into worms

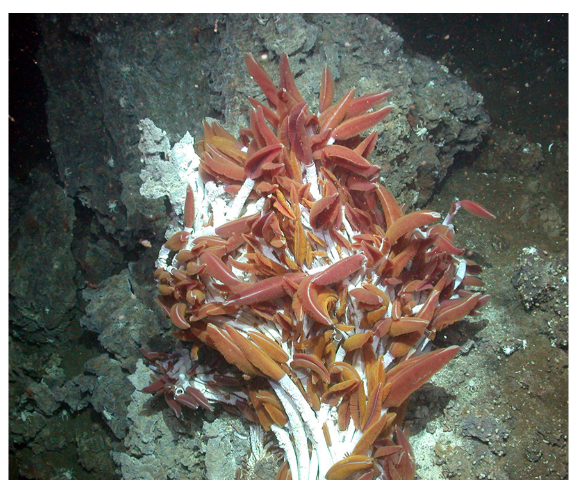
Aliens might also have transformed themselves into worms simply because they are beautiful. Biologist Damnhait McHugh loves worms the way others love birds, butterflies or tropical fish. “I think it's very easy to get people excited about worms if they can appreciate the diversity, the color, the different lifestyles, the different ways that worms feed,” McHugh says. Anyone willing to take up worm-watching as a hobby would be dazzled by what they see.



The 15,000 species of modern annelids live in every habitable niche on earth except the sky, from the most mundane patches of suburban lawn to hot, deep ocean vents. Of all the annelids, the marine polychaetes are the most uniquely and strikingly beautiful. They come in a startling spectrum of colors, and if you look closely you can see the intricacies of their durable bodies, the beautiful, constantly moving bristles that help many of them get around, and the feathery arrays on the heads of some. The spaghetti worm has a head of tentacles that spread out on the surface of the ocean floor like spilled spaghetti. Each tentacle has a groove running down its length. Food particles fall into the groove and get carried by a conveyor belt of cilia (tiny hairs) to the mouth.

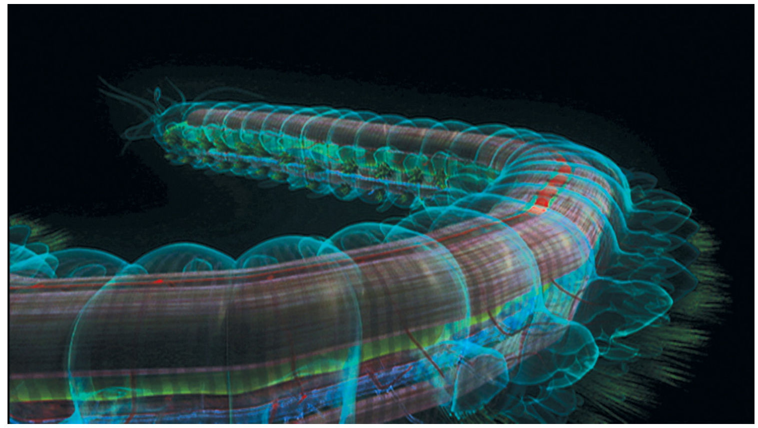
spaghetti worm

A very specialized tubeworm lives around hydrothermal vents deep in the ocean that spew out hot black smoke of concentrated hot hydrogen sulfide. The tubeworms actually live off the bacteria living inside its' body that in turn live off the hydrogen sulfide. These tubeworms have no digestive tract, but the bacteria (which may make up half of a worm's body weight) convert oxygen, hydrogen sulfide, and carbon dioxide into organic molecules on which their host worms feed.



hydrothermal vent tubeworm

The Work of Worms: Burrowing



But whether you think worms are beautiful or not, form follows function in nature and the basic mechanical equipment for making a living in the ground is an elongated body with a hydrostatic skeleton. A worm. But another annelid invention–segmentation–would make annelids not only the ultimate burrowers but also highly efficient at moving across the ground with a wiggling motion. Annelids consist of externally and internally repeating segments, except for the head, which contains a mouth and sense receptors for establishing direction, and the tail, which contains an opening through which waste passes. The hydrostatic skeleton is thus divided into separate compartments. (Insert annelid body) Earthworms, like many other annelids, creep along or burrow by coordinating two sets of muscles, one longitudinal and the other circular. These muscles work against the non-compressible fluid of the hydrostatic skeleton, altering the shape of these separate compartments. It's like squeezing a chain of water balloons. When the circular muscles of a region contract, that part becomes thinner and elongates. Contraction of the longitudinal muscles causes the segment to shorten and thicken and the worm moves forward as alternating contractions of circular and longitudinal muscles progress along the segments like waves.

In an earthworm, for instance, each segment has four pairs of setae, or bristles, that provide traction as the waves pass over the body. When the robin strikes, the worm digs in with its bristles and ripples its muscles, segment by segment to back deeper into its burrow. Obviously, burrowing into the mud to flee, a strategy still employed by earthworms against robins, was a great tactic for staying alive. The appearance of burrowing worms, the annelid ancestors of earthworms that can defeat the efforts of much larger animals bent on eating them, was a enormous step in the process of animal diversification because it added segmentation to the repertoire for growing a body.

Today, mudflats are full of burrowing polychaete worms. The lugworm, Abarenicola, lives in a permanent burrow eating mud and digesting the bacteria, detritus, and small organisms from it. There isn't much oxygen below the surface of the mud, so Abarenicola must pump water through its burrow to bring oxygen to the clumps of gills that line its body. If tube dwelling worms like Diopatra are numerous enough in mudflats, their tubes can stabilize the mud and prevent erosion. Sometimes during low tide, you can see thousands of tubes extending above the mud surface each with a decoration of bright green algae attached.

Worms, the Ultimate Recyclers

Burrowing worms thrived in ancient seas not only because they could get safely away from a predator, but also because burrowing brought the worms to rich new feeding grounds. Dead organisms and organic debris continually settle to the sea floor, but it was not until worms could burrow into these sediments that animals could eat this enormous treasure of food. Annelid predecessors were sponges, jellies, and flatworms, none of which have a gut for passing food from a mouth to an anus. The basic annelid body plan becomes a tube within a tube, a highly efficient arrangement because the worm can keep burrowing as it processes its food through its gut. If you eat by digging through your food, this is awfully important.

We have to keep in mind that even creatures like the lowly worm, we depend on them. We depend on their diversity. We depend on the role they play in the ecosystems. We should see ourselves, I think, as custodians of the great diversity of animals that we see around us today. But we should also remember that we are not masters of this diversity.

Damnhait McHugh, Biologist

As a worm burrows it eats, getting nourishment from bacteria and debris in the soil through which it is passing. While the effect of a single worm seems negligible, the cumulative effect on the earth is staggering. A feeding worm takes in dirt and plant debris, extracts food, and releases castings into the surface, effectively performing as a recycling engine for nature's most vital element, carbon. Collectively, billions and billions of individual worms are contributing more to keeping the earth alive and well than any global warming treaty. If all the material moved through earthworms alone was piled up on the surface of the globe, the heap would rise thirty miles, more than five times the height of Mt. Everest.