Shape of Life

Origins

Animal Eve

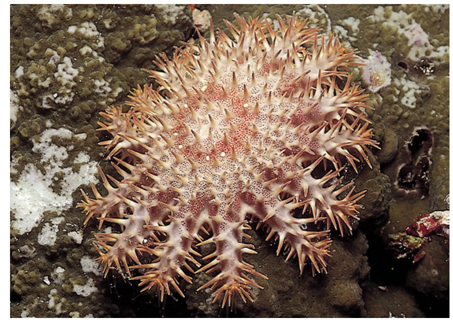
I'm obsessed with learning where we came from. And what I mean by that is not who your mother and father are, or your grandparents, but rather where do the organisms come from that gave rise to complex animals like us

MITCH SOGIN, BIOLOGIST

Imagine a family reunion, maybe held in July on Tampa Bay where your grandparents have lived since you were a kid and where you spent two weeks every summer in their skiff, shirtless and fishing for rockfish, burning yourself the color of persimmons. Twenty-five years later, you arrive in a rental car from the airport with your eleven-year old twin girls who barely tolerate the two-hour drive. They're uncertain about meeting a hundred new people, some of whom, you told them when you planned the trip, will look like them. The shapes and faces of your kin resolve slowly as you approach them standing around the picnic tables, the volleyball court and the barbecue pit. There is your grandfather, a widower, who carries so much of you in his features you know for sure what you will look like in fifty years. And there are your father and mother, aunts, uncles, their children, their children's children, some tall, some short, blondes, brunettes, even a couple of redheads, but most of them blue-eyed. Your daughters aren't really aware of the familiar physical cues they picked up in their cousins, but their long ears, cornflower-blue eyes, high foreheads, and sharp noses are somehow familiar, comforting, and safe.

The powerful connections that we call 'blood' obviously tie us to our kin through countless generations of seed and eggs, love, hate, joy, sorrow, mystery, and all things human. That sense of the familiar has been embroidered into our subconscious in just a few hundred years, and we can easily imagine what our ancestors looked like over that period of time. But deep time is not comprehensible. Six thousand years ago, we began recording history. Language itself has been around for only fifty thousand years. Our species, *homo sapiens*, appeared a hundred and fifty thousand years ago. Now try to imagine a million years, a hundred million. It's impossible, really, but only deep time contains the explanations of our ancestral connections that go beyond our familiar facial features. Grasping the reality of years in the millions requires us to resort to the uniquely human power of abstraction to get past the scale of our life spans, but only then can we begin to fathom our relationship with all other animals through time.

We know instinctively without comprehending the true depth of time, that some thread of life ties us to our non-human ancestors. But how far back do we need to go? The family album contains photographs from as far back as great-great-great grandfather and grandmother, but that is as far as you can get before personal history fades into the myth and legend. What then? As members of the primate family, we can imagine our ancestors back another sixty-five million years, as



Crown of Thorns Star (top)
Annelid (second)
Garden snail (third)
Monarch butterfly (bottom)

The porous nature of sponges is evident in two species of vase sponges

mammals two hundred and fifty million, as vertebrates a half-billion, to creatures whose hint of a backbone is enough to connect them to all of us. If we can trace our ancestors back through time for hundreds of millions of years, does the ancestry of other animals--snails, insects, worms, sea stars — extend back that far? And even more importantly, is it possible that all animals are somehow related way, way back in time?

We do share basic traits with all members of the animal kingdom: We are all made of many cells. We are all the product of the fertilization of a large egg by a smaller sperm, and from this single cell all animals transform themselves in a highly organized way into an adult body. Most animals have heads, mouths, eyes, and legs or some other way of getting around connected in a body made of many cells doing specialized work but interacting to produce a functioning whole. Do these traits connect all animals in the way a family's high cheekbones and eye color show a common ancestry?

If animals can be related through ancestry, there must have been a first animal, the pioneer who began putting together the animal way of life, who first carried those traits we now define as 'Animalness,' an incredible first being that started the process of populating the earth with the wondrous animal kingdom we see today, including ourselves.

Classifying

We have always been on a quest to trace our ancestry, to find the origin of animal life since the concepts of past, present, and future flashed into the brains of the earliest human beings, creating imagination, curiosity, and wonder. Through most of our history, we invented myths and legends to explain where we came from and most people believed that all the animals that are alive are all the types of animals there have ever been. The idea that new species appear and old species die off in a process we call evolution was utterly beyond our imagination until the systematic inquiry of science triggered a revolution in the way we understand our own existence.

> *The world becomes full of organisms that have what it takes to become ancestors. That in a sentence, is Darwinism.*
>
> Richard Dawkins
> River Out of Eden, A Darwinian View of Life

The chain of discoveries that eventually led us to draw some accurate conclusions about our origins and our relationships to other animals began just a few thousand years ago when humans began to apply our talent for classifying and comparing living things to trying to understand our ancestry. We celebrate ourselves as 'The Discoverers,' but we are also 'The Classifiers' and this has allowed us to build some understanding of the meaningful links between the animals, plants, rocks, and everything else with which we share the earth. When he wasn't working on the other foundations of Western Civilization, Aristotle constructed elaborate charts describing the relationships between animals in terms of their internal and external similarities, in essence classifying them. When he couldn't figure out whether something was animate or inanimate (which means 'having a spirit'), such as one of the colorful and puzzling clumps of life we now call sponges, he just said they were intermediates, or 'in between.' Until the eighteenth century, classification was pretty much a matter of just grouping things that looked, sounded, felt, or tasted alike, (or were somewhere in between). There was no one accepted system for organizing things like species or families of animals, and no one was thinking about where animals come from, because we presumed that all life was generated spontaneously or created by some kind of super-being.

In the mid-1700s, a Swedish botanist named Carolus Linnaeus set up a standard method for naming organisms that remains in use today. When he was alive, about ten thousand animals had already been described, and his was an orderly filing system with animals grouped within larger groups in a hierarchy based on common characteristics. Life is thus organized into groups defined by very specific characteristics shared by all members of the group. For instance, you are of the Kingdom Animalia; Phylum Chordata; Subphylum Vertebrata; Class Mammalia; Order Primates; Family Hominoidea; Genus *Homo*; and Species sapiens. When we talk about animals, we usually just refer to them by their genus and species, as in *Homo sapiens*.

Swedish botanist Carolus Linnaeus

Though Linnaeus didn't know it at the time, his system would remain basically correct to this day because his procedure classified animals according to common features that reflect true evolutionary relationships. Linnaeus was not looking for origins though, not looking for an Animal Eve because he was firmly rooted in his times and believed that all animals were created by a god. His work, he thought, was to discover his god's orderly design. God, Linnaeus thought, did the designing; he did the filing. Linnaeus did, however, pave the way for an enormous breakthrough in our understanding of the relationships between living things because he provided a communications channel so the inquiry and analysis of the past could inform future discovery.

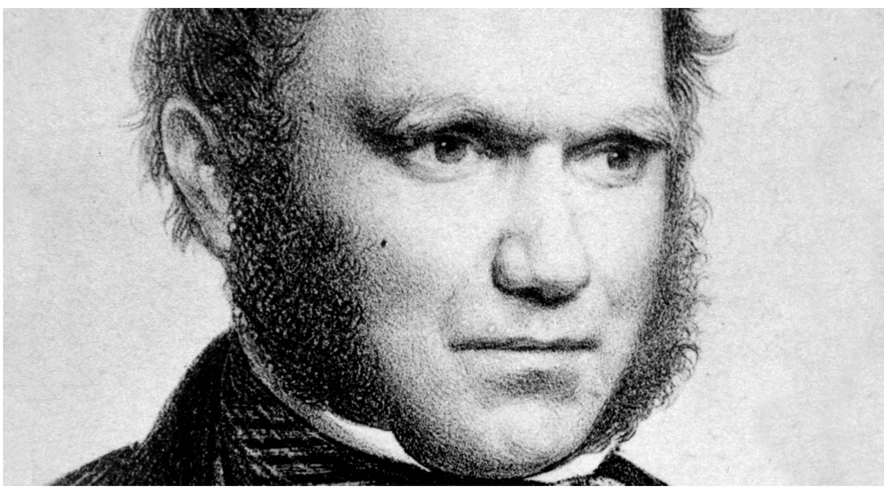
Darwin's Origin of Species

Then, just a hundred and fifty years ago, Charles Darwin upended the way we think about the presence of life on earth when he concluded correctly that animals, and all life, change shape in response to shifting demands of their environments. Darwin's celebrated voyage aboard the HMS *Beagle* is only part of a life of inquiry that led him to answer one of the greatest questions ever asked of nature: Where do species come from?

The time will come I believe, though I shall not live to see it, when we shall have very fairly true genealogical trees of each great kingdom of nature.

Charles Darwin, in correspondence

As with most scientific breakthroughs, Darwin's Theory of Evolution was an elegant synthesis of conclusions reached by earlier investigators, but one based upon his own inquiry from several perspectives that produced original insight. Linnaeus's classification system was of utmost importance to Darwin when he observed the incredible diversity of animal life in similar habitats around the globe. Aboard the *Beagle*, he wondered why forests in different places have different animals filling the same niches. At home in England, he bred domesticated animals and knew that physical traits are passed on from generation to generation. Darwin was also a geologist and knew that the rocks and sediments he studied could have formed only over enormous amounts of time – much more than the religious myths of his day could provide. Darwin was a paleontologist, too, and he was able to make the connection between the fossils he collected, their age, and the living animals that are related to those ancient beasts.



Charles Darwin

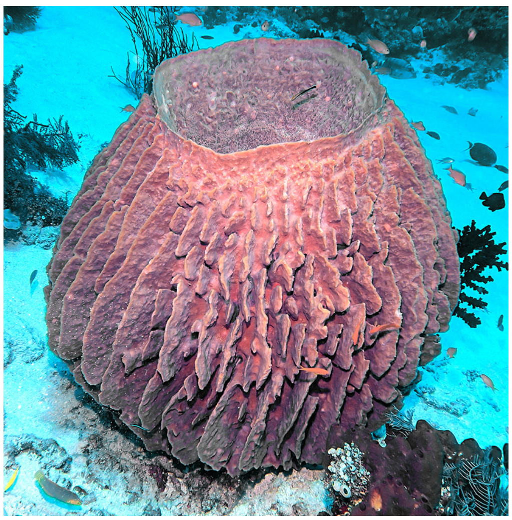
Other investigators never factored the true enormity of time into their conclusions. They had absolutely no concept of millions and millions of years and no idea that time of such magnitude played any role at all in the creation or existence of animals in the present. Finally, when Darwin went exploring off the Pacific coast of South America, he saw flora and fauna that had adapted – literally changed form – to survive in differing environments. In the Galapagos Islands, he encountered animals that were obviously similar to those living on the continent. He saw, too, that they were also different from the mainland and even different between the islands. These observations would help him put together his celebrated theory years after he returned to England. ". . . the struggle for existence," he wrote, "bears on natural selection." Animals that are able to secure food, avoid predators, and reproduce are those best suited for survival – the fittest. The natural processes of survival have selected them, and only them, to survive and become the ancestors of subsequent generations.

Looking for Animal Eve

Darwin proposed a process in which through time one species can change into another. A process in which different species are related in just the same way we are more obviously related to our cousins, aunts, uncles, and parents. Once deep time and the processes of natural selection and evolution enter into our search for our ancient ancestors, the family album gets really interesting. And so does the question of our origins. From the interlocking discoveries of the many scientific disciplines, including embryology, paleontology, and genetics, we can now construct branching diagrams that trace animals through time to common ancestors. Our own species, *Homo sapiens*, for instance, becomes distinct from its ancestral species, *Homo erectus*, at one of those branching points. By grouping common traits and, now, genetic similarities, we can move back through time from ancestor to ancestor, and from ancestral group to ancestral group.

"Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely the production of higher animals, directly follows."

Charles Darwin, The Origin of Species



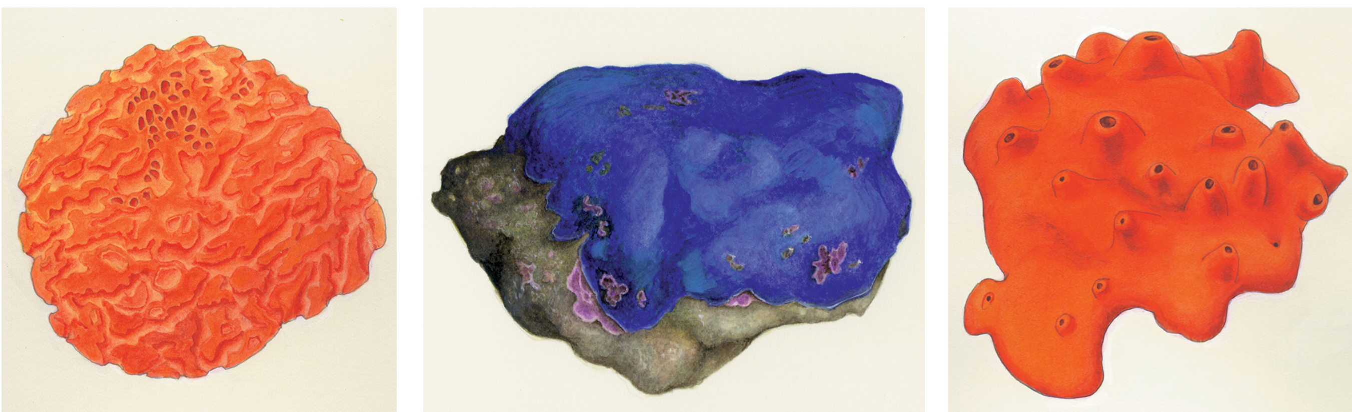
Barrel sponge

If we go far enough back in time to a sudden, great radiation of life five hundred and twenty million years ago, we see the beginnings of the branches of animals that would lead to thirty-five basic body plans called phyla (the word is from the Greek, meaning simply 'class'). Before that explosion of animals, we have evidence that three of those groups existed, the ancestors of jelly-like, worm-like, and sponge-like animals. All animals today still fall into one of those elementary thirty-five phyla. As conditions changed through time they have adapted the architecture of the primitive body plans to create enormous diversity.

As it turns out most animals are members of only eight of those thirty-five phyla. We have the branching diagrams or maps into the past for these eight major body plans – the Sponges, Cnidarians, Flatworms, Annelids, Arthropods, Molluscs, Echinoderms, and Chordates.

The next big question in our search for the earliest animal on earth, of course, is what came before these eight branches of life began their journeys through time? We know that species can beget species, so at some time in the distant past, a single phylum or body plan might have blazed the trail for all the others. Was there a single animal from which the others might have arisen? Or did animals evolve more than once?

In the last decade of the twentieth century, with evidence from fossils and the chemistry and anatomy of living animals, some scientists searching for our origins began to suspect that the first animal on earth, the Animal Eve, was a sponge. There was a lot of discussion, too, about whether or not sponges were in the direct ancestral line of modern animals. We know that sponges are composed of many cells, like all animals, and are clearly more complex creatures than the single-celled non-animal organisms from which they must have evolved. Single cells ruled the world for billions of years. Of the many types that eventually evolved, the Protists are the ones to have all the components of animal cells, but they do not clump together and cooperate like animal cells. On the other hand, sponges are made of many cells, but they, in many ways, still carry out life processes like single cells. Sponges are clearly on the edge of animalness. A sponge doesn't look anything like a horse, or a worm, or a sea star, or anything but another sponge, but it is an animal and a likely candidate to be our oldest ancestor.



A globular sponge (left) and encrusting sponges (center and right). Illustrations by Ann Caudle.

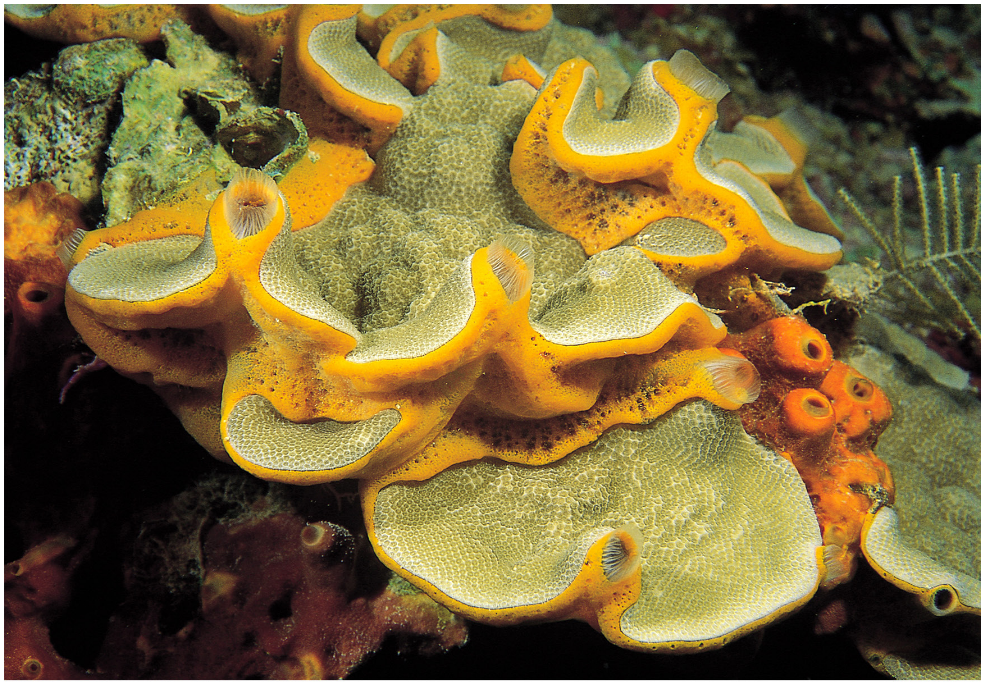
Is It An Animal?

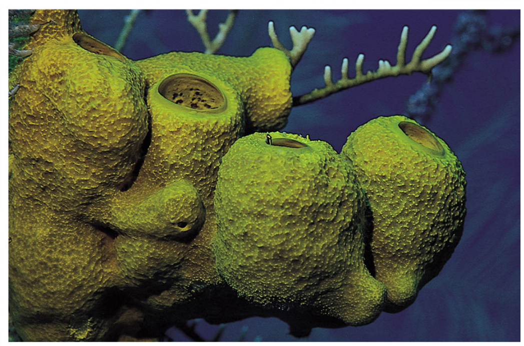
For most of human history, though, we weren't even sure that sponges were animals. Two thousand years ago, they were listed among Aristotle's 'Intermediates,' somewhere between plants and animals. His confusion is understandable to anyone who has ever seen, but not looked too closely at a sponge, which has no head, no brain, no bones, no mouth, and no internal organs. Sponges come in an astonishing variety of shapes that to us look like cups, fans, tubes and colorful, crusty smears on rocks and coral. They range in size from a few millimeters wide to more than a meter tall, like the great

Nature proceeds little by little from things lifeless to animal life in such a way that it is impossible to determine the exact line of demarcation, nor on which side thereof an intermediate form should lie. So, in the sea, there are certain objects concerning which one would be at a loss to determine whether they be animal or vegetable.

Aristotle, wondering about sponges

barrel-like glass sponge that lives in Antarctic waters. All sponges are aquatic, tied permanently to the water by their lifestyle and body plan. Of the 10,000 species alive today, only 150 live in fresh water, the rest in the ocean.





Sponges officially became part of the animal kingdom in 1825 when Robert Edmund Grant, a Scottish biologist, finally convinced his peers that the creatures he studied in the tide pools and tanks were neither plants, or Aristotle's Intermediates or blobs of goo. He had long believed that sponges were animals, but finally sold everybody else when he poured colored water into a bowl of sponges to show the particles flowing into the sponge through tiny pores and then 'vomiting forth from a circular cavity, an impetuous torrent." These beings moved, they pumped water through holes in their bodies; they must be animals. Grant named them Phylum Porifera, which means, "pore bearers." (The controversy continued, however into the 1980s when some biology texts still did not list sponges as true animals.)

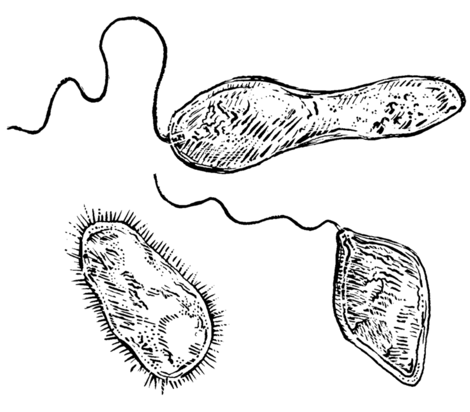
How Sponges Are Built

When I encounter a sponge I'm just in awe. They're just so different you cannot stop yourself from asking: What are you? What do you do? What do you eat?

Christina Diaz, Biologist

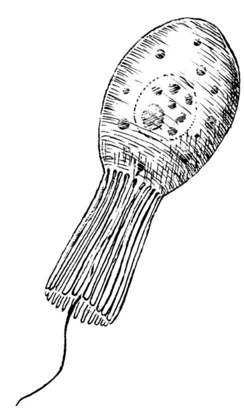
The anatomy of a sponge is not as likely to inspire awe as that of a horse, a lion, a giant squid, or a marlin, which feature complex structures like tissue and organs that are very clear in their statements about form and function. Sponges, though, are a modest collection of about six different types of specialized cells that handle reproduction, food gathering, eating and digestion. (By comparison, we complex humans require over 250 different types of cells.) Their bodies don't invoke images of power, strength or classical beauty until you take a much closer look, beginning with the stunning cells of which they are built.

Specialized animal cells are like the individual notes of an orchestra tuning up for the Brahms Violin Concerto, each note whole and independent but capable, with all the other notes, of becoming a complex melody. Not all living things are symphonic in this way. One of the great groups into which we have organized life in our attempt to understand the business of living on earth is fundamentally different from all the others: each member of Kingdom Protoctista – the Protists— is composed of only a single cell. Though some live as colonies with maybe two different types of cells and may appear multicellular, they still carry out life as single cells.



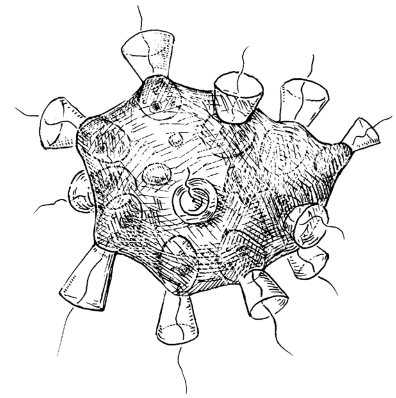
various single-celled protists

All protists are just single biological notes, capable of producing only the same single note in successive generations, crawling, oozing, and swimming in a vast cacophony of simple creatures. If protists as single cells came before animals, could there be some connection or transition between them and the first true animal? Amazingly there is one group of protists, called Choanoflagellates, Black and white called sponge-collarcell that, in fact look like one of the kinds of specialized cells present in all sponges. Both the protist and the sponge cell, called a choanocyte, feature collars surrounding long, whip-like appendages that keep in constant motion. And there is even a type of Choanoflagellate that lives as a group of cells, giving us a hint about one of the steps single cells took that move closer to the birth of the animal kingdom.



sponge choanocyte cell

True animal cells, on the other hand, are capable of specializing, communicating and reorganizing themselves as the animal grows. Life begins when a single cell – a fertilized egg – divides into two, then four, eight, sixteen, and on and on. Animal cells differentiate according to the genetic code stored in their nuclei, and then produce succeeding generations of liver cells, or brain cells, or, in the case of a sponge, choanocytes, or whatever kind of cells define a particular animal. A simple protest may have launched the world into a whole new way of organizing life. Somewhere along the line, maybe seven or eight hundred million years ago, a bunch of protist cells – probably choanoflagellates— living together as a colony began communicating so that some cells did only the reproducing and others did only the food capturing. Black and white drawing called protospoges Eventually, this way of working together would be so well established in the descendants of these adventurous ancestors that they had evolved to become an entire new life form: an animal. The single notes of the biological orchestra then began the to compose the first bars of complex music.

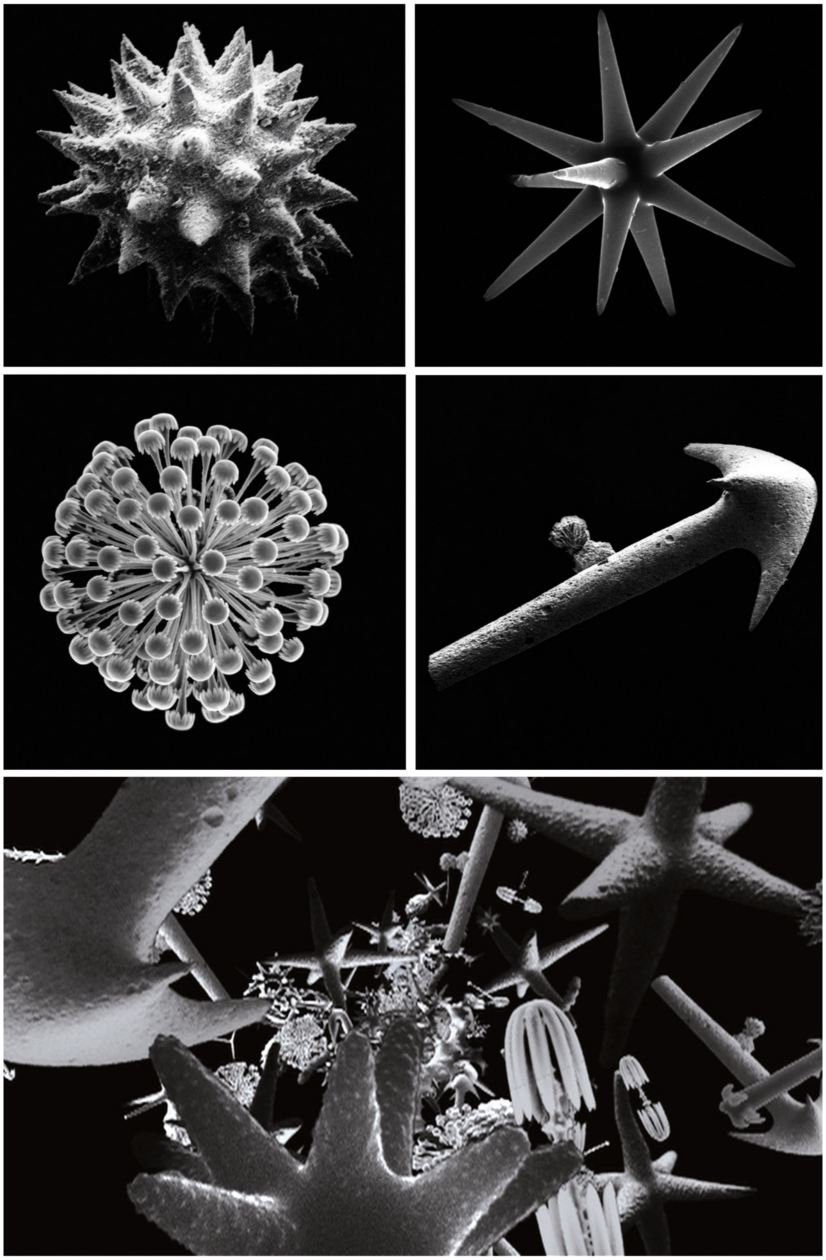


Colonial Choanoflagellate *Proterospongia*

The ensemble of specialized cells that form a sponge can pick out a tune like “Twinkle, Twinkle Little Star,” much simpler than Brahms’s “Violin Concerto,” but music nonetheless. The walls of a sponge’s body are only three layers thick, two of which adjoin either the water around it, or one of the many canals and chambers that weave through its interior, literally bringing the ocean into the body of the sponge. Between the layers of cells that create the boundary between the sponge and the water, inside and out, is a jelly-like layer called the mesohyl, which just means ‘middle fluids.’ Several kinds of cells wander in this middle fluid, including amboecytes (crawling cells), which produce structures to support the sponge. Amboecytes also capture food particles and pass them along to the other cells. In fact, some amboecytes are capable of performing just about all the jobs required to keep a sponge alive because they have retained the ability to transform into all the other different cell types.

Each type of cell has a specific job to do for the sponge. In a few types of sponges, porocytes, or pore cells, can form the holes in the sponge’s body through which water and food particles can pass. Myocytes, or contractile cells, surround the openings in a sponge and expand and contract to admit or inhibit the flow of water. Epithelial cells pave the surfaces of the animal. And finally, the hardest-working cells of all: the choanocytes or collar cells, which feature minute, moving whips (or flagella) that create the current of water upon which the sponge depends for its existence. Choanocytes are as important to a sponge as a beating heart is to each of us, but all of its cells do two things that allows us to call sponges animals: they work together and they communicate with each other.

Sponge's Skeleton

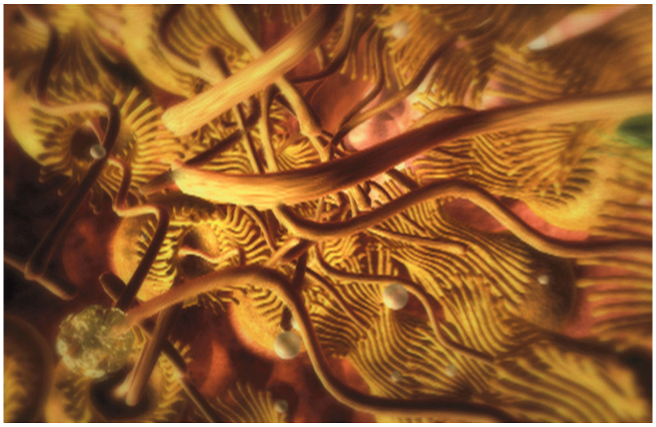


various spicules

A sponge's body is held together by a remarkable substance called collagen, a protein found in the bodies of all animals and one of the earliest clues to the membership of sponges in the animal kingdom. Collagen forms the supportive system that holds the cells together and maintains the specific shape of the sponge species. Among the more obvious truths about animals is that they have to have bodies to keep the cooperating, communicating cells together in one place. Collagen makes bodies possible. When most people think of a sponge, they picture the bath sponge in the shower stall, but this is really the soft collagen skeleton of a now-departed animal.

Many sponges have tiny, hard skeletons, called spicules, organized into scaffolding that is the microscopic rival of the Eiffel Tower in Paris, the George Washington Bridge in New York, and other elegant latticework masterpieces so pleasing to the human eye. Like fingerprints, spicules can be used to identify each species or a group of sponges not only by type of spicule, but by the way they are arranged in the sponge's body. Our simple, distant relatives actually mine calcium and silicon from seawater to produce these wonderful, glass-like structures, which come in a dazzling array of shapes and sizes. Each begins when spicule-producing cells coordinate in the secretion of a new spicule, a process that continues as the cells divide and migrate to the extremities of the spicules, sometimes growing into delicate, intricate webs.

Sponges appear humble in their simplicity, but they have left their mark on earth on a scale as grand as the Great Wall of China. About four hundred million years ago, sponges dominated the oceans as reef builders, a



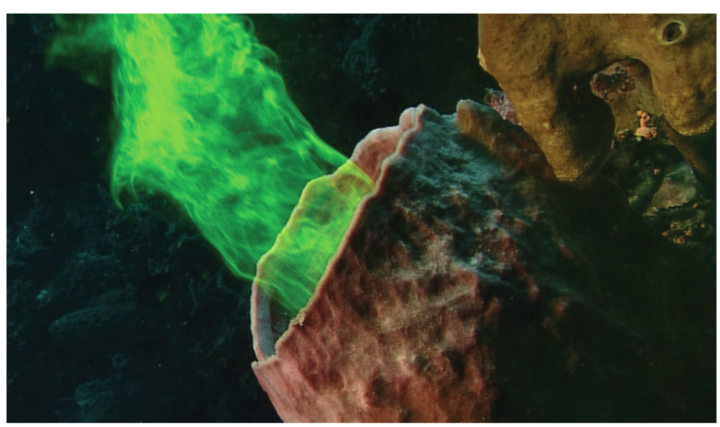
Stills from the animation "Wild Ride Through a Sponge" show choanocyte flagellae whip around inside a choanocyte chamber, creating a current through the sponge.

vital ecological chore now handled for the most part by their slightly more complex relatives, the corals (see Cnidarian chapter). Living reefs in the sunlight-rich shallows offer nourishment and refuge to thousands of species, drawn by the easy living with plenty to eat as a predator, and plenty of places to hide as prey. In the rocks of the Guadalupe Mountains of what we now call Northwestern Texas, you can still see the fossilized remains of a great sponge reef from the Permian epoch, which ended 235 million years ago. The remains of another stupendous sponge reef, much larger than the Great Barrier Reef off modern Australia, covers an arc across most of Northern Europe. The reef was built two hundred million years ago by sponges with particularly dense spicule frameworks that fossilized easily into rock so hard it was a favored building material for castles and buildings in the Middle Ages. As kings and queens of ancient reefs, and to a lesser extent today, sponges perform most nobly as spectacularly efficient pumps, filtering the water around today's coral-dominant reefs as valuable partners in the ecosystem.

Pumping Power

Pumping water through their bodies is as elementally sponge-like as intelligence is human-like, a trait so definitive it is impossible to imagine the animal without it. A typical sponge can pump an amount of water equal to its own volume of tissue in about eight seconds, or to express that power in another way, a sponge the size of a human finger can circulate through its body five or six gallons of water in a single day. The entire contents of bays and reefs with large sponge populations flows in and out of these simplest of animals every day, and in the shallows, the outflow from the sponges can be strong enough to disturb the surface of the water.

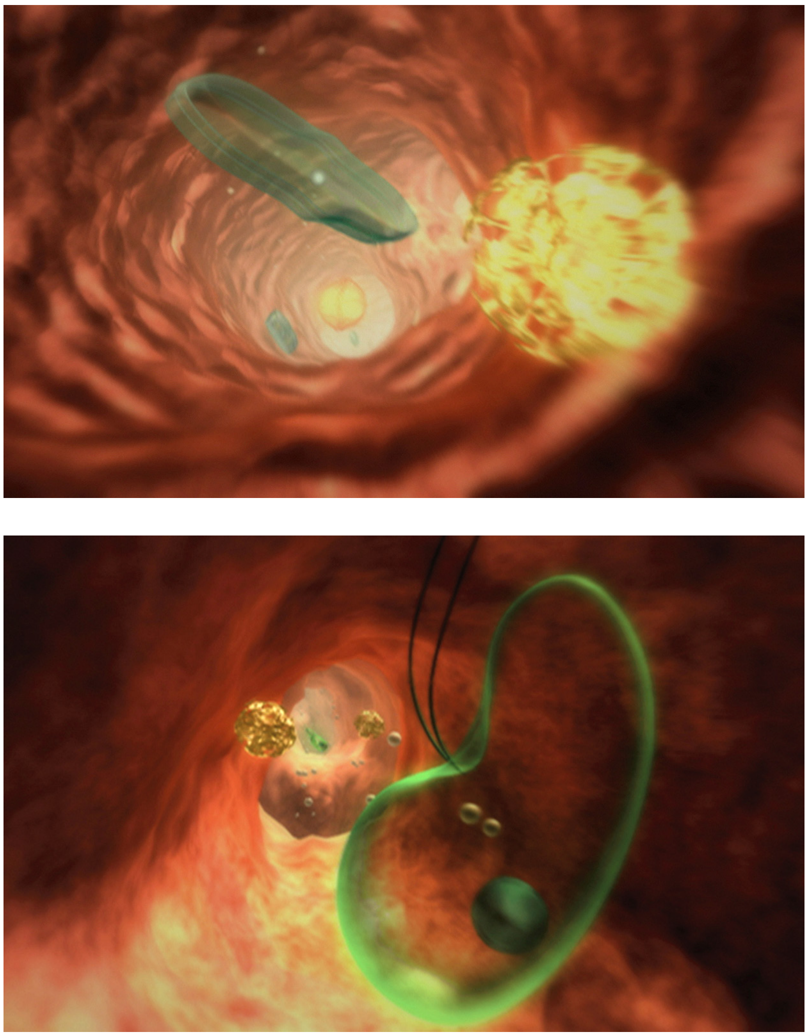
The private lives of sponges have captivated enough researchers that we now know that their pumping habits and strategies vary from species to species. Most of them pump water with their



Christina Diaz releases florescent dye near a sponge (top), and watches dye being ejected with the sponges current (bottom).

microscopic whips and some have daily pumping cycles, slowing flow in the dark by contracting their larger out-current openings, and opening wide during the times of day when the most food will be drifting by. Every so often, some sponges seem to stop pumping for several days. Incredibly, some sponges burp, actually reversing the flow of water through their bodies to clear sediment after a storm.

Pumping is not just stage magic for a sponge, but rather the sole means for these animals to breathe, get a meal and have sex. Imagine, for a moment, that you have shrunk to the size of a single-celled bit of organic matter drifting in the warm sea near a big barrel sponge. You are just hanging there in the water, but gradually you feel a slightly more powerful current that increases as you are drawn nearer to the sponge. Suddenly, you are within the creature, roaring through increasingly smaller canals past cells making new spicules, into chambers lined with thrashing choanocyte whips, and if you have not been snagged as the sponge's next meal, are eventually swept into the exit cavity, and back into the sea outside. Had Aristotle been able to take this ride into a sponge and seen its workings at the microscopic level, he would never have doubted that this "Intermediate" life form was an animal.

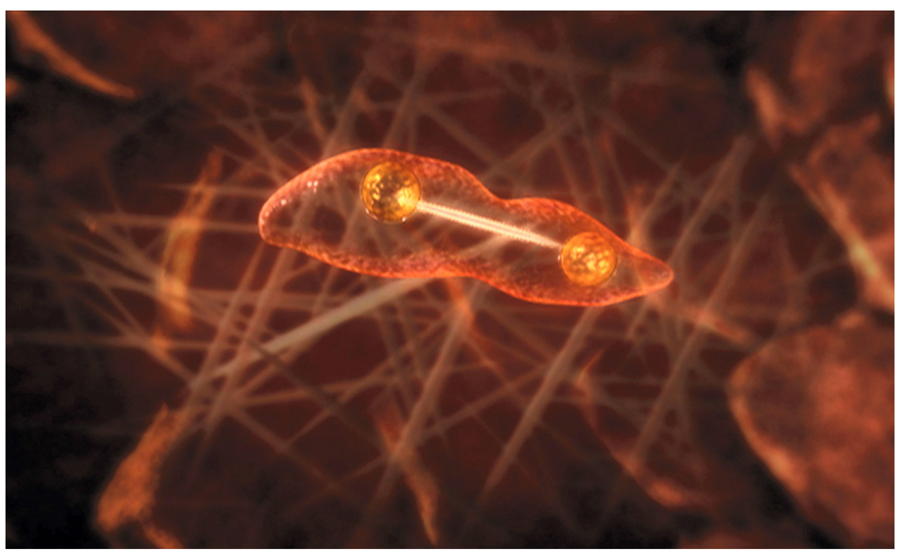


Stills from the animation "Wild Ride Through a Sponge" show protists and bacteria carried in the current.

A sponge must pump over a ton of water through itself to get an ounce of food. And its way of feeding is closely tied to its unicellular ancestry, in which endless pumping makes food-laden water available to the individual cells that absorb and ingest it. As the minute particles of bacteria and organic debris flow past the whipping flagella of the choanocytes, they are trapped by the amoebocytes, engulfed by their soft walls. Inside the cells, the microscopic bits of food are surrounded by a membrane that acts as a minuscule stomach in which secreted enzymes transform the food particle into usable nutritious chemicals for sustaining life. The tiny stomach is passed on to other cells that, because they have specialized to perform other tasks, are not able to capture a meal. At the same time, oxygen from seawater diffuses directly into the cells, and carbon dioxide is released into the out-flowing current. In other words, the water flowing through a sponge acts as the respiratory system.

A sponge doesn't exactly get in the mood, but at certain times of the year in tropical reefs, the temperature of the water or some other sponge sex-trigger transforms some of the choanocytes into sperm (notice the resemblance?) and some of the amoebocytes into eggs. Again using pumping as its chief ally in the survival game, the sponge blasts its sperm or eggs into the water in a cloud of potential life, and the next generation is on its way. Sponges, like all animals, can only mate with members of their own species, so they coordinate their spawning to ensure their eggs and sperm will meet in the water column. After fertilization, the sponge egg divides repeatedly and arranges itself into a larval stage – in a process again like most other animals. During this stage, the whips of their choanocytes face outward to propel them through the water until they settle on the bottom and anchor themselves to reefs, rocks, or some other good home, where they rearrange themselves into adult sponges.

Though sponges appear anchored in place, some of them are mobile. Very patient investigators have discovered that sponges can move by tracing their daily positions on the glass walls of aquariums and observing that they do get around, very slowly of course, propelled by the cumulative motion of their cells detaching from the main body and assembling in a new place, thus moving the edge of their bodies. The ability of sponge cells to move and reform a body is spectacularly documented in a legendary experiment in which a sponge is squeezed through a fine pored cloth, and eventually gathers itself back into small clusters, some of which will fuse together to build tiny sponges once again. And more profoundly, two different species of dismantled sponges will only re-aggregate with cells and pieces of their own species, demonstrating a powerful animal trait of recognizing 'self' from 'other'. This ability to differentiate between self and other is the beginning of what in more complex animals we call an immune system. An animal body that will accept its own more readily than another greatly reduces the threat of invasion by foreign cells.



Stills from the animation "Wild Ride Through a Sponge" shows how a cell pulls apart as it produces a spicule.

The entire repertoire of a sponge – its behavior – is clearly that of an animal. All animals exhibit behavior. The elementary cellular form and function of a sponge, though, place it at the base of the evolution of complexity in the Animal Kingdom. And its apparent derivation from colonies of single-celled organisms lead us to believe that this unlikely creature might be the earliest ancestor of all animals, including ourselves. Finally, two thousand years after Aristotle's early musings, and one hundred and fifty years after Darwin's brilliant flash of insight about the role of time and natural selection, the confluence of genetic research and fast computers allows us to know for sure.

Finding Animal Eve

Sponges lie at a critical juncture in the evolution of more complex life forms on this planet. They're clearly basal to other animals. Their common ancestor came from a unicellular world.

Mitch Sogin, Biologist

The absolute proof that a sponge is our most ancient ancestor took some time to find. Until recently, our search for the first animal depended on interpretations of ancient fossils and anatomy. Now, though, we are beginning to decipher those immortal markers we call genes, which contain the evidence of the ancestry we share in common with each other and with the very first animal to have every lived. We have been able to create a new kind of family album, one where the photographs come from genetic material in the nuclei of our cells we call DNA, (short for deoxyribonucleic acid) which contains the basic information to build an animal. The keepers of this wonderful new album are people like biologist Mitch Sogin.

Biologist Mitch Sogin

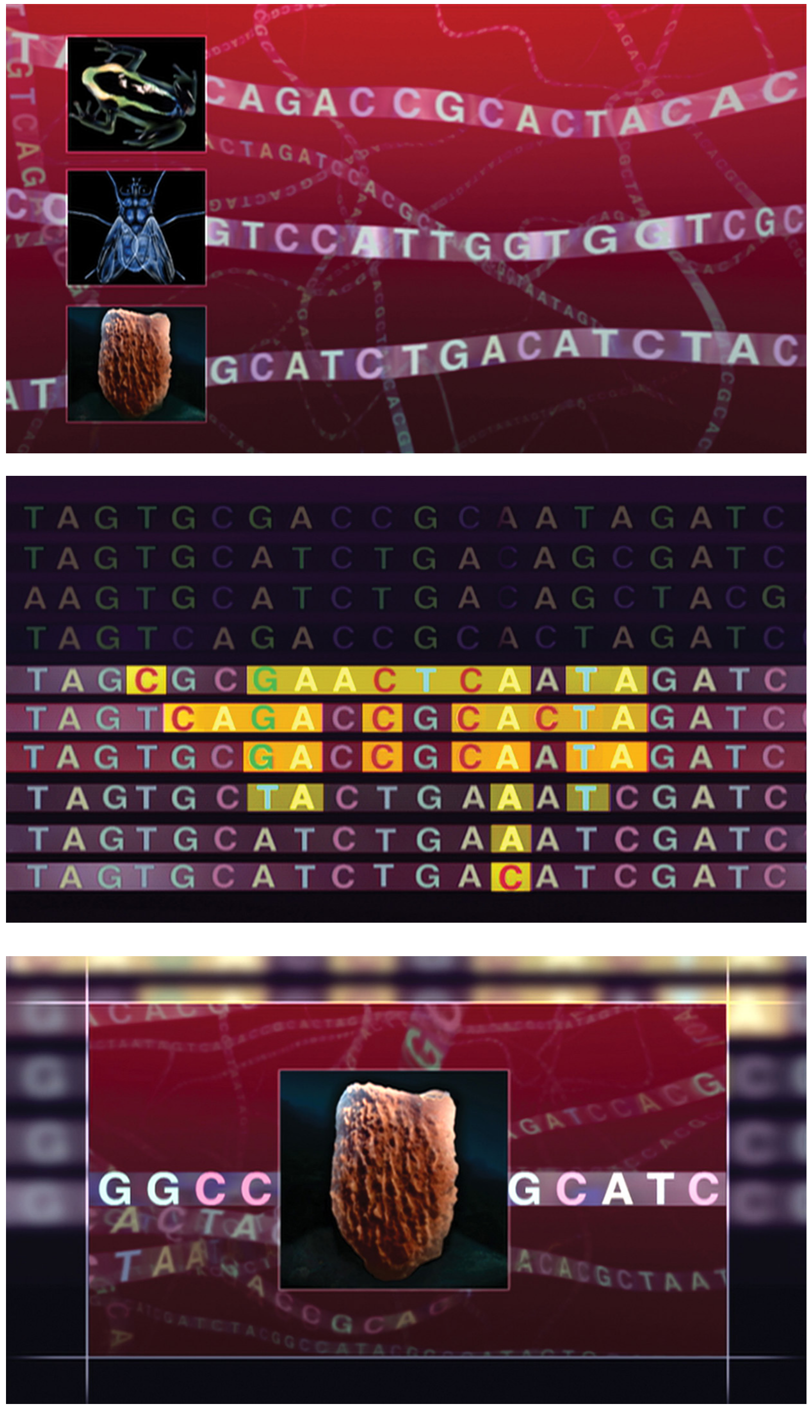
As new technology became available, Sogin decided to search the genes of different animals, and the possible ancestors of animals among the protists to see if he could find the animal group that gave rise to all the others. "In looking for the origins of animals, particularly from the perspective of a molecular evolutionist, you can take a top-down approach in which you say, 'I recognize that the first animal certainly was not a cow or a pig or a human. It must have been something much more simple.' And so the top-down approach would be to try and predict which of the various animals that we know about – most likely from marine environments – are those that are likely to be early animals."

In the 1980s, Sogin set himself the challenging task of discovering what creature lay at the base of the animal kingdom by looking where no one had looked before – inside the sponge's genetic code. First, he had to map the DNA inside their cells, a painstaking process known as gene sequencing in which the elements of the genetic code are mapped for comparison with those of other animals.

"Genetic sequences are very much like blueprints for constructing an organism," Mitch says in his lab at Woods Hole, Massachusetts. "They define everything that there is to know in order to generate a body plan. You have a set of genetic blueprints that defines who you are. I have a slightly different set of genetic blueprints that defines me. It's very much like the blueprints for building buildings, or cars, or whatever it is you have to have a plan for making. We can compare the genetic blueprints of different things. So, for example, I can compare the genetic blueprint of an automobile to that of a covered wagon. There are a minimal number of elements in those blueprints that are common between those very disparate kinds of vehicles. I can do the same thing with animals."

Since the same genes are inherited in long lineages of organisms in geological time and they change in evolution, 25 percent of the genes in bacteria are also in us. Sogin focused on a specific gene animals held in common with all animals and their possible ancestors, which shows the sequence of variations. He compared the genetic blueprints of sponges with those of other animals – mammals, insects, worms, and others – and focused on a gene they held in common. Genes are not identical and their subtle differences are telling. If the sequence of genes of two animals revealed few variations, the animals were closely related. By grouping animals by their shared common sequences of base pairs within a section of a particular gene, Sogin traced an evolutionary family tree, knowing that the animal at the base of the tree would be our oldest ancestor.

"For a long time, biologists have argued that sponges are basal to all other animals," Sogin says. Fossil spicules of ancient sponges are found, for instance, in just the right place in time when multi-cellular animals are thought to have emerged. "But there really wasn't any objective, certain way to make that claim until the advent of molecular sequencing capabilities."



The same gene from different species is sequenced (top)

Similar segments are compared to establish the pattern of the relationship (middle)

The sponge is the ancestral animal (bottom)

"We precisely determined the sequence of a gene from a sponge and compared it with the same gene in a jellyfish," Sogin explains. "Then we compare that same gene in a fly, a fish, a frog, and a human." He focused in on one particular gene to see how it changed and varied in the DNA of the different animals over evolutionary time, and he discovered that sponges, indeed, were the most basic, earliest animals that had transformed life on earth. "The sponge was the first animal with the genetic blueprint for living large," Sogin says. "All animals with more than one cell are based upon that same blueprint."

At the beach on Tampa Bay, the settling heat of late afternoon has driven everyone to hammocks and shadows except for the children who are flaked out on the sand. A mud-colored dog patrols the picnic tables and a few gulls wheel overhead, looking for scraps. An army of ants has formed skirmish lines up the sides of stewing garbage bags, and offshore, fish break the surface as the angle of the sun over the water acts as the cue to begin an evening's feeding in the low light that gives them an advantage over their prey. The family reunion goes on.

"Not a single one of our ancestors died in infancy. Not a single one of our ancestors was felled by an enemy, or by a virus, or by a misjudged footstep on a cliff edge, before bringing at least one child into the world. Thousands of our ancestors' contemporaries failed in all these respects, but not a single solitary one of our ancestors failed in any of them."

Richard Dawkins
River Out of Eden, A Darwinian View of Life