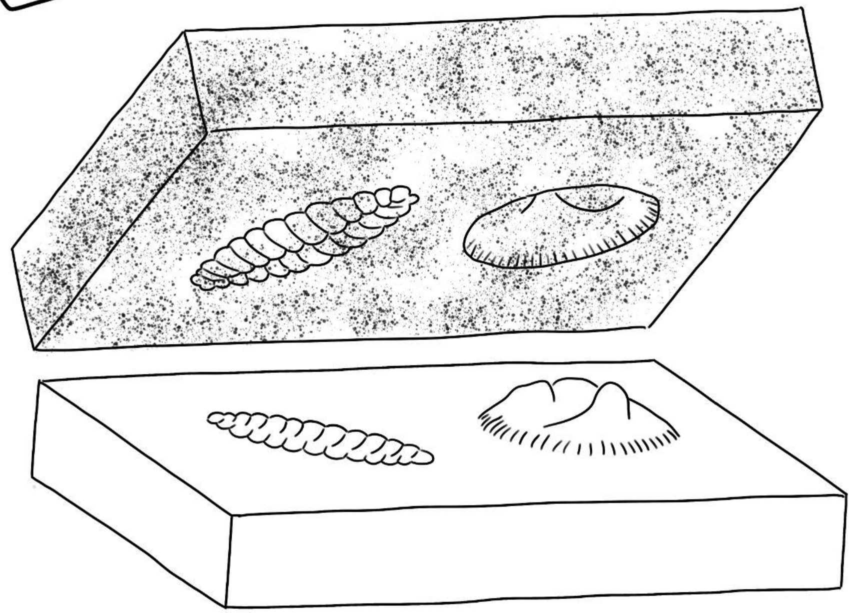
EDIACARAN ENCOUNTERS



A ZINE GUIDE TO PRECAMBRIAN LIFE

WITH AN ILLUSTRATED BESTIARY
OF STEM EUMETAZOANS,
PROBLEMATICA, AND THEIR KIN

BY DAVID NASCA

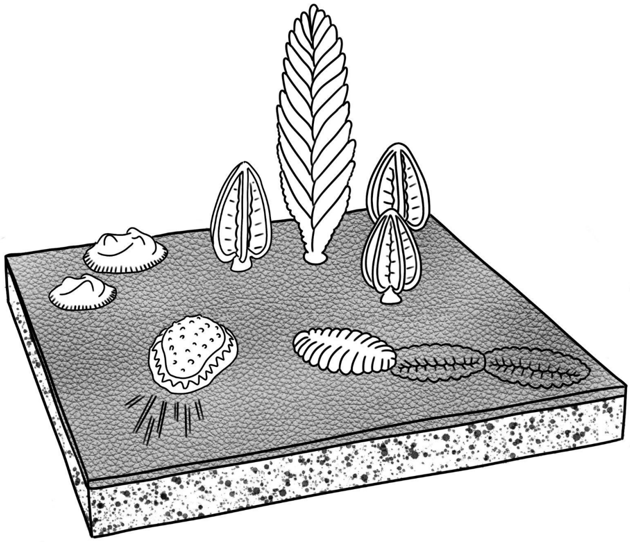
Author’s Note:

Ediacaran Encounters was written and illustrated during a summer 2025 residency at Eastern Edge Gallery in St. John's, Newfoundland, Canada. It is a companion to an ongoing suite of sculptural and ceramic explorations of Ediacaran communities, organisms, and preservation.

This zine reflects the current state of Ediacaran research as of 2025, filtered through the author's perspective as a visual artist engaging with paleontology and queer ecology. The study of Ediacaran biota remains one of the most rapidly evolving and contested fields in paleontology. New fossil discoveries, advanced analysis techniques involving computer modelling and statistics, and reinterpretations of existing fossils regularly reshape our understanding of these ancient organisms. What you read here represents current scientific consensus where it exists, educated speculation where it doesn't, and a healthy dose of choosing what to emphasize and how to frame it.

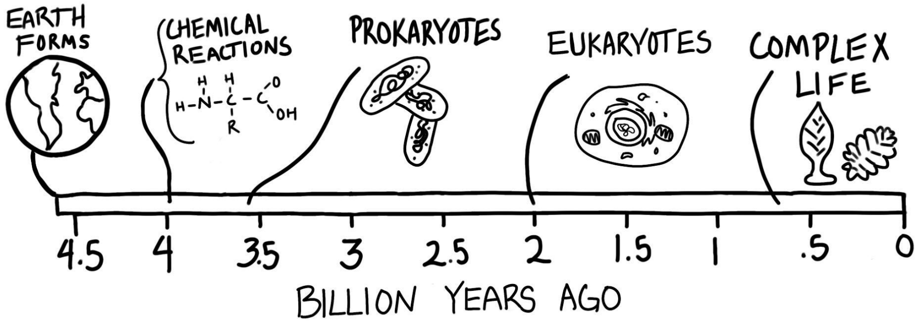
This zine prioritizes accessibility and wonder over technical precision, aiming to share the excitement of deep time discovery and queer ecology with curious minds of all backgrounds. It is an attempt at storytelling as much as it is a scientific text, and endeavors to narratively present a complex story and complicated discipline in a way that is intuitive.

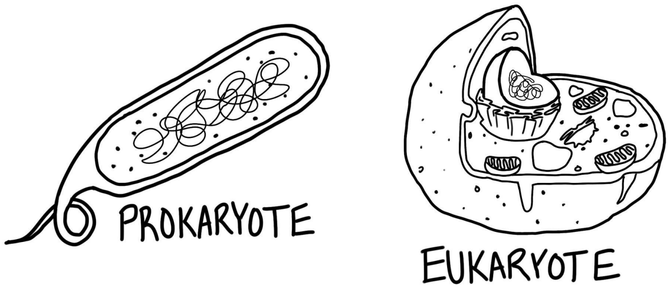
Grateful acknowledgment to Eastern Edge Artist Run Centre for the support with this project. Special thanks to Dr. Duncan McIlroy and the MUN Paleontology lab, especially Heléna Muirhead-Hunt, for the conversations and trips to the field..



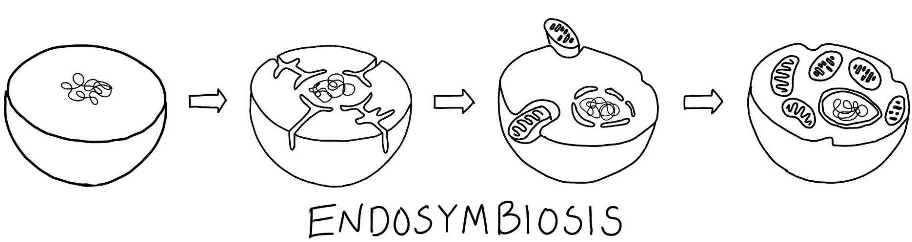
Earth is around 4.6 billion years old. Scientists know this by measuring radioactive decay in the oldest rocks and meteorites. The history of life on earth begins around 4 billion years ago. No one knows exactly how "life" began, but likely it started as chemical chain reactions. Life is a funny concept, we all think we know what is alive, but "life" actually isn't a word that is scientifically and rigorously defined in a way everyone agrees upon. But, around 3.5 billion years ago, we start to see evidence of the earliest life. We know this through a mix of evidence including:

- Stromatolites or layered rock structures created by microbial mats
- Microscopic fossils preserved glass-like rocks called cherts
- Chemical signatures in rocks like "banded iron formations" that formed when life started releasing oxygen into the atmosphere "rusting" the iron in rocks creating reddish layers.

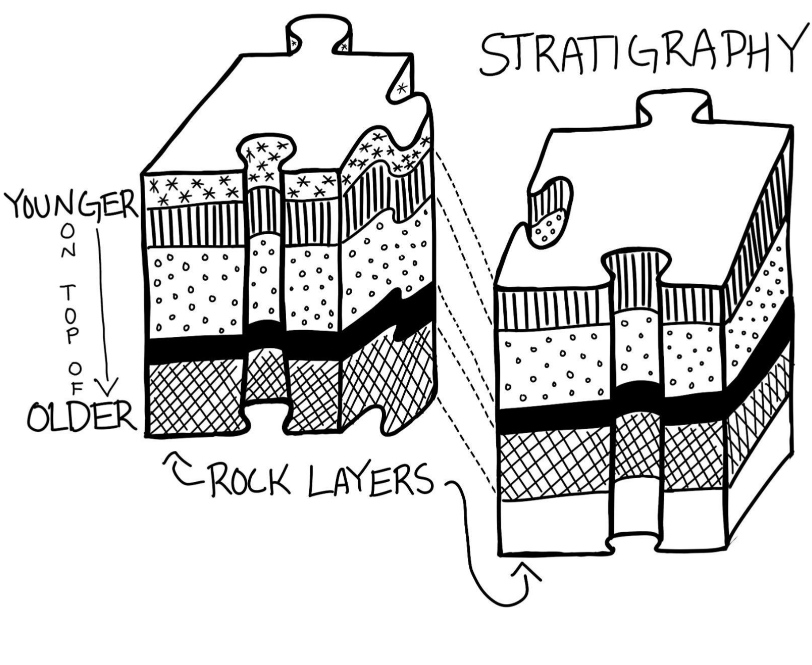




These early cells, called prokaryotes, were very simple and did not have organelles— small structures like mitochondria, which break nutrients down into energy, or chloroplasts, which turn sunlight into energy. Around 2 billion years ago, evolution tried something wild: what if cells stopped competing and started cooperating? Some simple cells absorbed each other, but instead of one eating each other, they became roommates. This process of collaboration, called endosymbiosis, created eukaryotic cells and formed the most successful partnership in Earth's history. Eukaryotic cells, while still very small, are much larger and more complex than prokaryotic cells.The evidence for the evolution of eukaryotic cells includes rocks bearing the chemical signature of cholesterol (which is only produced by complex cells) and microscopic fossils called acritarchs that have complex spikes and textures that are not seen in any prokaryotes. The name “acritarchs” means "uncertain origin” and scientists don’t know exactly what these were (a common theme in the early history of life!) but are pretty confident they were Eukaryotic.

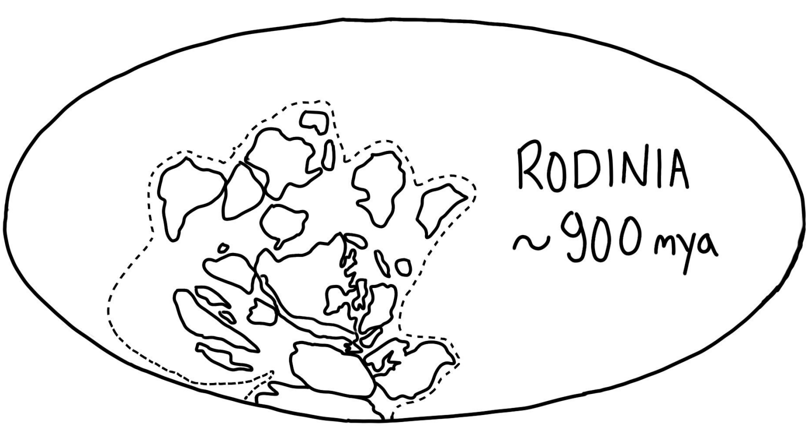


Scientists call the period from about 1.8 billion years ago, to .8 billion years ago the "boring billion". Even though evolution was happening, it was small scale and at a slow pace. During this period, there was relatively little tectonic activity or moving of land masses, and both ocean and atmospheric chemistry was fairly stable. Again we know this through looking at rocks. By studying rock layers, a field called stratigraphy, scientists know that most of Earth's land mass was part of a "supercontinent" called Rodinia and the chemical signatures of the rocks indicate stable conditions. Rocks are formed in layers, and newer layers form on top of older existing layers. You can almost think of it like making a jigsaw puzzle out of a cross-section of a tree. By matching and comparing the rings, we can interpret both the position of the pieces *and* the stable growth cycles of the tree.



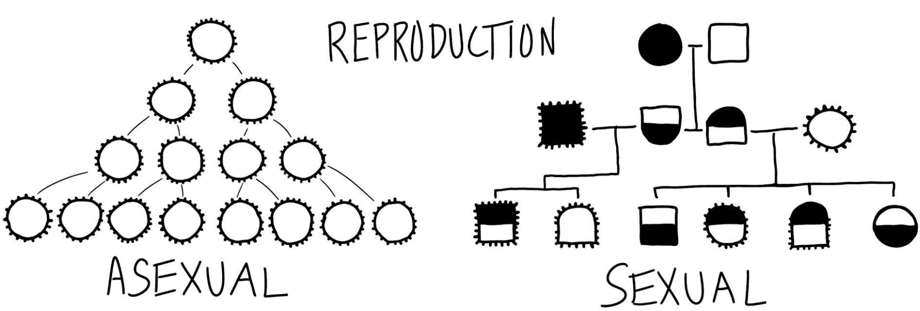
Around 800 million years ago, Rodinia broke up, ending the "boring billion". A combination of factors including massive volcanic activity throwing up sun-blocking ash and a decrease in greenhouse gasses as rocks dissolved into the ocean created "Snowball earth". Snowball Earth was not just an "ice age" like we imagine it. Ice reached all the way to the equator, but life persisted in some pockets like volcanic hot springs and hydrothermal vents on the ocean floor lying under sheet ice. This caused an extreme bottleneck effect where many forms of life died out, and only the hardiest survived. But we need to think about these cycles of stability and intense pressures not as "problems", but as opportunities for life to experiment and take new forms.

The extreme environments endured actually helped spur evolution. The simplest organisms reproduce asexually by dividing and creating identical copies of the parent organism. This is called asexual reproduction. During, or possibly slightly before, snowball earth, cells developed the ability to reproduce sexually. In variable environments, the ability to exchange genetic material is advantageous. It allows organisms to adapt and change quickly giving them an edge over asexually reproducing organisms. In the extreme pressures of Snowball Earth, these sexually reproducing organisms flourished.



In this context, sexual reproduction just means the exchange of genetic material between generations. Our cultural view of sexual reproduction is by no means a scientific one. These animals did not likely have distinct sexes and sexual reproduction just means the ability to exchange genetic material and adapt between generations. Sexual reproduction allows for increased genetic variation, it is why siblings can often look very different from each other, and allows organisms to adapt to new environments quickly. Once snowball earth finally melted, new environments like shallow coastal waters and new land masses emerged. Life quickly spread into all these new niches and strains of organisms that could reproduce sexually had a distinct advantage in evolving to take advantage of this new ecospace.

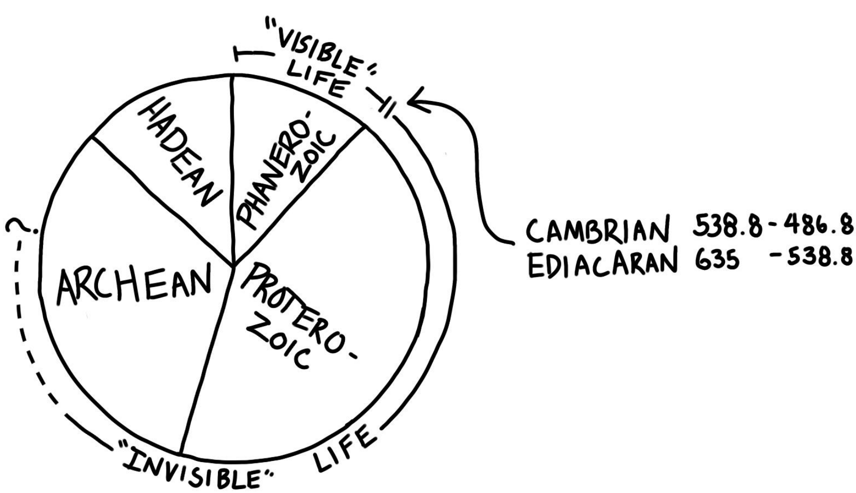
This emergence of new lifeforms after the end of snowball earth is sometimes called the "Avalon Radiation" after the Avalon Peninsula of Newfoundland, located on the traditional and unceded territory of the Mi'kmaq and the ancestral lands of the Beothuk people. This geologic terrane has some of the oldest fossils of complex multicellular life.



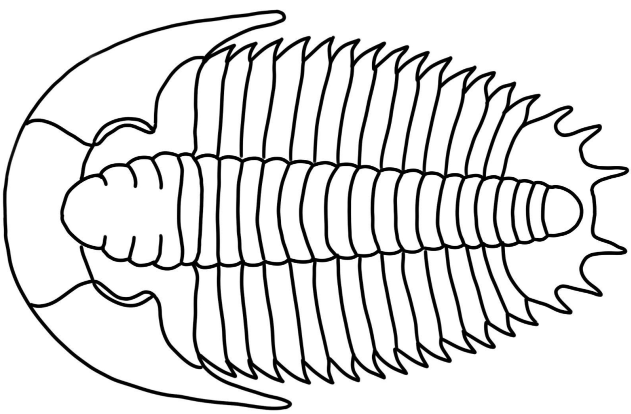
Before a deep dive into the Ediacaran period, we should talk about what it *isn't* first. Scientists have traditionally broken down earth into 4 eons:

- Hadean (4.6-4.0 billion years ago) When Earth was forming, a literal molten hellscape
- Archean (4.0-2.5 billion years ago) - When the first simple life appears
- Proterozoic (2.5 billion-541 million years ago) - A long stretch of mostly single-celled life including the "boring billion"
- Phanerozoic (541 million years ago-present) - The name means "visible life" and includes all life we think typically think of, including humans

These divisions are further broken down into Periods like the Ediacaran. Notably, the Ediacaran *is not* in the current eon, the Phanerozoic or "visible life" eon.



Up until the middle of the 20th century, people really knew very little about life in the Proterozoic. The Cambrian period, which was immediately after the Ediacaran, is rich with fossils of complex life like trilobites, corals, and mollusks that we all recognize as animals. But, the rock layers under the Cambrian were bare of fossils. Everyone knew this was a problem including Charles Darwin himself when he wrote "On the Origin of Species" calling the lack of Precambrian fossils "the most obvious and gravest objection which can be urged against my theory." How did complex animals like trilobites just pop up out of nowhere and what came before?

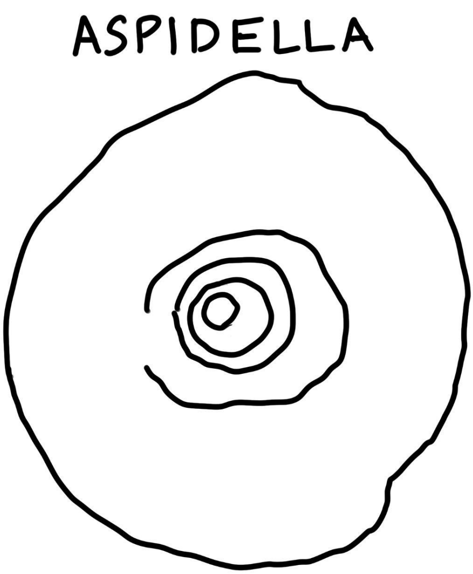


TRILOBITE (CAMBRIAN)

Scientists love describing, naming, and organizing. But the vast complex history and diversity of life is not easily sorted. Even today, scientists are constantly having to rearrange the tree of life, pruning branches and grafting them onto new sections. So when American geologist George Halcott Chadwick delineated the "Phanerozoic" or visible life eon in 1930, the Ediacaran was left on the "invisible" side of the divide. Or rather it soon would be, since it had yet to be discovered or named in 1930!

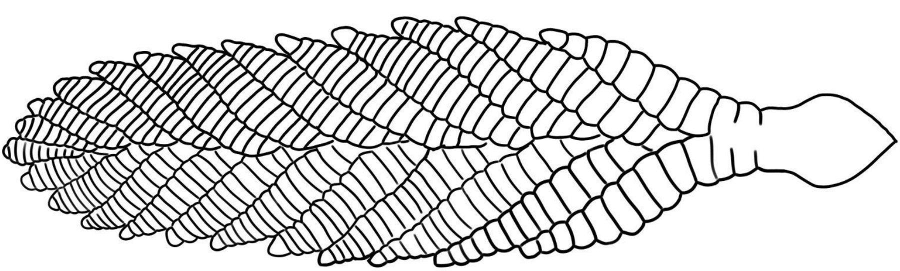
Undoubtedly, indigenous peoples were the first to “discover” Ediacaran fossils, and likely had their own explanation for these fantastic patterned rocks. But there are several contending stories for the first modern discovery of the Ediacaran, and they all illustrate how stubborn the scientific establishment can be to revise ideas once they become settled, and what voices get listened to when trying to change scientific thought.

The first Ediacaran fossil described is *Aspidella terranovica* in 1868. *Aspidella* is a mysterious fossil that looks like a pimple or boil with rings around it but made out of rock. However, scientists at the time held that no multicellular life existed before the Cambrian and refuted a biological origin for these fossils claiming instead that they were gas bubbles or inorganic concretions. When something looks like a fossil, but has a non biological origin, it is called a pseudofossil.



In 1946, Reg Sprigg, a geologist working for the Australian government discovered complex looking fossils while surveying the Ediacara hills in South Australia for an economic study. Reg Sprigg had training in zoology and geology but actually was not a paleontologist. Even in 1946, paleontology still held that no large fossils existed before the Cambrian period. He saw fossils that looked complex and animal-like in rock that he knew dated from the precambrian. He wrote a paper on the find that was rejected by the major journal *Nature* but was published in Australia. Despite publication, when he travelled to London for the 1948 International Geological Congress, his ideas failed to gain support.

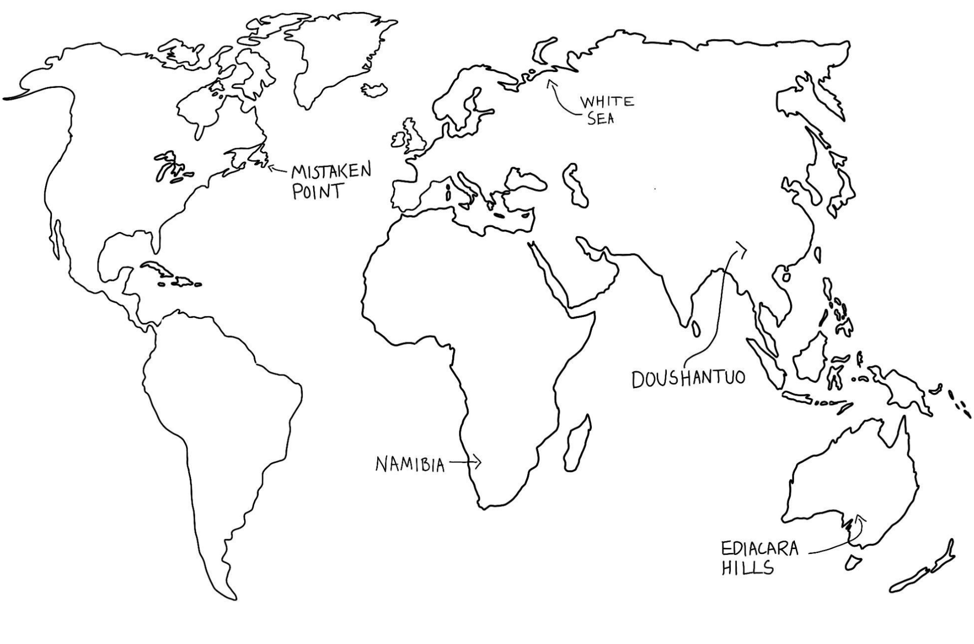
A decade later and over 10,000 miles away, 15 year old Tina Negus discovered a strange frond-like fossil while fossil hunting in an abandoned quarry in Charnwood Forest near Leicester, England. She took pencil rubbing and showed it to a teacher who dismissed her out right since the rocks in question were precambrian in age. A year later, another teenager, Roger Mason also saw the same fossil, also took a rubbing, and brought it to his father who taught at Leicester University. His father showed it to a colleague, Trevor Ford, who went out to the site to visit. In 1958 Ford published on the fossil naming it *Charnia masoni* after Charnwood Forest and Roger Mason. This 1958 paper marks the beginning of modern research into precambrian life.



CHARNIA MASONI

This research is still ongoing. The Ediacaran period was formally named and defined in 2004. It is the 96 million years from the end of the Cryogenian Period (snowball Earth) at 635 million years ago to the beginning of the Cambrian at 538.8 million years ago.

While you can buy a trilobite fossil at just about any rock shop, Ediacaran fossils are much more rare. While new fossil sites continue to be found, our understanding of Ediacaran life is heavily shaped by 5 lagerstätten, or fossil sites. From the German meaning "storage place", lagerstätte are special fossil sites that record extraordinary detail and a high abundance of specimens, often whole communities and ecosystems. Lagerstätte are rare, and Ediacaran ones, exceedingly so. There are five major Ediacaran Lagerstätte.



Avalon Assemblage (Mistaken Point)- Newfoundland fossil sites like the famous Mistaken Point preserve the earliest evidence of complex Ediacarans and preserve deep water environments dominated by rangeomorphs, mysterious frond-like organisms based on fractals.

Location: Newfoundland, Canada

Age: 575-560 Mya

White Sea- The White Sea assemblage of Russia preserves the most diverse Ediacaran communities in shallow marine environments. The exceptionally fine detail can often include traces of feeding, locomotion, and complex behaviors.

Location: Arkhangelsk region, Russia

Age: 560-550 Mya

Ediacara Hills- The Ediacara Hills of South Australia preserve a diverse shallow marine assemblage similar to the White Sea. Its dating is approximate and based on comparison to the White Sea assemblage rather than hard date constraints from radiometric dating.

Location: Flinders Ranges, South Australia

Age: ~560-555 Mya (contested)

Nama Group- The Nama Group of Namibia preserves the youngest Ediacaran assemblage right before the Cambrian period and includes the earliest evidence of animals building hard parts from minerals and beginning to burrow. Layers above actually preserve some early Cambrian fossils as well.

Location: Southern Namibia

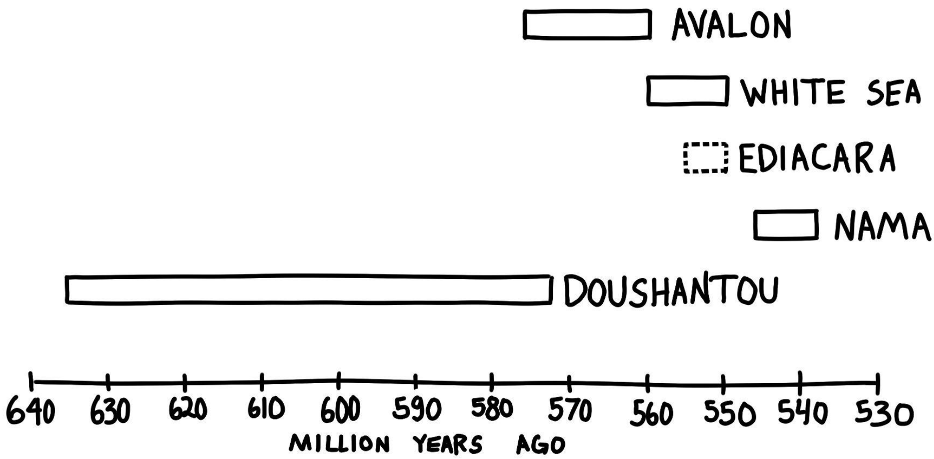
Age: 547-539 Mya

Doushantuo Formation- The Doushantuo formation has the longest time range and gives us important clues about the evolution and possibly life cycle of Ediacarans. Doushantuo fossils are mostly microscopic, although at least one large Ediacaran, *Eoandromeda* Is found in the Doushantuo, as well as other fossil sites.

Location: South China

Age: 635-551 Mya

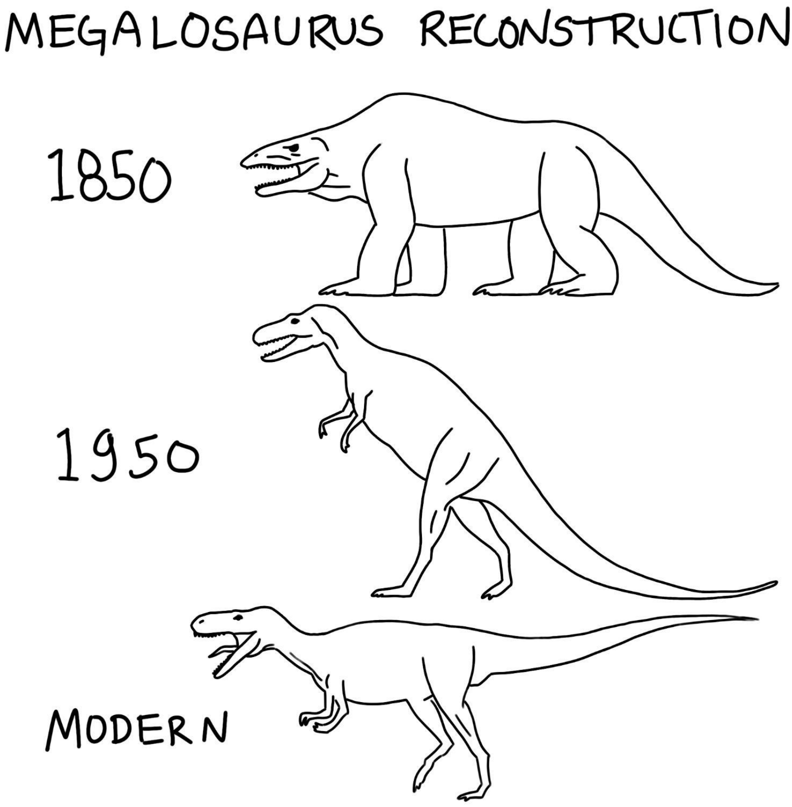
These sites are each just snapshots of one specific moment, but together they can give us a more complete picture of Ediacaran life. Each of these sites preserve different groups of organisms, preserved in different ways, in a fragmentary timeline. They show that life existed around the world, not just in one place. But keep in mind that the locations of these sites would've been very different 550 million years ago from where they are now!



Finding any fossil is a minor miracle. Estimates are that only 1 bone in a billion gets fossilized. To help visualize, this means if the entire population of the world, around 8.1 billion souls each with 206 bones, were to die, we could expect around 8 complete skeletons. Of course, that is 8 skeletons or 1,669 bones spread out over the whole planet so finding them would be tricky too! Paleontologists call this fossil resolution. Eras where we have more fossils have a higher fossil resolution than eras we have fewer fossils from. We have a pretty good idea of what dinosaurs were like since we have a greater fossil resolution from the Jurassic era whereas Ediacarans are still very mysterious. Fossil resolution is *how much* total information we have.

We also have to deal with what is called “preservation bias”. Environmental or even mineral factors can impact what kind of organisms are preserved and in how much detail. For example, Newfoundland and Australian fossils sites are great at capturing touchable, 3D textures, but the large grain size of the rock means that we can’t see super fine surface details or cells. These sites have a preservation bias towards larger organisms. The Chinese material is different entirely and most of the fossils are microscopic, exhibiting a very different preservation bias from other sites. This means at any fossil site, we are only getting to study a small subset of all the life present. A given fossil community is only present in a single rock layer. Subsequent layers may have a different preservation bias, but they will preserve different, younger communities. Preservation bias is *what kind* of information we have.

Fossils can also be traces like foot or claw prints or preserved burrows (called ichnofossils) or even chemical signatures in rock. But after fossils are found they need to be interpreted by paleontologists. When paleontologists are interpreting fossil evidence of an organism, it is called a reconstruction. Even the very best reconstructions *are not* the actual animal, they are a scientist’s best guess. How an organism is reconstructed can and does change over time as new fossil specimens and analytical techniques become available. For example, in the early 20th century, most reconstructions of dinosaurs showed them as slow lumbering animals whereas now, scientific consensus is that many dinosaurs were more active. New techniques such as using computers to compare 3D scans get developed, but at the end of the day any reconstruction is just somebody's (hopefully well informed) best guess. What’s more, many aspects of an organism in life such as color or how it moves or holds itself don’t fossilize. While we can make informed decisions, these aspects of reconstruction often involve creative thinking that is more like art than science.

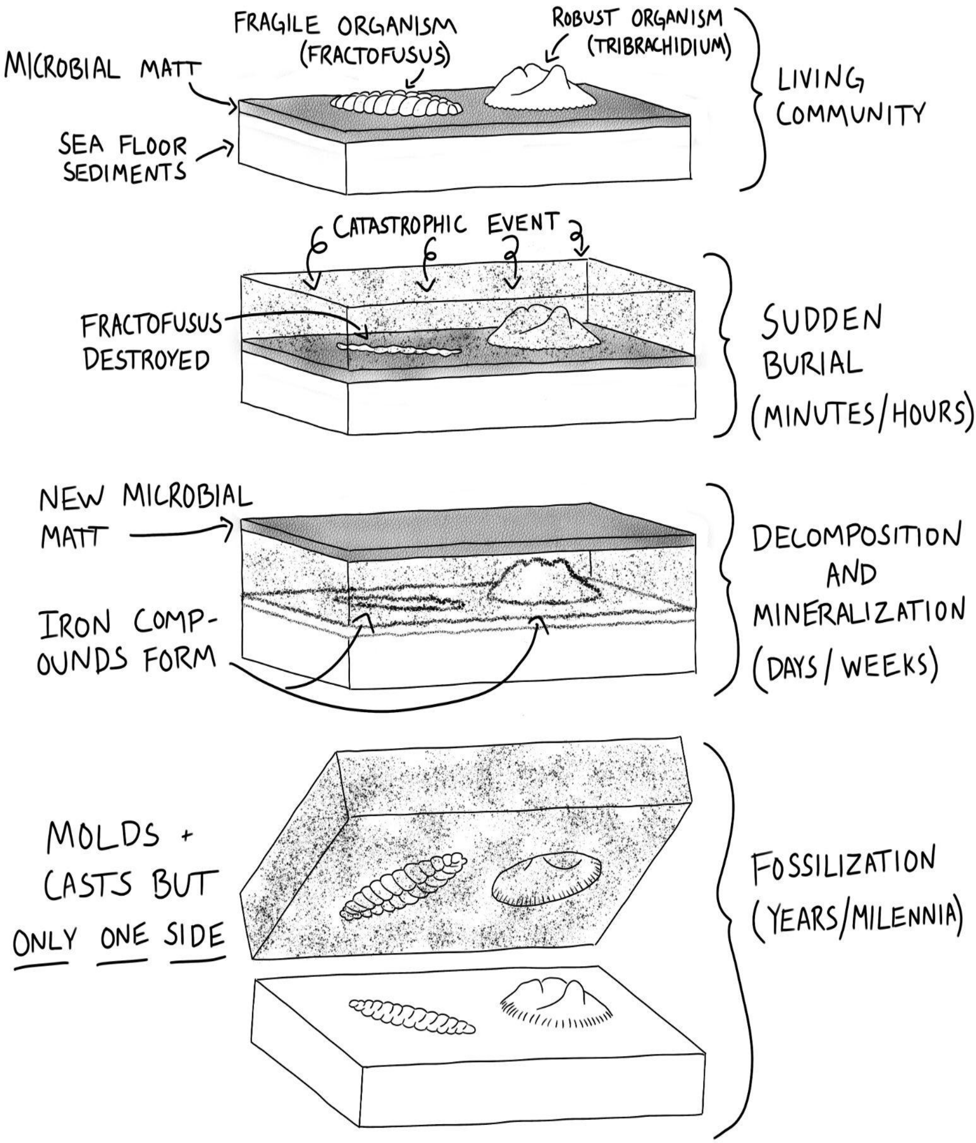


Unlike trilobites with mineralized exoskeletons like crabs or beetles, or dinosaurs with bones, Ediacarans didn't generally have hard parts to mineralize which makes their preservation even more rare. The study of how something fossilizes is called taphonomy. Taphonomy includes everything from when an organism died until it is discovered. It includes biological processes such as decomposition and geological processes like uplift as well. Since Ediacarans were soft bodied, they have some pretty unique taphonomy.

In fossils from the Mistaken Point, White Sea, and Ediacara Hills lagerstätten, biological material is preserved in textured relief. You can actually feel the surface of these ancient organisms as ridges and valleys in rock. In this type of taphonomy, microbial mats played a huge role in preserving the fossils. During the Ediacaran, the ocean floor was covered with a carpet of microbes like bacteria and algae. These microbial mats were complex, multilayered communities with surface microbes exchanging oxygen and layers beneath specialized for oxygen free conditions. All these layers were bound together by what amounts to a biological glue and trapped inorganic sediments into a rubbery carpet. These microbial mats were a crucial part of the ediacaran environment and food web.

When an event such as a volcanic eruption or storm dumped ash or silt over the ancient sea floor, it would cover the microbial mat and the Ediacaran organisms living on it. The microbial mat acted almost like a memory foam holding onto the fossil impressions while the sediments turned to rock. The most delicate organisms would be destroyed by the sedimentation event, and we only have their bottom side preserved as a "footprint" in the microbial mat. Organisms with a more robust texture would resist getting crushed, and the bacteria within the mat would begin to decompose them, producing iron and sulfur compounds in oxygen-free zones that stabilized the rock around them. These microbial mats also made fossils themselves, creating a tell-tale "elephant skin" texture that covers ediacaran fossil beds.

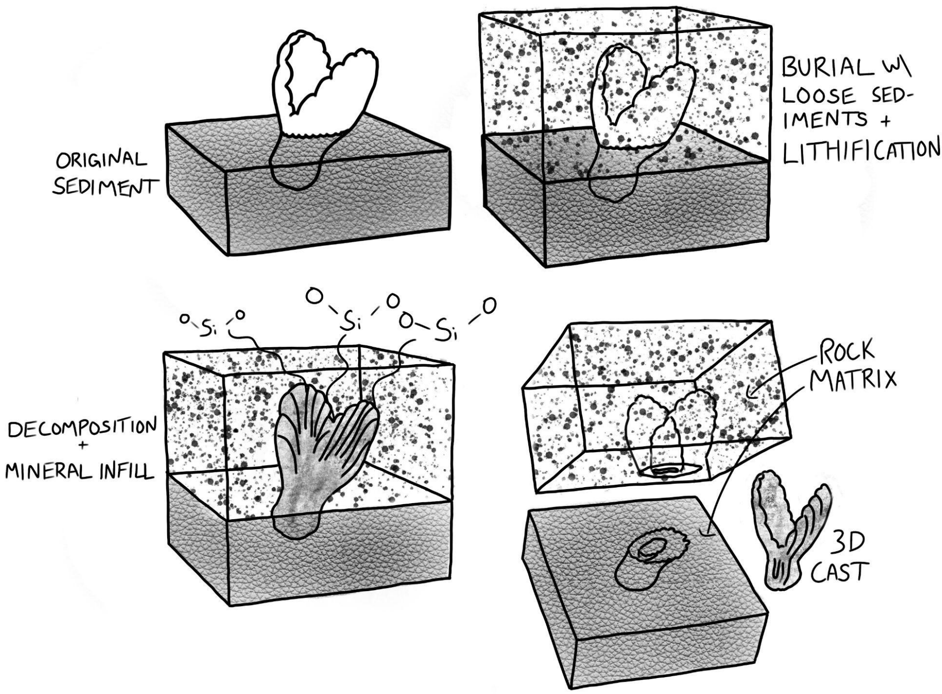
EDIACARAN TAPHONOMY



These fossils are essentially 550-million-year-old death masks of entire communities. When catastrophe struck, like volcanic eruptions or sudden burial events, ash and sediments poured down like liquid plaster over the seafloor. Fragile organisms dissolved away, leaving behind hollow molds like handprints, whereas robust organisms turned into casts. But, no matter if it is a cast or a mold, this taphonomic pathway can only capture one side of an individual organism. Usually these events buried living communities quickly, and organisms were buried as they lived. Often we have many fossils of one side of an organism, but none or only a few examples of the opposite side. This makes the paleontologist's job of reconstructing these organisms even more difficult. It’s almost as if we had hundreds of pictures of the underside of cars and none of the tops. We’d be able to guess these were mechanical and could move on wheels, but that is about it. If we had a just single picture of the top part of a car and it was a pickup truck, we might imagine all car bottoms by default were trucks, ignoring SUVs, sedans, and station wagons.

Nama style preservation is completely different and often preserves organisms in full 3D. Organisms in the Nama group were buried rapidly by storm deposits, but the sediments were less compacted and allowed groundwater to seep through. The surrounding sediments quickly lithified (turned to rock) while the organisms were still intact. The chemistry is complex, but in Nama-style preservation, microbial processes and silica-rich seawater helped create perfect 3D molds of the organisms. As the organism decayed away, it left a void space that captured both external shapes and some internal structures. Later, these voids filled with different sediments. While Ediacaran type preservation is like pressing a handprint into plaster, Nama preservation is more like casting a whole hand. Nama style preservation is extremely uncommon outside of the Nama group in Namibia.

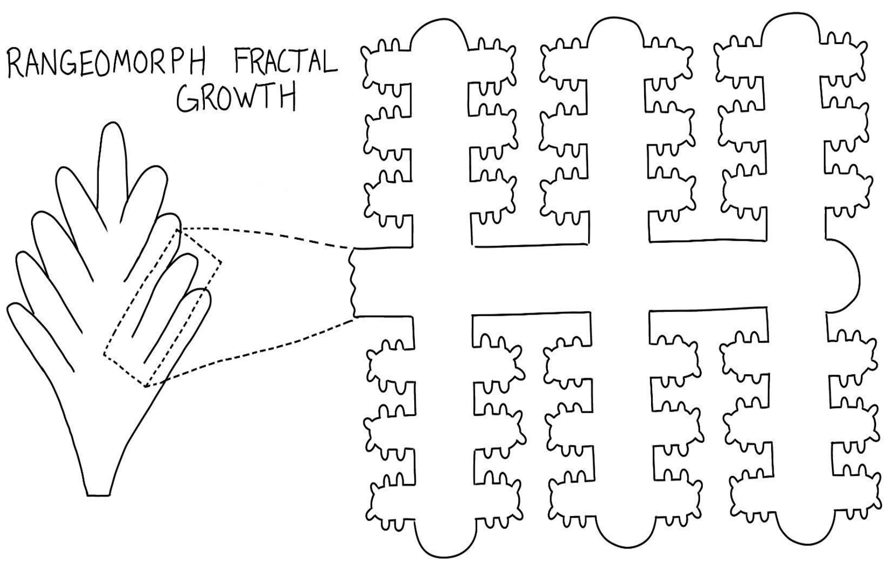
NAMA PRESERVATION



Doushantuo preservation is like Nama-style preservation, but shrunk down to a microscopic level. Instead of preserving whole organisms in 3D, Doushantuo fossils capture tiny embryos, single cells, and even the stages of cell division in incredible detail. Just like in Nama preservation, mineral-rich water flowed around these microscopic organisms. But instead of silica, phosphate minerals replaced the organic material cell by cell. These fossils are so small you need a microscope to see them, but they preserve cellular details like nuclei, cell walls, and even chromosomes during division. Some fossils show complete developmental sequences, from single fertilized eggs through multiple cell divisions to tiny multicellular embryos. This small scale three-dimensional preservation is completely different from the molds and casts of other Ediacaran sites. It has a massive preservation bias for cellular level detail and only one potential large animal, *Eoandromeda*, is preserved without dispute.

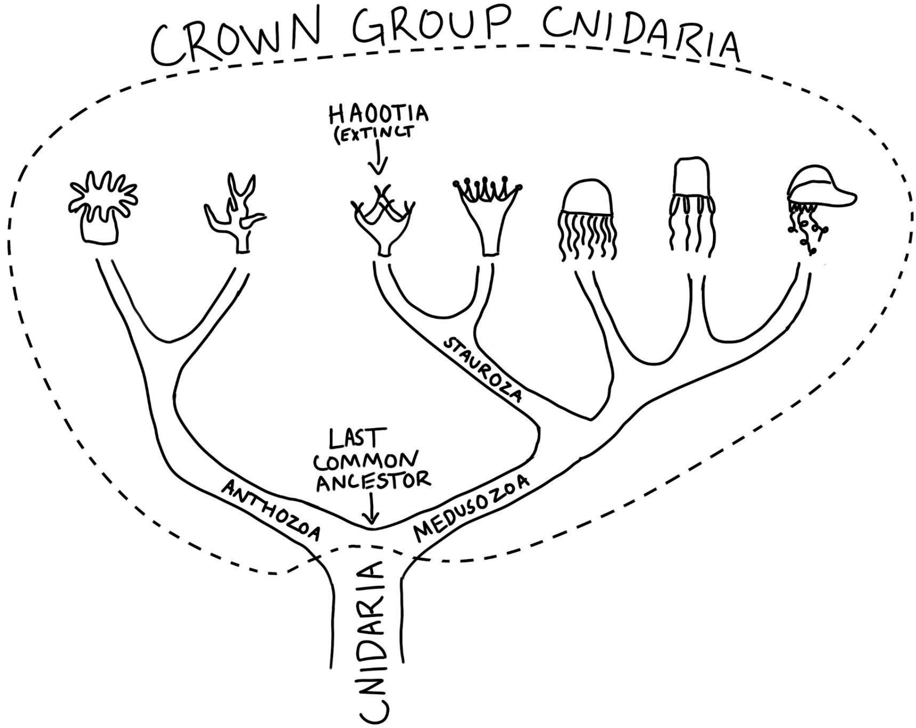
The Avalon Biota is the oldest Ediacaran biota with large and complex life. It was a deep ocean community that lived between 575-560 million years ago. We know it was a deep water community since we don't see any disturbing of the sediments due to wave action. In some sites, we see evidence that sediments tumbled down the continental slope leading us to believe these communities lived along the deep ocean floor above a microbial mat that blanketed the ocean floor. These organisms lived in a world that was perpetually dark and photosynthesis did not occur.

The Avalon Biota is dominated by mysterious organisms called rangeomorphs. Rangeomorphs are very mysterious and come in different shapes and sizes. Some were quite small, while others could grow to over a meter in length. Since we can infer that these were deep water environments with no light, we can say they aren't plants as we understand them. Yet rangeomorphs also don't seem very similar to any other living or extinct animals. Some scientists have proposed that they were giant single cells or symbiotic communities of multiple organisms like lichens. What we do know about rangeomorphs is that they grew in fractal patterns where each unit repeated itself at a smaller and smaller scale.



Most scientists now think that rangeomorphs never evolved into any modern types of living organisms. Rather, they were an early experiment on the way to modern animals that flourished and then went extinct. However, scientists still disagree on much like whether these animals stood upright or laid flat on the seafloor; and whether they were filled with sea water, some sort of cellular gel, or mostly formed out of flat, curling ribbons of cells.

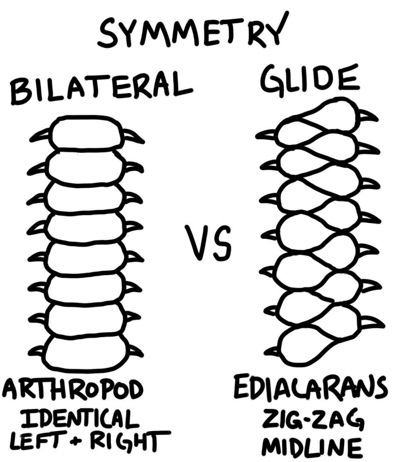
Despite the dominance of the mysterious rangeomorphs in the Avalon biota, the earliest example of an animal related to an animal living today is a member of the Avalon Biota, *Haootia quadriformis. Haootia* shows fossil evidence of muscle fibers and body shape remarkably similar to living Staurozoans or stalked jellyfish! When an organism is descended from the same last common ancestor as all members of a living group, it is called a crown group organism. Recent research places *Haootia* as a crown group cnidarian, the group of animals that contains sea anemones, corals, and jellyfish.



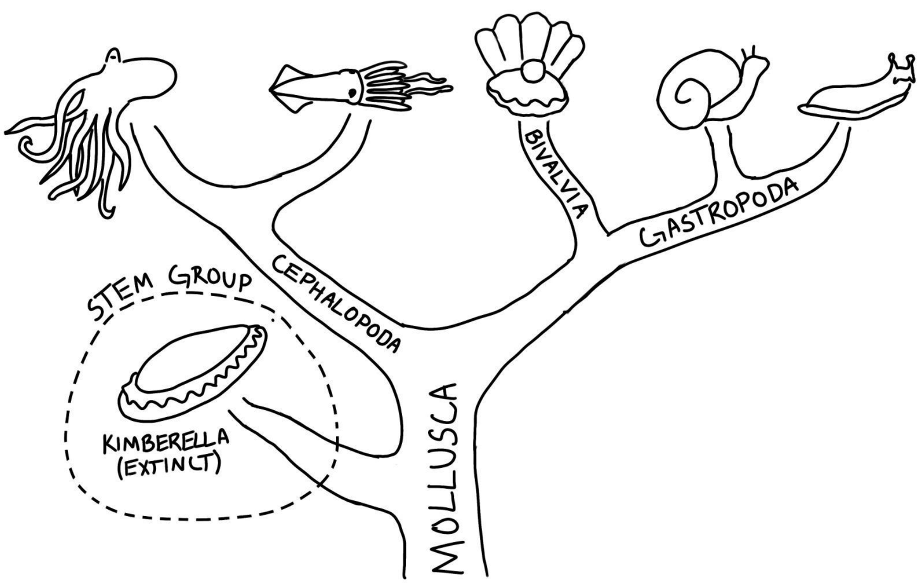
The White Sea Biota is from the middle Ediacaran, 560-550 million years ago. We have excellent fossils from both the White Sea region of Russia and the Ediacara Hills of South Australia for this assemblage of organisms. The White Sea Biota represents shallow water communities. We know that because the sediments do show examples of being disturbed by waves and some fossil sites present evidence that a given area might have been fluctuating between intertidal and off-shore communities as coastlines shifted.

Much like today's coral reefs are hotspots of biodiversity, the White Sea assemblage shows a huge diversity of novel body plans. Rangeomorphs are also present in the White Sea Assemblage, but they are not as dominant as in the Avalon Biota. Instead, we see tons of novel body plans unlike anything alive today. Many organisms like *Dickinsonia* exhibit glide symmetry where body units repeat at an offset along a central zig-zag midpoint, almost like if a centipede had only a left or right leg on each body segment. Some scientists think these may be distantly related to arthropods (animals like insects and crustaceans with bodies made up of repeating units) and others think they might also be mysterious experiments into multicellular life without a close relationship to current animal life, like rangeomorphs.

Other White Sea creatures like *Tribrachidium* have spiral symmetry of 3 or more parts. Some believe that these organisms passively fed by creating eddies through their swirling body geometry. These eddies would slow food particles suspended in the water column so they could drift down into pits where they were consumed or absorbed. Some scientists think that *Tribrachidium* and similar organisms might be more clearly animals than *Dickinsonia* and rangeomorphs, but even this is still debated.



We can reasonably assume that the microbial mats in shallower Ediacaran seas incorporated photosynthetic algae since sun could penetrate the water. This microbial mat was an important part of the ecosystem. One organism, *Kimberella*, is associated with feeding traces where they actively scraped and farmed the microbial mat. Kimberella is a fascinating organism with a complicated history of reconstruction. Most recent reconstructions of *Kimberella* resemble a sea slug with a domed, leathery shell on the back. Some scientists think that Kimberella may be an early branch of the mollusks (the group containing snails, octopuses, and clams), but this claim is contentious. This doesn't mean that octopuses evolved from Kimberella however. It means that at some point they shared a common ancestor. When an organism represents an early branch of a group that's still alive today, but isn't directly ancestral to modern forms, it's called a stem group organism and some think Kimberella is a stem-group mollusk.

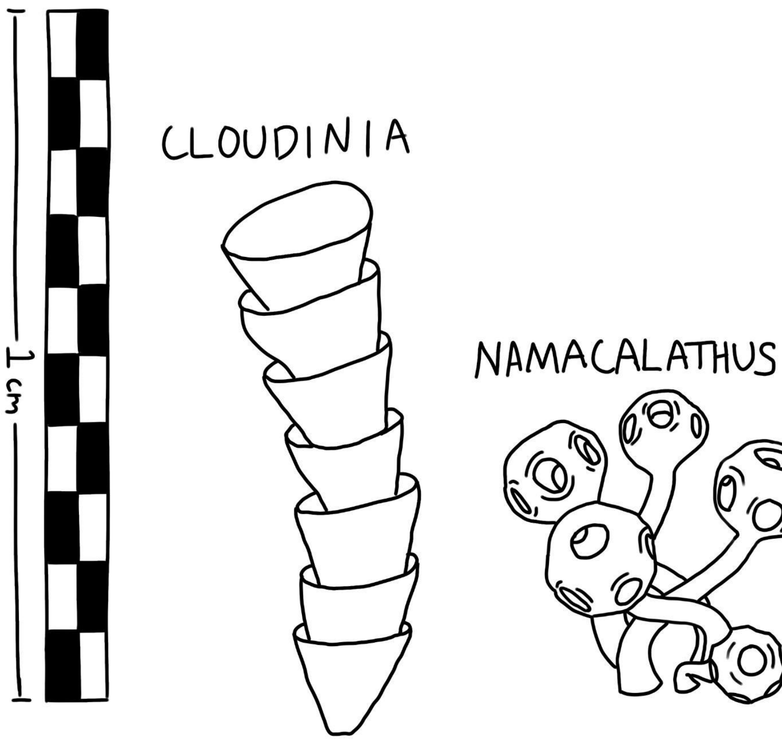


The Nama Biota is the youngest of the Ediacaran biotas and represents the final chapter of this strange world. We have excellent fossils from the Nama Group in southern Namibia, which gives this assemblage its name. The Nama Biota lived between 550-539 million years ago, right at the edge of the Ediacaran period when more familiar animal life was about to emerge.

Unlike the deep-water Avalon communities or the diverse shallow-water White Sea assemblages, the Nama Biota represents environments that were even more varied - from shallow marine to possibly even coastal settings. The fossils show evidence of living in higher-energy environments where storms and strong currents were more common.

We actually see a decrease in diversity with the Nama biota. It is tempting to think of this as an evolutionary “decline” over time but we also need to take into account preservation bias and that the Nama biota was one very specific community living in rough seas. Most forms like from the White Sea and Avalon assemblages are not present in the Nama biota, but rangeomorphs are making them the only Ediacaran lineage present at the beginning and end of the Ediacaran fossil window

The Nama biota is dominated by organisms with a body plan based on tubes like *Pteridinium* and *Ernietta*. There is some fossil evidence that these organisms actually incorporated sand or sediments into these tubes as a primitive, inorganic skeleton or anchoring mechanism. Often these creatures are described as quilted, or with a structure similar to chambered air mattress. Many scientists lean toward these organisms being another Ediacaran-specific lineage that didn't survive into the Cambrian.



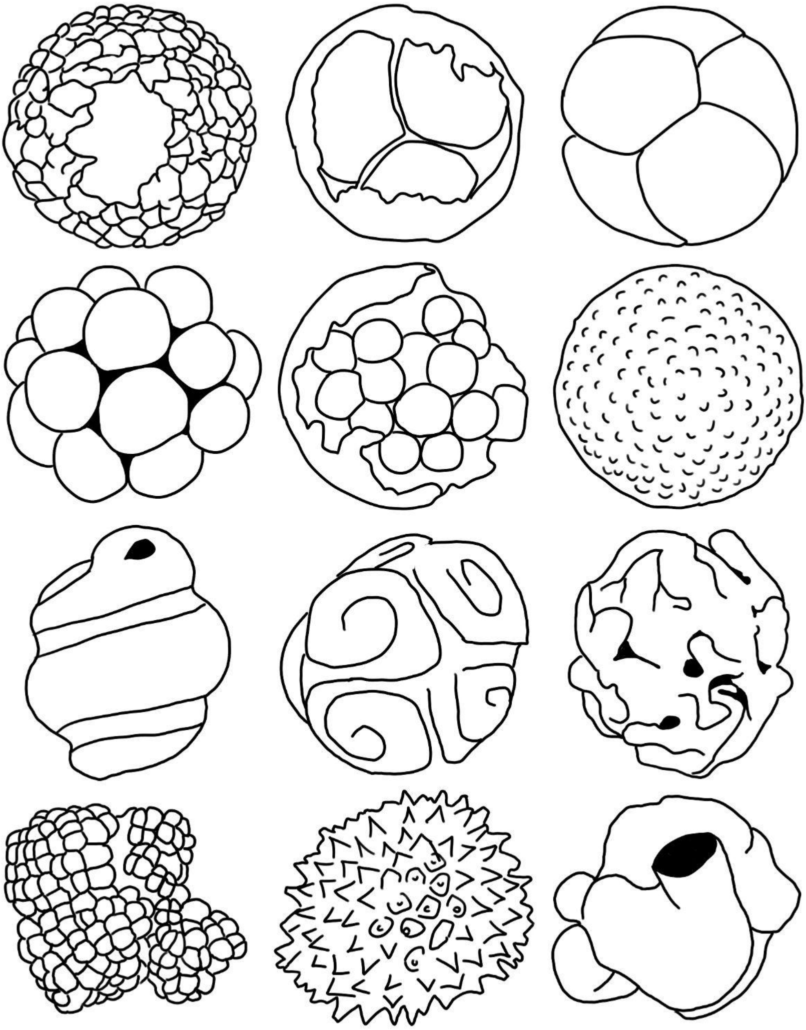
Some of the most revolutionary organisms in the Nama biota are also among the smallest. *Cloudina* and *Namacalathus*, measured in millimeters, represent a major evolutionary breakthrough – they were the very first organisms to build hard, mineralized shells. This innovation would prove crucial for surviving in the increasingly competitive world that was emerging at the end of the Ediacaran period and is a major step in the history of life, even though these organisms were very tiny, and likely were not major factors in the ecosystem where they developed.

The Doushantuo Assemblage is not a biota like the others, but is an important part of the fossil record of the Ediacaran period. It is the earliest, longest, and most enigmatic of the Ediacaran assemblages. This range spans from right after “Snowball Earth” and overlaps with all the other Ediacaran biota. The Doushantuo represents various shallow marine environments over tens of millions of years, from lagoons to continental shelves – a diverse set of conditions where early life was experimenting with multicellularity.

Unlike the other biotas we've discussed, the Doushantuo fossils are preserved in a way which captures organisms at the cellular level in incredible detail. What makes the Doushantuo so remarkable is that we're looking at life at a completely different scale. Instead of large, complex organisms like Dickinsonia or rangeomorphs, we're seeing microscopic embryos, single cells, and simple multicellular clusters. Some of the most famous Doushantuo fossils appear to be animal embryos caught in the process of cell division - showing 2, 4, 8, and more cells as they developed. These might be larval stages in the life cycle of larger Ediacarans, evolutionary steps towards larger life, or just a microscopic scale component of other ediacaran ecosystems that preservation bias excluded from fossil sites that record larger life forms.

The Doushantuo has a strong preservation bias towards very small cellular details rather than large creatures. However, at least one member of the White Sea biota, *Eoandromeda*, is also preserved in some of the topmost layers of the Doushantuo formation! This incredible find raises more questions than it answers. Was *Eoandromeda* a survivor that bridged two completely different ecosystems? Or an early organism from a different ecosystem beginning to colonize? Or were other larger animal-like creatures present in the Doushantuo, but macroscopic material is exceedingly rare in the fossil record due to preservation bias?.

DOUSHANTUO MICROFOSSILS

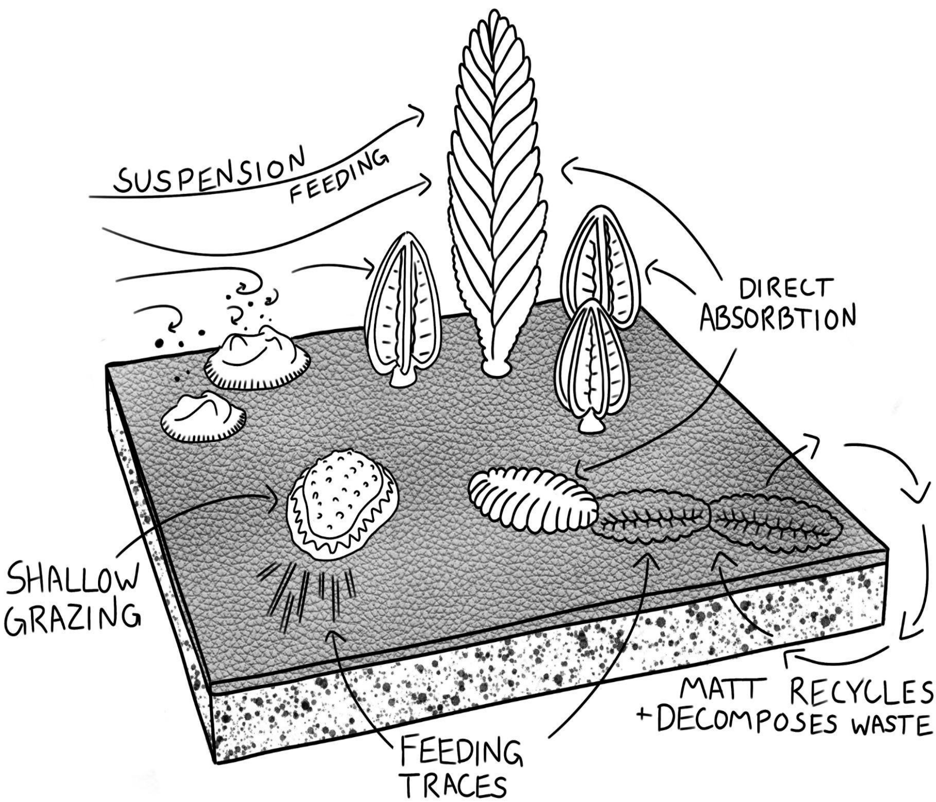


While these different biota come from different environments separated by millions of years, we can start to make a more complete picture of the Ediacaran world by looking at them together. What emerges is a portrait of life trying radical experiments on an unprecedented scale and an ecosystem that operated on different principals than modern ecosystems do. Even thinking of evolution as we know it isn’t really applicable here.

Rangeomorphs weren't “trying” to become animals as we know them; they were exploring fractal growth patterns and modular construction that created forms unlike anything in our modern world. They likely fed by passively absorbing nutrients from the water column and came up with an ingenious method to do so. Their fractal growth pattern allowed for a massive amount of surface area in a compact body and allowed them to become one of the most successful groups of Ediacarans. Modern animals have evolved to fulfill a huge range of ecological niches from intestinal parasites to blind cave fish, but no organism since rangeomorphs have exhibited a body-level fractal growth pattern aimed at maximizing surface area to passively feed from their environment. These weren't "primitive" or "simple" organisms - they were beautiful and sophisticated solutions to the ecological opportunities available in the Ediacaran world.

The classic view of evolution is framed as a competition for scarce resources with multiple levels of predators and prey. In the Ediacaran, there was certainly a limited amount of resources, but the selective pressures on organisms were very different from all following eras. The Ediacaran was a world without predation or even scavenging. No organism was hunting, chasing, or eating other organisms. Decomposition occurred in a closed loop system where waste and dead organisms were recycled by the microbial mat. The closest thing to active feeding we see is *Haootia* filtering organic matter out of the water column or *Kimberella* gently scraping microbial mats.

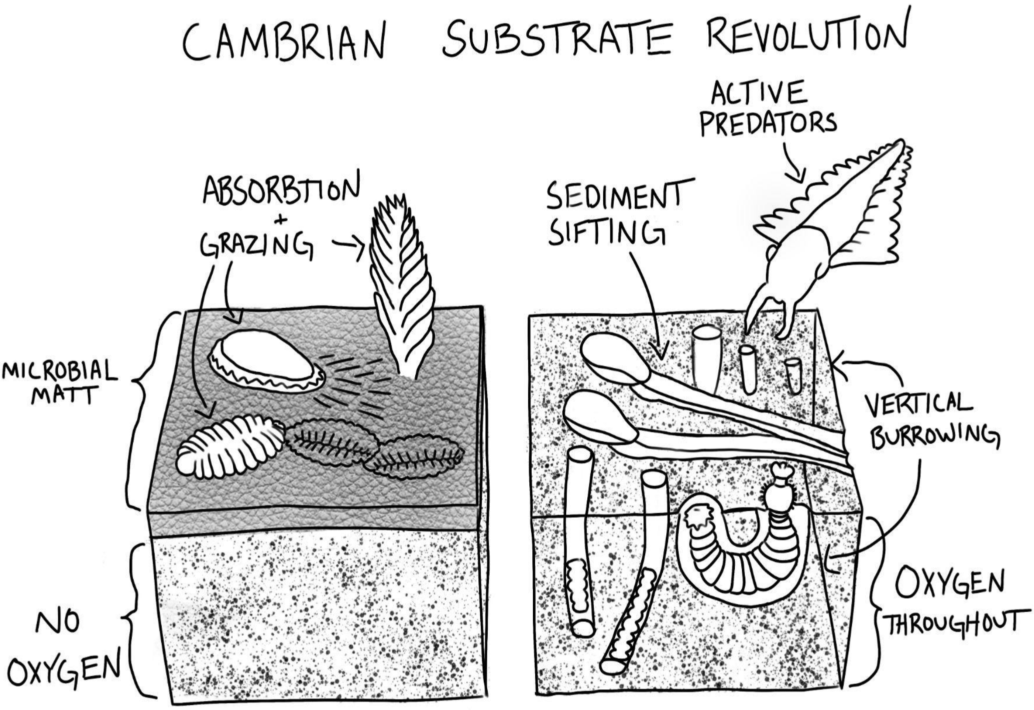
These microbial mats that blanketed the Ediacaran seafloor weren't just a food source - they were the foundation of this entire ecosystem. These collaborative communities of bacteria, algae, and other microbes created a living carpet that bound sediments together, recycled nutrients, and provided the stable substrate that allowed larger organisms to flourish. Selective pressures in the Ediacaran encouraged cooperation and efficient use of resources instead of strategies based on competition. It was a world built on cooperation from the microbial level up to the largest rangeomorphs swaying in the deep ocean currents.



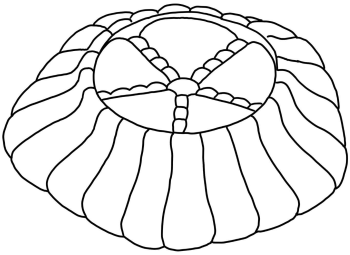
No one knows where, how, or why competition evolved, but by the time of the Nama biota we start to see a shifting picture. *Cloudina* and *Namacalathus* develop hard shells, indicating that they likely needed protection from something. A few *Cloudina* fossils have small holes that appear to be drilled through them. Some propose these bore-holes as the first direct evidence of predation. But if *Cloudina* developed a shell in response to predation that means they were already being preyed upon before they had a shell. And if *Cloudina* developed a shell then predators later developed the ability to drill through that shell to reach the soft tissues inside! This game of tag with one organism evolving in response to pressures from other organisms, sometimes called the predator-prey arms race, defines all subsequent evolution.

Alongside evidence of predation, we also see a second fundamental change in the Nama biota period– organisms began to disturb the microbial mat-covered substrates. This could be directly related to predation, with some organisms either trying to hide from predators or predators beginning to actively hunt in the microbial mat rather than gently graze or absorb from it. Or it could be an extension of organisms experimenting with developing things like distinct "heads" and "tails" and the ability to move. However it came about, this also radically altered Ediacaran ecosystems. For millions of years, microbial mat communities provided the slimy foundation for Ediacaran life. These early burrowers were ecosystem engineers, fundamentally changing the rules of the game by destroying the stable, cooperative substrate that had allowed the Ediacaran experiments to flourish. When organisms began disturbing the mat, it not only broke up the continuity of the surface, it introduced oxygen into the lower layers changing how nutrients were cycled.

This burrowing and disturbing of sediments and the end of the Ediacaran is called the "agronomic revolution" by scientists studying the Ediacaran/Cambrian transition. Instead of living on and with microbial mats, organisms started having an extractive relationship with the environment for the first time. They began churning sediments to look for food or shelter and fundamentally altered the ecosystem. The word "agronomic" shares a root with "agriculture", meaning farming. It is almost like the great change in human society when we went from being bands of nomadic hunter-gatherers to sedentary farmers. This turn in human society created concepts like ownership, private property, and belonging to a certain group. Likewise, the agronomic revolution and beginning of predation, ended the idyllic world of the Ediacaran.

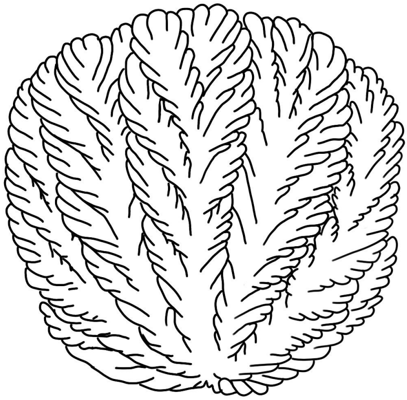


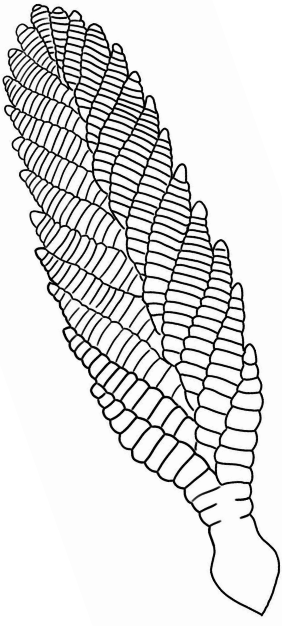
It is tempting to think of this as a sad story, but in science, and the history of life, there are no sad stories, just interesting ones. The next 500 million years of evolution are deeply fascinating from the early Cambrian "super predators" who rapidly evolved to fill ecological roles as top predators in emerging ecosystems; to the first animals to crawl up from the ocean to colonize land; to giant flying reptilian predators, and ultimately to us humans. We are the ecosystem engineers of our current era and are radically reshaping the world we live in and will, inevitably, leave behind. But for nearly 100 million years, life had proved that there were other ways to be complex, other ways to fill ecological space, and ways to organize communities that encouraged cooperation over competition.



Arkarua
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: 0.3-1 cm
Arkarua has pentaradial symmetry like modern echinoderms (sea urchins, sea cucumbers, and starfish). Because of that, some scientists think it was a stem echinoderm.

Bradgatia
Biota: Avalon, White Sea
Found: Newfoundland, White Sea
Size: 3-20 cm
Bradgatia was a rangeomorph with a more bushy and less geometric appearance– almost like a cabbage where each leaf exhibited fractal growth.

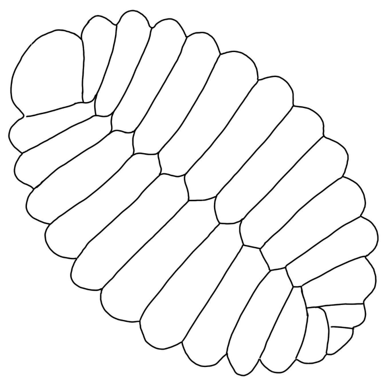


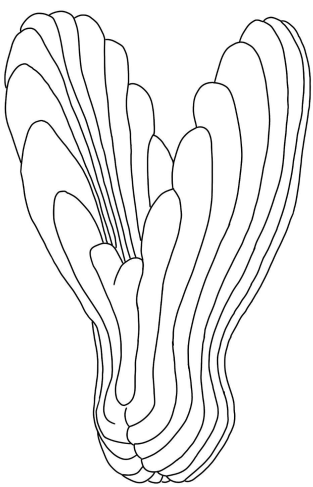


Charnia
Biota: Avalon, White Sea, Nama
Found: Newfoundland, White Sea, Namibia
Size: 1-65 cm
Along with being the first Ediacaran to be recognized as such by science, *Charnia* is a rengeomorph member of all three Ediacaran biota. Opinions differ as to whether is stood upright in the water column or reclined on the microbial mat.

Charniodiscus
Biota: Avalon, White Sea, Nama
Found: Newfoundland, White Sea, Ediacara Hills, Namibia
Size: 2-30 cm
Charniodiscus is a widely distributed rangeomorph with a distinctive holdfast that attached it to the microbial mat and a stalk. It may have stood up in the water column above mat dwelling organisms.

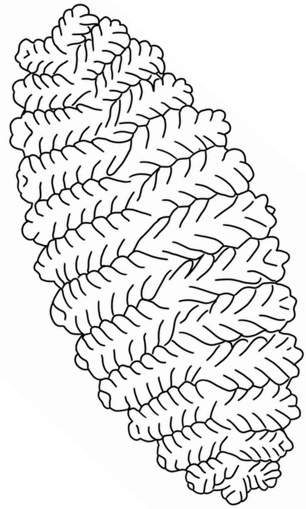
Dickinsonia
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: 0.4-140 cm
There several recognized species of Dickinsonia with a HUGE size range. The largest species, *Dickinsonia Rex*, is about the size of a beach towel. While the different species vary in size and shape, they all have characteristic glide symmetry

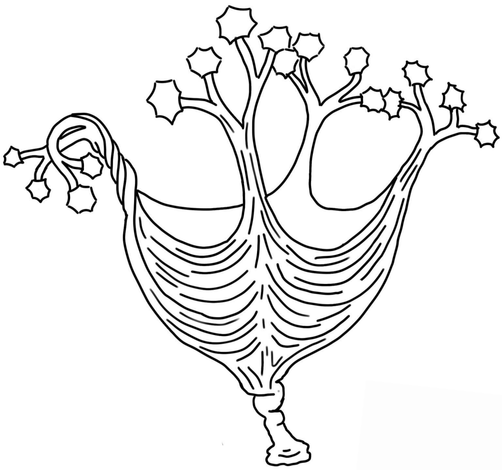




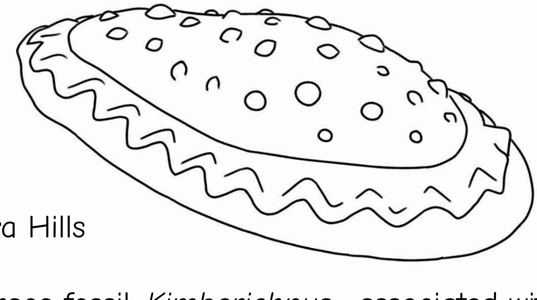
Ernietta
Biota: Nama
Found: Namibia
Size: 3-20 cm
When first discovered, scientists were so puzzled by *Ernietta's* strange bag-like shape that they described it as 29 different species! Later, these species were “synonymized”, or condensed as *Ernietta plateauensis.* Scientists now think the differences between individuals are based on preservation in different positions - squished, stretched, or folded.

Fractofusus
Biota: Avalon
Found: Newfoundland
Size: 2-42 cm
Fractofusus is thought to reproduce like some plants do with runners. Larger mature individuals would send out runners to create clusters of smaller clones, which then produced their own tiny "baby" clones nearby. This reproductive strategy means that some fossil surfaces will have thousands of individuals in a range of sizes.

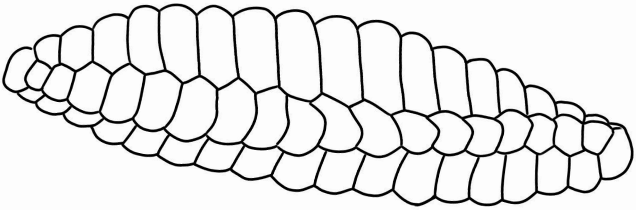




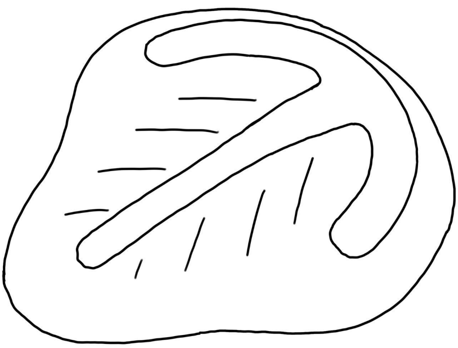
Haootia
Biota: Avalon
Found: Newfoundland
Size: 5-10 cm
Haootia might be the oldest animal with muscles. Its four-fold symmetry and preserved fibrous impressions suggest it had muscle tissue similar to modern cnidarians, like jellyfish and sea anemones, so it likely was able to move.



Kimberella
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: 0.5-15 cm
Kimberella has a special trace fossil, *Kimberichnus* , associated with it. These *Radulichnus* appear as fan shaped scratch marks in the microbial mat. This means that Kimberella likely moved and grazed on the microbial mat. These traces are incredibly important because they provide behavioral evidence - showing not just what Kimberella looked like, but how it lived and fed providing clues to the larger Ediacaran ecosystem

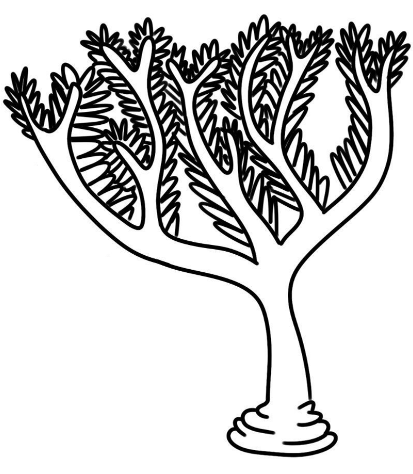


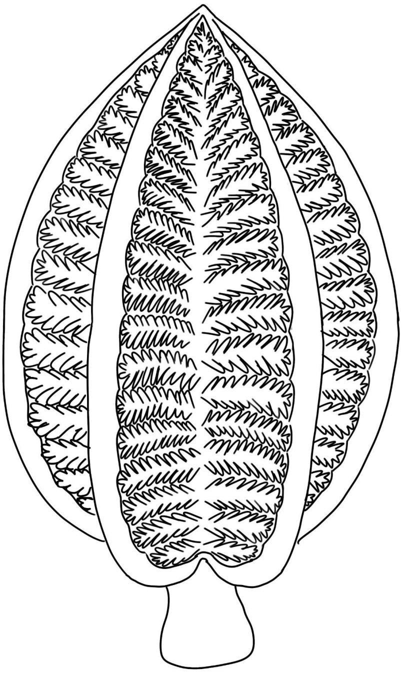
Pteridinium
Biota: Nama
Found: Namibia
Size: 6-19 cm
Pteridinium had a chambered body, almost like a pool raft. Like an inflatable raft it could collapse from a three-dimensional form into a flat ribbon when buried by sand. Some fossils preserve both states, inflated and deflated,, suggesting these creatures were basically living water balloons with a three-winged architecture.



Parvancorina
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: 1-2.5 cm
Parvancorina means "little anchor" and this organism is defined by ridge shaped like an anchor. This is one of the best earliest examples of clear "head" and "tail" distinction in the fossil record. Some scientists believe they have even found evidence for early eyes on the front ridge.

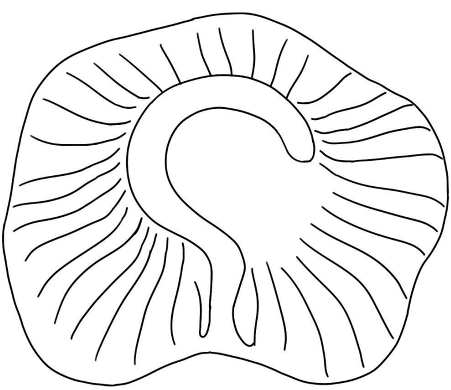
Primocandelabrum
Biota: Avalon
Found: Newfoundland
Size: 3-15 cm
.*Primocandelabrum* is a rangeomorph with a structure with a base, central stalk, and ornately branching arms resembling an old fashioned candlestick.

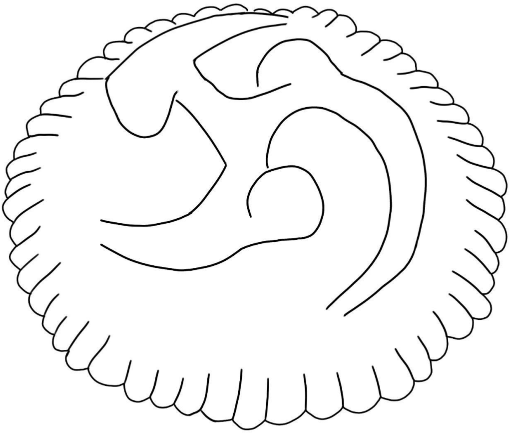




Rangea
Biota: White Sea, Nama
Found: White Sea, Ediacara Hills, Namibia
Size: 10-100 mm
Rangea is a rangeomorph found in later biotas, but not the Avalon Biota. This is important as it shows how body plans based on fractals continued to evolve throughout the Ediacaran meaning that they weren't some sort of evolutionary "dead end".

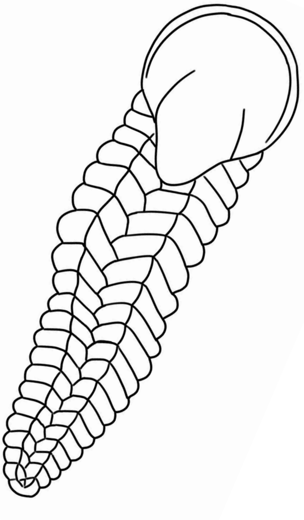
Quaestio
Biota: White Sea
Found: Ediacara Hills
Size: 15-80 mm
Quaestio means "question" in Latin - and this organism is exactly that. It is roughly disk shaped with a backwards facing question mark on its back. This kind of feature called left-right asymmetry makes it the oldest known animal with clear asymmetrical features like hermit crabs, flounders, or even handedness in people.



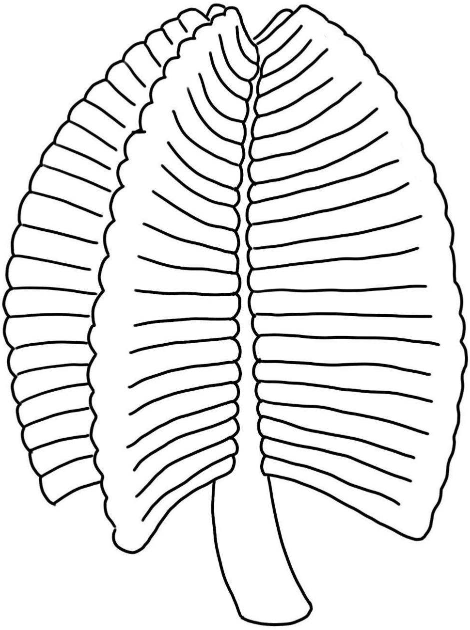


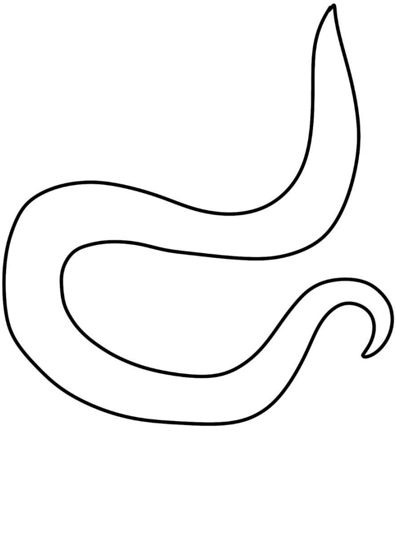
Tribrachidium
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: .5-5 cm
Tribrachidium has a totally unique body plan with three-fold symmetry - imagine three identical parts spiraling out from a center point, each rotated 120 degrees from its neighbor. Almost like a propeller, these swirling ridges may have created water vortexes above the organism, causing food particles to drop out of the current and fall toward its center for feeding.

Spriggina
Biota: White Sea
Found: White Sea, Ediacara Hills
Size: 3-50 mm
Spriggina has a notorious history of reconstruction. Despite being first described in 1947, scientists have not reached a consensus on whether the broad crescent shaped end was a “head”, “tail”, or even a holdfast structure that was buried in the microbial mat. Part of the reason is that like many Ediacarans, we only have fossil evidence of one side.



Swartpuntia
Biota: Nama
Found: Namibia
Size: 12-19 cm
Swartpuntia is chambered like *Ernietta* and *Pteridinium,* but has a central stalk. It may be the very last Ediacaran. It is found in rock strata just below the Cambrian transition in the Nama formation. Fossils of *Swartpuntia* (or a similar organism) have been found in Cambrian era strata in California meaning it may have even survived into the Cambrian.





Uncus
Biota: White Sea
Found: Ediacara Hills
Size: 0.6-3 cm
Despite looking a bit "boring" compared to other Ediacarans– it is basically a hook shaped worm, the description of Uncus in 2024 was major scientific news. Uncus is one of the clearest links to modern groups of animals found in the Ediacaran and represents the first confirmed ecdysozoan—the group that includes insects, spiders, and nematodes—bridging a massive gap between molecular predictions and the fossil record.

About the Author David Nasca is a Chicago-based visual artist working primarily in sculpture. His work draws on living and extinct organisms as a lens for exploring queerness. He studied at Deep Springs College and received a BA from the University of Chicago (2012) and an MFA from Cornell University (2022). He is Assistant Professor of Ceramics at College of DuPage.

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