Preface

Students of the history of the earth and the life upon it are natural storytellers. One of them may pick up a pebble from the trailside and describe its origin starting from the fires inside a dying star–where oxygen and silicon are produced by the fusion of helium atoms, then thrown into space, eventually coalescing into the rocks that form new planets. Another natural historian might look to the opposite side of the trail and begin a description of the DNA in a sapling there. That DNA encodes a record of the history of life on earth, read in the genes it shares with all other organisms. It also encodes the blueprints for the formation of cells, which form organs, which form organisms. This description of DNA will have been prelude to the story of one cell–a cell that divides into millions of daughters, which form into a sheet of tissue, which forms the autumn leaf now twirling round its stem between the storyteller's fingers. In the same way, a lone mushroom at the foot of an oak might prompt another naturalist to claim that the living landscape all around is one single being–the roots of every tree connect with all the other trees through a network of symbiotic fungi that links the entire forest together into a single, grand organism.

These storytellers would highlight spots in their scripts with points of fact we can all see, facts that anchor their stories to reality. At the same time they would call upon our imaginations to breathe life into features of the natural world that lie beyond our sight. We will never witness the conversion of helium to oxygen in the core of a dying star. We cannot inspect the nucleotide bases of DNA stacked one-by-one upon each other in their helices–their dimensions are smaller than the wavelengths of light with which we see what we believe. We will never witness the forest-wide breadth of the microscopic fungal network inter-con-

necting all the trees beneath the trail–it lies hidden underground and crumbles to nothingness in our hands as we unearth even a small part of it.

Nevertheless, these concepts serve their storytellers well. They conjure a framework of understanding upon which we organize the things we can see. We see the rocks, the plants, the animals, but through them we imagine the motions of tectonic plates, the capture of photosynthetic sunlight, the evolution of species. That framework of understanding allows us to predict what we will find in times and places not yet seen.

Stories in this volume employ that device. They flow from what has been observed, to illustrate what we would predict. We have not sailed at thirty miles per hour thirty feet above the Tasman Sea at midnight along with the Neon Flying Squid. Nevertheless, we have enough information to envision that flight. Inference of such events draws upon our creativity–the descriptions are conjectural, predictions of that which has not yet been confirmed directly. Likewise, the illustrations in this volume are also extrapolations–works of creative nonfiction.

Other narratives we will never witness directly are told in the impulses passing through the minds of the animals with which we share the planet. We cannot know their thoughts; nonetheless, we can project what we know of them into tales told as if seen through their eyes, so to see their reactions to new situations. Stories of that sort are also contained in the pages that follow. Each account describes one thread from the broadest of our imaginary tapestries–the web of life.

These threads are the subject of the age-old discipline of natural history. It is one of the longest-established of the sciences and has been subdivided and renamed many times. Nevertheless, natural history is still a very active field. Our knowledge of its facets is expanding at the same exponential pace as is that of the more recent scientific disciplines. In the background notes behind the stories, the reader will see that more than one-third of the citations are no more than ten years old. We are still driven–more now than ever before–to deepen our appreciation of the world around us and to weave a framework of understanding around what we have found so far.

Stories in the Sand

The coral heads pack the reef like a field of boulders between which no level ground shows. Every niche is filled -- shelves of coral extend from the reef's outer walls, branching fan corals rise from the gaps between crowns of cauliflower corals and skull corals, one growing on another. In the continual competition for space, the faster-growing corals bury the slower beneath them, eventually compressing their forbears into limestone, raising the reef on the skeletal remains of previous coral generations.

One patch of white seafloor stands alone as the sole flat spot in this stone garden. There is no sand between the coral heads here–close inspection reveals the white patch to be a mélange of skeletal remains: curved pieces of worn seashell, broken shards of bleached coral, bits of bone. Every fragment retains a trace of its original character–an edge of blue, a pearly surface–just enough to attest to the life-span of growth and prosperity won from the ocean by the maker of each–all against very long odds.

This rare, white landing pad is the site of a cleaning station. The coral masonry at its edges shelters a family of Blue-streak Wrasses, diminutive fish only a few inches long, slow swimmers with yellow head colors grading along their length to neon blue, and a lateral black band widening toward the tail. Their signal coloration is invitation to the main fish of the reef to come in and be freed of their parasites, which for the wrasses are food.

Above the flat, sand-white surface, a Blue Jack hangs motionless, gaping as if about to strike. The jack's silver scales shimmer with iridescence, reflecting its perfect health, maintained by daily visits to this cleaning station. The diminutive wrasses flit about its head and gills, pecking here and there, eating the tiny lice and isopods that would grow and multiply to torment this fish if not removed.

The whole tableau of jack and orbiting wrasses is framed in the gape of a huge tarpon suspended in mid-water just behind the scene. The motionless predator appears frozen at the instant of attack, her smaller prey fallen in the shadow of her yawning jaws for their one last instant. With the exception of the wrasses, all these sleek reef fish are piscivores–they all eat each other, the bigger growing at the expense of the smaller. But the fish in the foreground at the cleaning station feel no pressure wave building in the water, no indication of the gathering momentum of a strike in their direction. The tarpon drifts in the background, marking time, her mouth hanging open merely to signal that she is waiting in line for her turn with the cleaning fish.

Sixty feet down in the twilit depths of the reef's outer wall, a Black Grouper hangs suspended, staring out through the opening of a dark coral cave. A spinal stiffening has beset this big sea bass, resulting from an infection taking longer than usual to cure itself. Ordinarily the master of the reef, this fish has not been abroad in the open water for many days.

The struggle for survival has guided this grouper through a lifetime of deadly risks, leading ultimately to a position of dominance on this reef. She began life decades ago, tumbling in the wake of a huge Basking Shark that was trolling across the surface just where she hatched from a floating egg. The shark's wide-open maw sucked most of her siblings out of the water beside her. Of the few other fry that survived, most lasted only long enough to encounter a wild variety of similar fates: they were speared by sea birds, stung by invisible threads and raised paralyzed toward the diaphanous bells of jellyfish, snapped up by bigger bass; ninety nine percent of her generation did not survive their first year.

She was lucky enough to catch many a smaller meal but never to be caught herself while she drifted across the ocean. When she reached the shelter of this coral oasis, she quickly learned the strategy of seeking the easy prey -- those that, through age or injury, had lost that supple flick of the tail that could keep them ahead of her attack.

As she glided through her dominion, the other fish gave her a wide berth. They expended just enough energy to signal they

were not about to let her get within a fish length, maintaining the distance over which they would have room to evade her strike. Smaller fish had a smaller turning radius and could easily maneuver beyond her massive lunge, given enough warning. Nonetheless, should she turn even slightly in their direction they would immediately sprint for more distance or dive for cover.

For many years the sea bass grew, producing millions of eggs each season that floated away to the surface, none of which would grow to be as lucky as she had been. She prospered, increasing in bulk to the point that she matured further, metamorphosing to become a male. His jaw grew out, fixing his countenance in a permanent distemper that matched his new attitude. He was combative, chasing off schools of barracuda or blue fish; anything he could catch up with, he ate. He grew to nearly one hundred pounds, and each season he shed his milt over millions of grouper eggs. The hatchlings found their chances of survival improved if they did not drift back to his reef. His presence gave the other bass of his kind two choices as they matured in his dominion -- stay away, or stay female.

Today, however, he shows none of this belligerence. A lesser male, should one dare to visit his territory, would immediately sense the passivity in his comportment and respond with a relentless attack, driving him into exile and starvation. As it is he has not eaten in a month. He hangs in his dark hole deranged with hunger, the sensation of his teeth closing on smaller fish a fading memory. He has lost the dash of speed needed to finish an attack, but now an alternative image stirs him -- he will just open his mouth and let his prey swim in. In his delirium, thoughts of his jaws closing on smaller fish blur together with thoughts of the wrasses swimming between his teeth at the cleaning station . . . Slowly he floats from his cave and back into the open water.

The hammerhead shark patrols from reef to reef, looking for skates and rays. She sees her world through an electromagnetic vision that shows her only the fish–visualized by the signals generated by the electric currents coursing through their nervous systems. She carries her electromagnetic sensory organs on opposite sides of her winged head; this positioning allows her to triangulate her scanning, giving her a stereoscopic sense of the

living environment. She follows her flattened snout from one stimulus to the next, watching for fish no longer able to keep up with their schools–or no longer able to keep hidden–easy targets, easy meals. She is oblivious to anything else–anything without a nervous system. Now, she senses the presence of a bass in the middle distance, and her course automatically comes around in that direction.

The sea bass recognizes the pressure wave in the water behind him as he coasts above the coralscape. It is the hammerhead he has known for years, making her regular rounds over the reef. He alters course to move aside, expending just enough energy to signal that he is not about to let her get within striking range. He is not as supple now as he normally would be and has to scull with his pectoral fins to find the speed to give the shark her customary berth.

The shark reflexively focuses on the unusual amount of fin noise in the movements of the bass. She also notices that he is not moving cleanly aside, not affording the right-of-way she usually commands. She accelerates in his direction, on a collision course that should quickly motivate him to resolve the situation.

The increased force of the aggressive shark's bow wave impresses a warning upon the bass from behind. He summons the energy to keep his distance -- to keep up the appearance of respectable separation, pumping with every fin to make up the speed that the soreness in his back deprives him of.

The shark continues to accelerate, an instinctive reaction triggered by the uncharacteristic lethargy in the bass's response to her approach. Suddenly, she is moving too fast to think, sprinting ever faster through the water with a sustained burst of power, a hurtling missile of olive-gray momentum, scattering in panic all the smaller nearby fish.

She strikes the bass squarely, the force of her crushing bite rolling him over, and shakes herself violently side-to-side, her rows of teeth cutting against each other, sawing off his head. She maintains her speed, zigzagging off toward open water, prepared to evade any bigger sharks that might appear and attempt to steal her catch.

The bass head descends through the water column, trailing a thin mist of blood, and crunches down squarely in the middle of the flat surface at the cleaning station. There is no motion anywhere around. Every fish has fled for cover, every antenna, every tubeworm, every anemone retracted instantly at the shockwave of over-pressure in the water, followed by the scent of blood.

After long minutes, the wrasses poke their heads from their coral redoubt. Though they are among the smallest fish on the reef, they are paradoxically some of the most fearless, relying on the protection conferred by their special status. The boldest among them leads the rest across the opening to greet the great bass head that waits there motionless for their attention. The wrasses swim past the vacant eyes to pick parasites from between the scales here and there, floating carelessly into the open mouth. They momentarily disappear into the darkness behind the even ranks of teeth, doggedly pursuing the high concentration of arthropod parasites they find. They hurry against the impending darkness to finish their work, and when every last nit is finally removed from their patient client, they retreat within the deepest recesses of the coral to hide from the creatures who take over the reef after darkness falls through the water.

Out of the blackness of the night a swarm of crabs materializes to descend on the fish head. As the hours wear on, the largest crabs on the reef arrive, following the scent carried on the tides. They walk sideways, gingerly avoiding the fields of stinging flowers into which the corals bloom after dark. The smaller crabs scuttle out of the way of the larger, leaving the largest atop a seething pile of pincers and shells that conceals the object of their attention.

By dawn they have vanished, their work done, and quiet has returned to the bright, flat patch on the reef. The first shafts of sunlight to penetrate the water fall on nothing more than a few white, geometric plates of skull bone settling among other bleached pieces of coral and shell there, each a testament to one productive life wrested from the ocean–against very long odds.

Science Notes

The coral reef carries the greatest density of animal diversity of any realm of the planet (Kohn, 1977). Its inhabitants embody a record of the evolution of life from its earliest marine beginnings. The breadth of evolutionary successions includes complex examples of co-evolution, such as the collaboration of corals and their endosymbiotic algae, the cohabitation of clown fish within the arms of stinging anemones, and the cleaning symbioses involving species of cleaning fish or shrimp, and their wide variety of client fishes. Reef cleaning stations are archetypical examples of symbioses between species (Cote, 2000). These interactions reveal adaptations in behavior among the participants. Predatory behaviors are suspended—attack on cleaner wrasses, such as the Blue-streak Wrasse (*Labroides dimidiatus*; to five inches in length), by their clients is rare, an aberration (Losey, 1987). (The opposite occurrence—cleaner wrasse mimics, such as fangblennys *[Plagiotremus]* or saber-tooth blennies *[Aspidontus],* taking advantage of the established symbiotic cleaning-station relationship to sneak-attack the client fish—exemplifies yet a further layer of evolutionary complexity [Cote & Cheney, 2005].)

Near the top of the reef food chain stand the groupers (*Serranidae;* sea bass), often the dominant predatory fish on the reef. The groupers, like many of the invertebrates on the reef, are "broadcast spawners," adding the milt and roe they produce to the free-floating oceanic plankton. The groupers adjust their sex ratios—larger fish becoming male to optimize spawning efficiency (Shapiro, 1987). Larger sharks, riding at the top of the food chain, are among the grouper's predators. The shark's search pattern includes the scan for bioelectric currents generated in the nervous systems of their prey (Kalmijn, 1971).

Illustration: *The bass fades away; end of a dominant life on the reef.*

References

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