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A man's testicles might not seem like something to be used for navigation, but they were and are in native Oceania. So are stars, driftwood, clouds, seaweed, winds, birds, weather, the smell, taste and temperature of the ocean, interference patterns on the sea surface, and the olfactory sense of an on-board pig. How? Our search for the answer begins in our 50th state.

Hawaii is the most isolated archipelago on Earth–over 2000 miles from any other land–but it was inhabited by Polynesian "wayfinders" by 500 A.D. at the latest and possibly as early 100–200 A.D. Hawaii's Pacific-Ocean neighborhood engulfs a third of our planet and is larger than all our continents combined. It's 995 parts water to 5 parts land, yet almost all of its more than 10,000 islands had been discovered long before European explorers arrived in the region a few centuries ago. Extensive, open-ocean voyaging settled the vast, remote "Polynesian Triangle" of islands and made possible the astonishment of Captain Cook at coming upon what he called the "most extensive nation on Earth." The people of this Polynesian "nation" shared a language, culture and genetic inheritance. But they were illiterate, “savage” and lacked the maps and instruments of Western civilization. So, Westerners had difficulty believing that native wayfinders were reliably traveling the open sea while their own forebears–afraid of falling over the edge–were clinging to their coastlines. The European discoverer of the Marquesas Islands, wrote, “The Polynesians do not have a compass or ships big enough to make long ocean voyages like we do. Therefore, their islands must be just off the coast of an undiscovered continent that is just beyond the horizon.”

The debate over wayfinding is more scientific today, but it’s no academic argument about history. It’s a real-time struggle-to-the-death between native and Western ideas about human intelligence, the place and purpose of people in the universe, and the nature of reality. But in all of the debate, one crucial element has yet to be considered: the bedrock of Western thinking is being shattered by chaos theory.

Until chaos theory, we had no way to examine turbulent systems like oceans. Science just assumed sea waves are random in shape and in distribution, and that any wave’s appearance must be a matter of chance. Blind to any order in our oceans, we figured that navigators without Western technology could only blunder about. We assumed that the only way to achieve order here would be to superimpose a man-made order with a longitude-latitude grid. So we devised instruments for building the grid, installing it, and locating ourselves on it. Then our navigators journeyed greater distances with greater accuracy. But they’ve had to be constantly jockeying back and forth between the fish’s-eye view from their boats and the bird’s-eye view of their grid-maps. Over time, they’ve grown to relate more to the grid than to their environs.

The wayfinder, with no mathematical model wedged between him and his environs, concentrates 100% of his attention on his place in the sea and sky. With this one-pointedness, he processes all of his data on his course, speed, the current, etc. His point of concentration is his navel, called the piko in Hawaiian. This is considthat has yet to be written. The wayfinder's voyage across the ocean is not just a quest for more coconuts, but the outer expression of an inner journey. He journeys because, like Hipour, he feels called.

The End

ered the center of one's body and being, so that it–not the brain–is the point from which to live. Instructions for psychologically locating one's piko and for staying centered there have been passed down through the centuries in chants. Instructions for wayfinding explain that your piko is your canoe.

Today Western ideas about turbulent systems like oceans are being transformed by chaos theory, as it discovers order which science had always mistaken for randomness. The surface of the ocean turns out to be highly modulated, and actually contains a remembrance of all its earlier structures.

Does the wayfinder know about this order? He knows he can count on the sea and sky to tell him where distant land is. For example, a swell bending around an island casts a turbulent "shadow" downwind of the island with a pattern that reveals the island's location. A swell reflecting off a shore gives away land's location. Warm air rising over an island creates a high cloud pack that remains relatively stationary, while low, over-the-water clouds get pushed along by the trade winds. So the high cloud pack advertises the island before it appears on the horizon. When the sun or moon is directly above a coral atoll's lagoon, its brightness reflects onto the undersides of nearby clouds, giving away the atoll's location. With the sun at a certain altitude the lagoon reflects a jade-green onto the clouds. When the sun and moon can't help, the wayfinder looks to his on-board pig, who can catch the scent of a distant atoll, its snout pointing the way. Wooded islands reflect a tell-tale dark green onto nearby cloud bottoms. Drifting debris whispers of turf windward. Floating seaweed gives away up-current land. Birds, too, offer guidance because even sea birds need nests on land for their young. Spotting birds at day's end, the wayfinder knows they're heading toward land. Spotting them in the morning he knows they're leaving land to go fishing. He knows the flight range of each species of bird where he's navigating and knows which birds are migratory, so if he were a Tahitian about 2000 years ago, watching the migrating golden plovers–these are not sea birds–and wondering where they go, he might have taken a cue from them and discovered that their other home is Hawaii.

The handful of remaining wayfinders are sharing their wisdom with a handful of Westerners like David Lewis, an early-retired physician and a highly experienced navigator. Lewis has recounted his experiences in The Voyaging Stars: Secrets of the Pacific Island Navigators. He tells about blind Kaho, who "bade his son Po'oi indicate where certain stars would appear and had him luff… into a breaking wave, that he might feel and taste the spray in his face. Then he dipped his arm down into the sea. 'This is not Tongan water but Fijian,' he announced. 'The waves are from the Fiji Lau group near Lakemba island. Let us alter course to the westward.' Next morning they duly sighted Lakemba…"

The technology of wayfinding is the patterns of nature, and these patterns reach to the stars. To see how stars participate, we need to remember that any star always rises in the east at the same point of north-ness or south-ness and sets in the west at the same point of north-ness or south-ness, so long as we stay still. A star's risings and settings, then, are east-west mirror images of each other and are often known in wayfinding as "pits" or ruas. Imprinted on the wayfinder's memory and "mindscreen"–like cross hairs on a gunsight–are the ruas of about 150 stars. Everything he perceives, then, is in relationship to his "star compass." Just as telephone poles and trees "move" past us when we're driving, the stars do (very slowly) when we sail. The wayfinder knows that when ruas are moving past him it's because he's changing what we call latitude. Sailing north, they shift south. Sailing south, they shift north. Knowing how much travel equates with how much rua shift, he lets the movement of the ruas tell him his latitude.

Some stars are special. To see why, we need to remember that as stars rise and set, some follow northerly arcs and others southerly arcs. Only the special zenith star passes directly through the line of your erect spine. The gold-orange Arcturus does this at the latitude of Hawaii because it's the same degree north of the equator

our classical-science yardsticks and categories than we were on nature.

Wayfinders are ignorant of our yardsticks and categories. They wear no Euclidean filters on their perceptions and they understand that "the sea is full of signs." Sensitive to these signs, the Hawaiians developed 160 words for different kinds of wind and 138 words for different kinds of rain.

Unfortunately, this still doesn't tell us how the wayfinder integrates his inputs because nobody but the wayfinder knows. However, there's hope of our knowing if we remember that the stars are no more distant from the wayfinder than his testicles. This is because he views the heavenly bodies, not just as celestial particles, but also as "waves:" he sees the sun, moon and stars describing the cycles of his life. Not surprisingly, the Hawaiian word for sun is also the word for a day. The word for lunar month also describes what the uterus does: protect, care, nourish. Of course, the heavenly bodies describe seasonal patterns for all of us, but a people whose survival depends on gardening, fishing and navigating in harmony with these patterns is profoundly aware of them. To these people the movements of celestial bodies are a matrix of cycles linking life-on-Earth with the heavens. So the sky is the womb of our seasons and, thus, of our lives. Since this sky isn't "up there" or "out there," this universe isn't the remote universe of classical science which has no place or purpose for people. Rather, it's an alive, whole universe with no "inputs" to "integrate" because it has no separations to be joined. This may be why Mau Piailug, when asked by the National Geographic how he navigates, responded: "I just use my head."

Missing from–and leaving a gaping hole in–this very superficial overview of Oceania's radical technology are the are the prayers, chants, disciplines, rituals, dreams, signs and visions which are part of the technology because the wayfinder is not just a technician, but a shaman. Most Westerners ignore or dismiss the shamanic elements, so the "other side" of Oceania's radical technology is a story

For centuries almost nobody knew about people like Mau Piailug. But in 1969 a wayfinder named Hipour acted on an urge to re-navigate with indigenous methods the long path of his ancestors between the islands of Puluwat and Saipan. His success–just as the West was being startled by the technology of its own ancestors through research at places like Stonehenge–generated waves that washed up on Hawaii's shores. The wayfinding renaissance had begun. What we've learned since Hipour's catalytic voyage may never tell us how Hawaii was discovered, but it's introduced us to a radical technology and reminded us that something radical–the word comes from the Latin radix , meaning root–shocks us out of the stupor of our cultural conditioning and jolts us back to our roots. The "electric" contact with our origins explodes in original thinking, and with this kind of thinking we evolve.

The radical technology of wayfinding shocks us with its independence of our technology. But what really threatens our view of the universe is the complex array of totally unrelated inputs–just about everything from stars to pig snorts to testicles–that the wayfinder weaves into a picture of his position. Most of these inputs are from phenomena that don't lend themselves to precise measurement and, because they're of different orders, don't allow like-to-like comparison. Yet, measurement of comparable things is essential to classical science.

Fortunately, chaos theory is revealing that a lot of what we'd always seen as complex is complex only in the context of the unnatural Euclidean geometry that's dominated Western thinking for nearly 2500 years. Many phenomena we'd always seen as unrelated are unrelated only when viewed through the classical-science filter. Without that filter we're perceiving a unity we were blind to for centuries. For example, we're seeing how the "fractal" pattern in the bronchial branching of our lungs is mirrored in the movements of a fast-flowing river and in the growth of certain vegetable forms. Different natural systems behave identically, but we never saw this until recently because we were focusing more on

as Hawaii is. Arcturus, called Hokulea –star of joy–in Hawaiian, points the way to Hawaii because Hawaii is the only Pacific island directly beneath it. So Hokulea is a "guiding light" for native Hawaiians, much as the Star of Bethlehem is for Christians. Other stars are guiding lights to other islands: Sirius to Tahiti and Spica to Samoa.

To see how the sun helps out we need to remember that Earth is tilted to the plane of its orbit. So, the north end of our axis points toward the sun for six months and away from it for six. In the northern hemisphere, while you're pointed toward the sun, it rises and sets in your own hemisphere, tracing a big, high arc and taking many hours to do so: summer. While you're pointed away from the sun, it rises and sets south of you, tracing such a low, small arc that it's up for fewer hours: winter. In the southern hemisphere your seasons–sun arcs–are reversed. Aware of this and always aware of the date, the wayfinder lets the sun tell him his latitude when the stars aren't out.

Dealing with what we call longitude involves other techniques. For example, if the wayfinder is traveling north toward an island he aims well east of it. When the zenith star tells him he's at the island's latitude, he begins "coasting" west on the easterly trade winds, keeping the zenith star overhead until he hits his target.

What does he do when it's cloudy? As the sun or stars disappear, he translates his position into the language of wind, wave and swell angles. He notes the ratio of pitch to roll induced in his boat by the dominant swell, and keeps to his course by keeping this ratio constant. If the wind changes he notes it before it affects the waves and adjusts his mental calculations accordingly. He recognizes different winds as much by their character as by their direction. He may track the wind with a pennant attached to the mast. He may monitor wind, waves, swells and the relative angles between them by mentally timing the dippings of the tip of the sail.

To get a feeling for what the wayfinder is doing all this time with his testicles, it helps to understand ocean swells. These enormous formations are powered by distant storms and steady trade winds and shouldn't be confused with surface waves which change direction as the local wind shifts. Swells march in consistent ranks across thousands of miles. The swell entertaining surfers in Honolulu is generated by winds south of New Zealand. If you can read the shape of a swell you can tell the direction and strength of the current beneath it, and this is critical because if you don't know what the current is doing you can steer a perfect course and still get lost. The wayfinder reads the swell by sitting cross-legged and nearly naked on the bottom of his all-vegetable-matter canoe and feeling its in his testicles.

David Lewis tells of a wayfinder named Tevake: "He kept course by keeping a particular swell from the east-north-east dead astern, a swell that was effectively masked for me by the steep breaking waves thrown up by the squalls… It may seem incredible that a man could find his way across the open Pacific by means of a slight swell that probably had its origin thousands of miles away… He had made a perfect landfall in the half-mile gap between …[two islands], having navigated for between 45 and 48 miles without a single glimpse of the sky. "I was no stranger to the complexities of navigation, having three times crossed the Atlantic single-handed and having been the first to skipper a catamaran around the globe–and that through the stormy Straight of Magellan. Nevertheless, Tevake's feat was evidence of a skill far beyond my own experience."

Ironically, Western science is playing a key role in undermining our doubts about native wayfinding. Computer simulations of nature's processes are the midwives of chaos theory, and computer simulations of Pacific winds and currents are making it hard to write off the entire settlement of the Pacific to accidental drifters because the winds and currents make the journey from Asia toward the Americas almost entirely "uphill." Of course, the odd party of fishermen could accidentally drift thousands of miles to a new island if it had enough drinking water on board, but Polynesian

fishing canoes don't carry women, seeds, plant slips, domestic animals, or agricultural and hunting tools for sustaining human life on previously uninhabited islands. In addition, recent archeological evidence seems to support native oral accounts of round-trip journeys across thousands of miles of open ocean, and investigations by people like Lewis are finding native methods accurate and effective. Summarizing his investigations, Lewis says: "What my friends Tevake, …[and other wayfinders] demonstrated beyond argument was that the ancient methods of navigation were also fully adequate for deliberate two-way voyages across these enormous empty sea lanes that we know the Pacific Islanders crossed a millenium ago." Referring to the debate over wayfinding, Lewis confesses, "There is no longer any debate in my mind."

Unfortunately, the handful of remaining wayfinders live so far west of Hawaii that their methods aren't exactly the same as those used in Polynesia. So nothing they do translates into proof of how Hawaii was discovered. Yet the search for Hawaii's discoverers is what's propelled the revival of interest in wayfinding. This interest gave birth to the Polynesian Voyaging Society in Hawaii in 1973 to build a performance-accurate replica of a traditional, double-hulled canoe. This 60-foot vessel, appropriately named Hokulea , would use only traditional, non-instrument methods to re-trace the voyages celebrated in ancient chants. Hokulea successfully sailed the 2,500 miles from Hawaii to Tahiti in 1976 as the State of Hawaii's contribution to the U.S.A.'s bicentennial celebration and has had many successes since, but there was a sad irony at its bicentennial journey's core: a fully initiated navigator had to be brought in from the western Pacific to lead the effort because wayfinding had long since died out in Hawaii. This man, Mau Piailug, kept the accustomed vigil–sleeping only in catnaps–during the entire 40-day voyage without sight of land. While never napping more than half an hour at a time, his estimates of Hokulea 's position were never off by more than 40 miles.