DOWN AT THE ROCKY SEASHORE

by Robin Milton Love

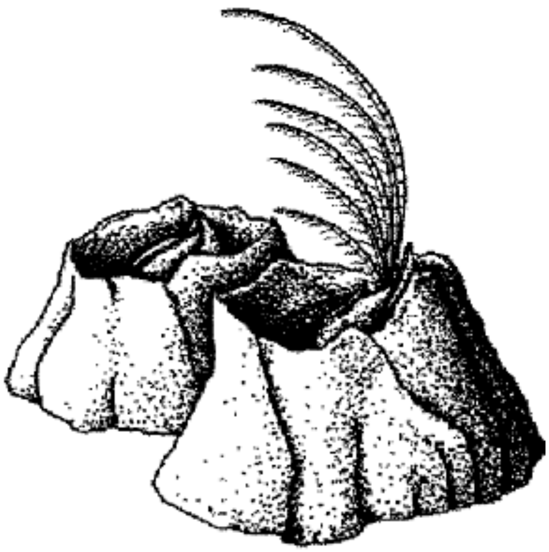
Did you ever notice that there are some things that everyone loves? For instance, everyone on Earth loves oatmeal chocolate chip cookies. The truth is that for even the most humble among us, if you give us an oatmeal chocolate chip cookie, our lives are vastly enriched. The rocky intertidal zone is the oatmeal chocolate chip cookie of marine habitats and you are indeed fortunate to be among those able to explore its wonders. Years from now (when you are a grouchy octogenarian), your one fond memory may be of those wondrous days spent among the rocks and crannies.

And why is that? What is it about this habitat that elicits such a response? Perhaps because the rocky intertidal is such a sensual, aesthetically pleasing experience; it engages your senses. First, as you look around, there is the sheer riot of life that covers every surface and pervades every crevice. And not only are there lots of living organisms; there are often hundreds of different kinds. Frequently, the plants and animals will be covered or invaded with other organisms and occasionally even these will be homes for still more tenants.

Or perhaps it's the sounds you hear if you are real quiet and hunch down inside a crevice. There's dripping and streaming water, of course, and birds calling and flying. But sometimes, if you are *real* quiet and put your ears close to the rocks, you can also hear crabs walking, algae swishing in the pools, and fish flopping. And then there are an almost infinite number of textures; ranging from the sticky tentacles of sea anemones, sharp spines of sea urchins, knobbled skins of sea stars to the almost unnaturally silky skins of sea hares and other sea slugs. Mixed through all of this is that remarkably thick, low-tide smell, redolent with life, death and decay. I would mention the tastes in this habitat (a great many of the plants and animals are edible), but we feel it's better to look than to cook.

What we are going to do in the upcoming pages is walk you through the intertidal and talk about what it's like physically, what major organisms live there, how they cope with the physical world and what impact humans have on this remarkable environment.

Okay, What's It Like?



Barnacles

First, you should realize that the rocky intertidal zone is a habitat with an attitude. It is no picnic living there. When it comes to marine organisms, this is not a place for pencil-necked geeks. Of course, all organisms in all other environments have it tough; but most often they have to overcome living (*biotic*) challenges, such as finding food, avoiding predators, or resisting diseases. Organisms in the rocky intertidal face these problems, of course, but they also face the added dimension of inhabiting an environment with extreme non-living (*abiotic*) conditions.

In one respect the intertidal zone is totally different from all other land and water communities. It is exposed to water part of the time and dry at other times. The equivalent on land would be if, say, a redwood forest was in air part of the time and in a vacuum the rest. Because the water environment is so different from the air, intertidal organisms face an almost bewildering range of conditions in the course of a day, a season or a year.

What kinds of conditions? Well, a typical member of the rocky intertidal (it could be a mussel, sea star, alga or crab) faces a range of abiotic challenges. First, as the tide rises and falls, it is alternately drenched and dried. When this happens the organism's temperature can decrease rapidly as cold water splashes its sun-warmed body or, alternatively, it can heat up as it is exposed to the air. This latter often happens in hot, tropical areas. Breathing is also going to be a problem. What works in water (gills) may not be very effective in air, and what works in air (lungs) just can't cut it in water.

Our friendly creature also has a problem when it rains and it is pelted by fresh water. Remember that experiment you did in 10th grade biology? The one where you put a nice crisp stalk of celery in a glass of saltwater and the next day the stalk looked completely limp. Then, you put the limp stalk in freshwater and, *voila,* the stalk became stiff again. A body responds differently when in salt water (water tends to leave it), then in fresh water (water tends to go into it). How can our organism cope with these very different environments?

Then there is *wave shock*, the remarkably powerful force of crashing water. As I write this, I can look out the window and see waves roll over an intertidal ledge, then smash into a cliff, sending water 10 feet high. How does our typical organism not get swept away or crushed? Waves also send water splashing up into the high intertidal. But, unlike tides, they do this unpredictably.

Organisms high up in the intertidal can't depend on large waves every day and must be able to withstand prolonged periods of drying.

There are other potential problems from the environment. In polar or near-polar regions (i. e. Alaska or Newfoundland), ice forms on the shore lines, then scours the rocks as it moves. In much of the world, sand is carried onto the shore in summer (when the waves are gentle), then carried offshore in winter (with storm waves). In the process, some rocky areas are covered with sand during part of the year, burying the intertidal organisms.

Okay, this is obviously a pretty tough place to live. Why don't we talk a little about the major factors that control what organisms live where in the intertidal.

The BIG Factors

Tides

Obviously, tides are a major (perhaps the major) controlling force in many intertidal habitats, because they dictate how long organisms are under water. Tides are rhythmic, predictable, periodic changes in the height of a body of water. The tides are caused by a combination of the gravitational pulls of the sun and moon and the centrifugal force caused by the rotation of the Earth/moon system. Throughout the year, tides vary in their heights, and the highest highs and lowest lows occur together during the new and full moons, when the moon and sun are directly aligned with the Earth. These extreme tides are called *spring* tides, which comes from the Old English word *springen*, meaning to jump or move quickly. Spring tides occur every two weeks and alternate with less extreme, or neap, tides.

Tidal *patterns* (how often highs and lows occur within 24 hours) and *ranges* (the difference between high tide and low tide water levels) differ in different parts of the world. Some areas, such as much of the east and west coasts of the United States, usually have two high and two low tides per 24 hours. These are semi-*diurnal* tides. On the other hand, Gulf Coast states tend to have one high and one low tide (*diurnal* tides) during the same period. Tidal ranges vary dramatically, depending on the shape of the water basin the tides flow through. The narrow Bay of Fundy, in New Brunswick, Canada, has tides of about 50 feet. This does not mean that the water goes inshore 50 feet. It means that it rises in height that amount. So if the land is pretty flat, the sea might flow inshore for miles before reaching the necessary elevation. Tidal ranges for much of the west and east coasts of the United States are around 6–8 feet. The Gulf Coast tides are narrower, perhaps a foot or two.

Waves

Waves also play a major role in deciding what organisms live where. Not only can waves knock organisms off their perches, they (along with tides) dictate how high up into the rocky intertidal water will splash. Far more territory gets wet during a 6-foot tide with 10-foot storm waves, then with a 6-foot tide and one-foot placid waves. Though they help determine sea life along all shores, waves are particularly important along much of the Pacific Coast, where wave size varies a great deal. The size of waves depends on several factors. The most important is the size of the area a wave travels through without being hindered by islands or undersea ridges. The more wide open an area, the larger the waves that can be generated. If you stand on the shore anywhere from Cape Flattery, northwest Washington to Pt. Conception in central California, there is absolutely nothing between you and the Aleutian Islands. That is a long way and it allows some fearsome waves to form. Of course, wind velocity is also important, which helps explain why waves tend to be higher during storms. On much of the Gulf Coast, waves tend to be small, and they are a factor only during hurricanes and other storms. Because waves have such a profound effect on sea life, any protection from their power alters the makeup of the animals and plants living in the habitat. For instance, along the Pacific Coast, wave-swept rocks are home to the powerfully-built sea star *Pisaster* (or ochre star), which can hang on even when slammed by direct hits from huge waves. In the same vicinity, but in protected tide pools, lives the more delicate bat star, *Patiria*, which can barely hold its own in very mild surges.

The shape of the coastline has a large influence on wave action. The rocky shores of *open coasts*, where waves come to shore unimpeded, tend to have somewhat fewer plants and animals then habitats in *protected coasts*, where the force of the waves is deflected somewhat. More commonly, coastlines tend to be at least partially protected, by offshore kelp beds, reefs or by irregularities (such as indentations) in the coastline. Somewhat protected rocky shores are usually chock full of goodies, because compared to the open wave-swept habitats, they are an easier environment in which to live.

Rock position and location are also important factors. Because waves and tides have such a large influence on the environment, not all places in the rocky intertidal are identical. Generally, the higher up the intertidal you are, the more extremes (in wetness, waves, wind etc.) you will face. Moreover, vast differences in these conditions may occur even on a single rock. For instance, the top of the rock is drier and more subject to wave action then a crevice. The southwest-facing part of the rock (which faces the sun most of the day) is drier than the north-facing side (which tends to be in shadow). The crevice is probably drier and more wave-swept than the under parts of the rock. And the deep pool next to the rock is continually wet and probably quite protected from many waves. Commonly, different organisms will be found in these different areas, even if they are inches apart.

Substrate

The type of substrate found in the intertidal also effects what lives there. For instance, granite is pretty tough stuff, it takes a lot of waves and a lot of water to begin to crack, chip or flake it away. On the other hand, sandstone or shale is (relatively speaking) pretty delicate; crevices, holes and cracks develop quickly. These openings provide habitat for many animals which cannot live on open rock. Therefore these softer substrates may have a greater variety of organisms than ones found on harder surfaces. On the Gulf Coast, there are few natural rock outcroppings. Take heart, however, for there are an abundance of rock jetties and dock pilings to choose from. These structures often provide homes for a myriad of organisms.

Serendipity

Trips to the intertidal are almost always excursions into the aesthetic. Very early one February morning I was exploring a pool at San Simeon (in central California). My nose was running, my boots were filled with cold water and the fog was in, muting all colors to dull browns, greens and grays. The ledge I was examining was covered in fleshy algae, which totally obscured the underlying rock. I lifted the algae up and on the newly-exposed surface was a Hopkins Rose nudibranch, a sea slug covered with jillions of cute little protuberances and colored a remarkable cerise. The contrast between the muted, fog-shrouded rocks and this extravagant creature was wondrous.

These brief, subtle and quite unacademic moments, are marvelous gateways to discovery and curiosity. They are the reasons you and your students will return to the tide pools again and again. As you practice slowing down and looking closely, tiny and wonderful worlds will unfold more and more frequently.

A Few Ways Organisms Survive in the Rocky Intertidal

Let us assume that rocky intertidal organisms face two major problems: drying out (and that includes changes in temperature as well) and being dislodged and killed by wave action. How do organisms cope with these problems?

Drying Out

Location in the intertidal is the main way animals find their drying out comfort zone. If they like it drier, they live higher up; if they like it wetter, further down. Even within a zone, there are differences in wetness and organisms take advantage of this. Crevices, cracks, and holes are shady and often contain pockets of water; here you will find those animals which prefer a bit more moisture. In fact, these slightly wetter areas allow organisms that would usually be found in the lower and wetter intertidal to live higher up. Intertidal organisms, particularly those high up the intertidal, often have shells which can be tightly closed or skins that are particularly thick. Both of these can trap water and help provide protection from evaporation. Some anemones cover themselves with bits of shells and rocks to provide shade.

Wave Action

First, as with protecting against drying out, almost all the animals that live in heavy surf have hard shells or tough skins. Many of these organisms have evolved clever ways to hang on in surge conditions. Sea stars have tube feet, mussels have special tough threads with glue on the ends and barnacles have a cement so effective, even in a wet environment, that dentists are thinking about using it to keep fillings in place. Other organisms find places where waves are disrupted or blocked. Periwinkles, limpets and other snails tend to congregate in partially protected crevices. Sea urchins, hermit crabs, and sea slugs, to name a few, all tend to live in protected pools. At the extreme are boring clams with shells resembling files. They bore into rocks and live their lives sealed off from the environment, except for a small hole, through which water and food travel.

What Lives There?

Okay, we are done with all the preliminaries. We know what factors influence rocky intertidal inhabitants, now let's look at what you are likely to see and where you will see them.

Probably the best way to do this is to work our way down the intertidal, from the highest splash zone to those rocks uncovered only at the lowest of low tides. We should pay particular attention to the upper areas, because, unless your timing is particularly good and you catch a substantial low tide, it is more than likely you will only be able to visit these higher levels. And let's be honest here, there is little in life worse than carting 33 small people to the intertidal only to have nothing to show them because the tide is too high. In reality, there is plenty of life to instruct and entertain your students, even in the highest zones. You just have to know what to look for, and how to look. The secret is to get down on your belly, move slowly, look closely, and be patient. So let's start out with stuff you can find, and things you can see, if you can only get to the highest parts of the intertidal.

There is no question that as you go down the intertidal, from the high and dry to the low and wet, you will encounter different species. These aquatic Organisms arrange themselves by the amount of time they can tolerate being *out* of the water. In the highest intertidal, the *splash zone*, animals may be out of the water for days between high tides (and/or large waves) high enough to cover them. By the same token, in the lowest of the intertidal, animals may be uncovered for only a day or two a year. Every species has a unique set of environmental requirements and if these requirements are not met, the organism eventually passes on to that great tidepool in the sky. This is the basis for *zonation,* the occurrence of organisms or groups of organisms with the same requirements, in specific areas. In the case of the rocky intertidal, some zones are so well-defined that they can be seen all around the world. As an example, in North America and in Europe the little barnacle *Chthamalus* is always and only found in highest part of the intertidal. It can live lower down, but there it meets another barnacle, *Balanus*, which grows faster and just pushes *Chthamalus* out of the way. Okay, if *Balanus* is so hot, why doesn't it live further up; why can't it push *Chthamalus* out of the highest intertidal? It turns out that *Balanus* can't withstand the dry conditions found in the uppermost intertidal. So, we can say that in the upper rocky intertidal there is a *Chthamalus* zone and a *Balanus* zone. Naturally, the higher the tidal fluctuation, the wider the zones. But even on the Gulf Coast, which has a relatively small tidal range, there are discrete zones, though these bands may be only a few inches each.

Ed Ricketts

Thinking about zonation reminds me of Ed Ricketts. Hang around marine biologists and marine biologist wannabe's long enough and you will inevitably hear the name Ed Ricketts, the author of *Between Pacific Tides*, that most graceful and humane of field guides (and the source for much of the information in this text). Between the 1920s and 1940s, Ricketts was the Pacific Grove-based specimen collector, intertidal biologist and philosopher, with the libedo of a weasel, who was the lightly fictionalized "Doc" in John Steinbeck's *Cannery Row* and *Sweet Thursday*.

Ricketts was a most remarkable person, with an unusually fluid and unfettered mind; one that found inspiration equally in tidepools, the *Tao Te Ching* by Lao Tzu and the poetry of Robinson Jeffers. It is a rare person indeed who could simultaneously influence zoology students at Stanford University (many of whom absorbed and later researched his ideas on intertidal habitats) and mythologist Joseph Campbell (a long-time friend and fellow seeker of inner wisdom). In an age where most biologists on the Pacific Coast were content to identify and classify organisms, Ricketts was asking how intertidal organisms related to one another and to their environment. He was particularly interested in zonation, how and why organisms are limited to specific areas in the intertidal. Many of the questions he asked were later taken up by a generation of modern-day ecologists.

For more of the essential Ricketts, check out *Log from the Sea of Cortez* by Steinbeck and Ricketts. It's a marvelous book, filled with humor, natural history, insights into the human condition and some remarkably obscure philosophy. John Steinbeck, in his introduction to the *Log from the Sea of Cortez*, summed up his many years with Ricketts in this way: "no one who knew him will deny the force and influence of Ed Ricketts. Everyone near him was influenced by him, deeply and permanently. Some he taught how to think, others how to see or hear. Children on the beach he taught to look for and find beautiful animals in worlds they had not suspected were there at all. He taught everyone without seeming to."

We like to think that much of MARE is based on the approaches pioneered by Ricketts. Ricketts was a fine and respected scientist. He was also unpretentious and most of all he had fun at what he did—just as we hope you and your students will do as you explore the Rocky Seashore.

I can think of no more fitting epitaph than this: There is no question that many of us want to be like Ed Ricketts.

The Uppermost Zone

Don't be fooled, despite what you might think at first glance, there are animals and plants here, but they may be quite hard to see. Probably the most common critters are *periwinkles,* rather small snails, whose drab appearance makes them tough to spot. While they may be out on the open rock, they most often prefer hunkering down in cool, shaded crevices (of course, a crevice to them may be only one-inch deep). Periwinkles are as close to a land animal as you can get and still be aquatic. They like being doused only occasionally with sea water and if you keep them underwater, they will drown. On the other hand, some have been kept high and dry for up to 42 days without ill effect. Periwinkles, and for that matter many other snails, use an *operculum* to prevent drying out, to keep fresh rainwater from getting in and to help ward off predators. An operculum is like a trap door; it's a shell-like little contraption that the animal grows on the back of its foot. When the snail pulls its body into the shell, the operculum is pulled in last and makes a neat little seal across the shell opening. This seal is apparently extremely tight. Periwinkles have been fed to sea anemones, only to be spit out half a day later, with a nicely polished shell but life intact. Like many other intertidal snails, periwinkles are primarily vegetarians; they scrape the rocks with their *radula*, a little bit of cartilage, covered with lots of tiny teeth. Virtually any day you visit the intertidal you will see periwinkles mating; they are the ones on top of one another. On some occasions in the spring and summer, it is hard to find a periwinkle that is *not* mating.

Tiny, dirty-white, brown or gray acorn barnacles (*Balanus* or *Chthamalus*) are also very abundant along the splash line. You will find these rather nondescript characters in large masses (often crowded shell-to-shell) almost always on vertical, or at least sloping, rocks. At first glance, these animals appear to be dead; after all they are not moving about, have no parts that are moving about and are very poor conversationalists. Most of these animals are quite alive, merely waiting for the perhaps one hour or so per week when they get splashed. Despite their appearance, barnacles are closely related to crabs and shrimps. Basically, a barnacle is a shrimp-like animal which has glued its head to a rock, grown a shell about itself and catches food by thrusting out its feet into the water. When it is out of water, it retracts its feet and securely closes off its shell opening with a set of hinged plates. The way to tell if the animal is alive is to look for the hinged plates. If the shell is really empty (you have to look closely), the animal is dead.

Along this stretch of rock you should also find mound-shelled limpets, another kind of snail, but often not quite as high up in the intertidal as the uppermost periwinkles or barnacles. Inevitably these animals will be tightly bound to the rock; you probably will not be able to remove them with your bare hands. Rarely will you see a limpet move about in the day light; they usually just sit there, probably asking each other koans as part of their Zen meditation. In fact, most limpets are *nocturnal*, they are active at night and inactive during the day. If you go to the intertidal at night (few people do, but it's really cool), you can see how active these snails can be. Like periwinkles, limpets are algae-eaters, and they spend the night rambling over the rocks looking for food. While smaller species cruise all over the rocks, one kind, the owl limpet, actually does a bit of farming. Each night, it patrols its territory and wards off intruders, thus protecting the algae supply from grazers (other than itself, of course). What is really neat is how it differentiates between competitors and potential predators. When it encounters a competitor (say a smaller limpet species) it pulls the front of its shell against the rock and bulldozes the offender out of the territory. If it comes upon a predator (there are several kinds of snails that eat limpets), the owl limpet raises up its shell and slams it onto the foot of the enemy. This causes the enemy to lose its hold on the rock and it often gets washed away by the next wave.

While you are up in the rocks, try looking in the mounds of kelp which have washed up on shore, particularly those around the high tide line. Often these have beach hoppers living under them. Beach hoppers are amphipods (another shrimp relative), which live in sand burrows during the day and come out at night or when its cloudy. They feed on kelp and other plant material.

A Little Further Down

If you can get a bit further down the intertidal, there are many more kinds of organisms to see. You will still find periwinkles, limpets and barnacles, but they may be different kinds (the barnacles are usually bigger) and they have to compete with other organisms for space.

Three large organisms are typical of this habitat and they are often found together. They are all also found further down in the intertidal. These are the mussel, sea star (starfish) and gooseneck barnacle. So typical are these animals in this zone that it is often called the mussel-sea star-gooseneck barnacle zone. Probably the most obvious of the three is the mussel, a handsome black shellfish. Mussels are *bivalves*, those members of the phylum Mollusca that have two shells. Other examples of bivalves are clams, oysters, and scallops. Mussels are usually found where wave action is heavy. They anchor themselves to rocks (or any other surface) using *byssal threads,* which are very tough brownish hairs with glue on the end, extruded by a gland in the animal's foot. Mussels can withstand considerable drying, closing up their shells to prevent water loss. Small mussels, in little groups, are found high up in the intertidal, but the further down you go, the larger the mussels become and the more massive the mussel clumps. Very often, mussels form aggregations of hundreds or thousands of individuals, which solidly cover much of this zone. In turn, the clumps form a habitat for other kinds of organisms. Some of these organisms, such as worms and small crabs, live deep within the clumps, where wave action is low. Others, such as barnacles, may attach themselves to the mussel shells.

Sea stars begin here, and the lower you go in the intertidal, the more abundant they become. Sea stars are particularly common on mussel clumps, as mussels form a major part of their diets, along with barnacles, sea urchins, and limpets. Sea stars are vastly intriguing animals, and which probably play a major role in deciding what animals are common in the intertidal. Some scientists believe if it were not for sea stars feeding on great quantities of mussels, these shellfish would eventually cover most of the intertidal, excluding many other organisms. The sea star species which are common in this high intertidal have thick, leathery skins, which help prevent drying out at low tide. Sea stars come in a rather becoming range of colors; red, orange, white and bluish seem to be particularly common. And while five arms are the usual for many species, some may have fewer and some may have as many as 24. Sea stars walk and hold onto prey using *tube feet*, tiny elongated suction cups which are found by the hundreds on the underside of the body. Using these feet, the animals are able to walk over uneven, wet, slippery surfaces with nary a hesitation, as well as withstand a steady pounding by waves. Having selected a prey, say a mussel, the animal wraps its arms around the prey and begins to pull on the shells with its tube feet. Rarely is a sea star able to pry open a mussel using only brute force. Rather, as it maintains a steady pull (which may last for hours or days), the animal extrudes its stomach through its mouth. This it slips through a minute space between the mussel's two shells and begins to digest away the muscle holding the two shells together. Over time, the muscle is weakened, the shell is pulled further apart and the sea star digests its prey. It then pulls the digested material into its mouth.

Sea stars are very tough organisms. They can regrow lost arms and, if an arm and part of the central body are removed, this fragment will regrow a complete new individual.

Interspersed among the mussels, or in separate clumps are gooseneck barnacles. Goosenecks do not resemble acorn barnacles, but they are close relatives. These well-named creatures have white triangular plates attached to a long tough tube that is attached to the rock. When covered with water, the plates open up and long feathery feet emerge, sweeping the water for small animals. Like mussels and sea stars, goosenecks are pretty resistant to drying out. At low tide they tightly close their plates and, with their leathery necks, are quite resistant to desiccation. Goosenecks were originally called "goose barnacles," a name popularized by John Gerard, a 16th century nature writer. Gerard, who obviously knew how to tell a good story, claimed he found birds ready to hatch from the shells of these barnacles.

Wandering around these various animals, or hiding in crevices, are a number of rather pugnacious small shore crabs. When alarmed, which seems to be most of the time, they quickly scurry off, running sideways or backwards.

When truly harassed, these animals raise their claws up in what must be the universal offer to "put up your dukes." They are primarily scavengers, consuming whatever is dead or dying. A mild warning: handle with care, if at all, since these crabs will give you a somewhat painful pinch. Sadly, this often results in more harm to the crab, by the startled tide-pool explorer, than vice-versa.

Beginning in this zone, primarily in tide pools, live hermit crabs. These are soft-bodied crabs that only live in the shells of dead animals, almost always snails of some sort. In many intertidal areas, most of the snail shells will be occupied by hermit crabs, rather than by snails. These are completely harmless animals, they never pinch. When you pick up their shells, the quickly retract, hiding away for a while. If you are patient, and hold them steady in your hand, they usually come out and walk about, carefully inspecting the premises. It is likely that hermits are incapable of actually killing a snail for its shell, so they have to wait for shells to become available. This is a nerve-wracking task indeed, for as a hermit grows, it needs progressively larger shells, so there is an eternal search for bigger and better homes. A hermit will compulsively check out every empty shell in its sight (as well as anything that might be a shell), a process which involves touching it, lifting it up and inspecting the insides. If the new shell looks good, a hermit will switch to it almost faster than you can follow. Hermits spend a remarkable amount of time "fighting" with each other, apparently coveting their opponent's shells. No one seems to be badly hurt from the experience, though often the "winner" takes over the "loser's" shell and the loser has to make do with the winner's vacated split-level.

Further Down Than That

Obviously, the difference between *Further Down* and *Further Down Than That* is a subtle and, really, quite artificial one. The reality is that as you go further down into the intertidal, some organisms (the ones that prefer to be dry part of the time) become less common, then cease to exist, while others (the ones that like to be wet most or all of the time) come into being and then dominate. Moreover, even within these zones, there will be differences in environmental conditions and thus in what organisms are found there.

For instance, there is a difference between what occurs on open rock and what lives in tide pools. All of the animals we discussed above can be found in tide pools, but some others are only found in these pools. Probably the best examples are the fishes which occupy tide pools starting in the previous zone, but are far more common in this one. In the higher levels of the intertidal you will find perhaps one or two species, while the very lowest intertidal pools may harbor 10 or 20 forms. It is usually very hard to spot these fishes, as they tend to be *cryptic* or camouflaged, with colors and/or body patterns that blend in with their surroundings. However, they do periodically swim about, so stealing up to a pool and remaining very still for a few minutes can be rewarding.

In general, sea urchins and sea anemones are more common in this zone than in the previous one and they are more common in tide pools than on the open rock. Sea urchins are close relatives of sea stars. Like sea stars, they have tube feet and their mouths are on the undersides of their bodies. However, unlike sea stars, sea urchins are covered by a hard shell (called a *test*) and by spines. The spines, which in some species are quite sharp and in others are rather blunt, are movable. If you put a finger or pencil against an urchin's shell, it will quickly move its spines toward the irritation. Most urchins dine on algae, scraping the stuff up with five small teeth (called Aristotle's Lantern) circling their mouths. Many sea urchins are easily dislodged by waves and some actually excrete a chemical that helps them to grind their way into their rocky homes to escape from some of the waves' force.

Sea anemones are relatives of jellyfish; in a way they are like an upside-down jellyfish that is attached to a surface. The delicate flower-like character of an opened anemone belies the thousands of stinging cells found in each tentacle. The microscopic stinging cells contain tiny whip-like strands and a potent toxin. When the cells are touched (say by a small fish or shrimp) the cells open, the whips and toxin snap out and nail the prey. Quite quickly the anemone pulls in its tentacles, drawing the stunned or dead prey into its mouth. If you touch an anemone tentacle with your fingers, you can feel the whips hitting your skin, but only as a sticky sensation. The skin on your fingers is too thick to be pierced. I had a teacher who once put his tongue on an anemone (the skin of the tongue is quite thin) and the class was quite taken by the way the instructor danced about after the experiment. The swelling and discoloration only lasted a few hours.

There are several very intriguing exceptions to the rules about where anemones and urchins live. For example, there is a very funky urchin (*Colobocentrotus*) in the intertidal of Hawaii that lives where heavy waves crash. However, it is specially adapted to this environment, by having flat, blunt spines, which fold down over the shell forming an almost smooth surface when wave action is heavy. On the west coast there is a small green anemone, *Anthopleura elegantissima*, which is very common on open rock, often fairly high up the intertidal (a larger form is also found in tide pools). This anemone forms huge colonies and, because it tends to cover itself with broken shells and bits of gravel, it often looks just like bare rock or sand. Unless you are quite wary, the only way you may find them is when you step on "rock" and water oozes out. What is most fun about this species is that an entire colony (which may have hundreds of individuals and be a number of feet across) is composed of individuals which are clones of one another. In other words, the colony started with one individual, which budded off another, genetically identical, individual. Both of these identical anemones budded off others and so on. What happens when two colonies, which are busily budding and covering a boulder, meet? The individuals of one colony can instantly tell that the individuals of the other are not identical with themselves. Fighting erupts between the colonies, with the anemones on each side touching the other with special stinging tubes. If you look carefully at a rock containing two or more colonies, you will see an irregular line of bare rock (often the only bare rock on the boulder) that is a "no anemones land" where this warfare is occurring.

Humans and the Rocky Intertidal

The animals in the rocky intertidal are tough, but they are not immortal. We can damage and kill them easily, particularly when we enter their habitats. These organisms have evolved special adaptations for surviving in a very harsh environment. But they have few defenses against human impact. Think about it this way: When we enter the rocky intertidal we become a *part of that habitat.* We are just one more organism among the many. We have a responsibility to what is now (at least for the time we are there) our shared community.
So we have to follow a few simple, but ultimately essential, guidelines:

1. If you pick something up:

a. Pick it up gently.
Don't force or tear it.

b. Put it back where you found it.

c. Put it back in exactly the position you found it.

What this means is that if you pick up a sea star (gently), do not take it home to die. And when you put it back, put it back in the same pool you found it. In most intertidal areas it is not only a bad idea to collect, it is also illegal without a special license.

2. If you roll over a rock (there can be interesting things under rocks):

a. Roll it over once, for the whole class.

b. Don't keep the underside exposed too long, the creatures tend to be delicate.

c. Gently roll the rock back into the same position you found it.

3. Don't leave anything in the intertidal area that you brought with you.

Marine debris (garbage thrown away from ships and from shore) is a major problem throughout the world. It is not only unsightly, but also dangerous to many organisms. From turtles choking to death on pieces of plastic to seabirds throttling themselves on plastic six-pack rings, the extent of damage to marine organisms is large. We have a responsibility to ourselves and our planet, so you might consider encouraging your students to do a mini-cleanup of the beach before you leave.

Simple Precautions

It is important to remember that for all its beauty, the rocky intertidal is not an amusement park. No one has tailored this environment to be risk-free. It is not up to code.

For instance, on land we generally take traction for granted. We assume that, except for very rare instances such as that massive cherry jelly spill down on Main Street, the surfaces we walk upon will be reasonably secure. In the rocky intertidal the opposite is true. You must assume that every surface from the A Little Further Down zone to the water line is covered with cherry jelly. And the reason it's so slippery is only partly due to the fact that things are wet. Many of the organisms on these rocks (*particularly the algae*) are either slimy or very smooth. Either way, your tread must be careful, considered and light. In general, walk on bare rock and aim for low spots even if it means getting your feet wet. Consider walking with one hand and both feet or even both hands and both feet; it will give you more stability. As far as footwear goes, I like rubber knee boots, but tennis shoes with plenty of tread are also good. Whatever you wear, expect to get wet, it's just part of the ethos.

On the other hand, it's dangerous to get too wet; as in knocked over by a wave. This is amazingly easy to do, particularly when near the water's edge and when you are inspecting something really fascinating. *Always* keep your ears open for waves and check the sea frequently. In fact, it is best to be overly cautious. When you first arrive, watch the surf for a few minutes to see what the wave action is like, that will help dictate how close you want to go to the water. And remember, incoming tides can bring waves in very rapidly.

Lastly, some tide pool etiquette. Never go tide pooling alone. When you take your class, have students work in pairs or trios, with one person spotting for waves while the other looks in pools. Never turn your back on the ocean and never run or jump. Keep the group within earshot of you and bring at least one adult for every ten students.