Animal Magnatism

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The nighttime sky was aglow from the impossible number of stars. The Milky Way, though always present along this stretch of the barrier island, unfurled across the heavens with such brilliance as to force you to stop and take notice. Temperatures had plunged throughout the day signifying a cold air mass was moving through. The world was still. Creatures big and small were conserving heat and energy. Yet overhead, there were the unmistakable calls of tundra swans. Under the cover of darkness they flew, pushing their way south from the Arctic, a voyage their species has made since the dawn of their existence.

For several weeks now, the numbers of birds on the island had swollen to mind bending proportions. Hawks, falcons, passerines (song birds), shore birds, you name it, they were moving south. Day after day I watched as a seemingly endless string of double crested cormorants worked their way down the coastline. Even the humpback whales were beginning to make an appearance. The fall migration was in full swing.

Migration is one of the most basic of instincts for many species. Witnessed on every continent, in every ocean, the seasonal movements of animals is one of the most profound phenomena to occur on Earth. At first glance however, it seems like a relatively simple concept. Broken down, migration is all about food and sex. What else would be so pressing, so demanding, that animals would routinely undertake such a costly, and statistically deadly journey? Migration is survival. It is the continuation of oneself, and the continuation of one's species.

What causes animals to migrate is easy enough to explain. How exactly animals manage to do this on the other hand, is the knot in the stomach of some researchers that keeps them awake at night. Birds navigate across continents, whales across open oceans, even insects like the monarch butterfly undertake monumental journeys with such precision as to baffle humans for centuries. The ability for these creatures to navigate back and forth over thousands of miles along the same routes that their ancestors have for time unknown, is the profundity of migration.

Soaring far above the world of Terra firma, the tundra swans that call out above my house at night are undergoing an arduous round trip journey of some six thousand miles. These birds are most likely on their way to Lake Mattamuskeet where they will spend the winter. The largest natural lake in the state of North Carolina, some 17 miles wide and 9 miles across, the average depth of this lake is only a foot and a half. Mattamuskeet for this reason is the holy Mecca of North America's eastern tundra swans. With nearly a hundred thousand swans by the month of December, this lake is home to one of the South's great wildlife spectacles. Drawn in

by the abundance of wild celery and chufa, these birds congregate in mass upon these waters to both feed, and to select a mate for the coming spring. For a swan to find this single location though, is an act of navigational perfection that requires a mastery of the natural forces present throughout our world.

Traveling by day allows for the use of land marks, the positioning of the sun, and the polarity of the sky as navigational aids. Traveling by night, there are the stars to find your way by, much as the old mariners traveled across the oceans. These are not full proof plans however. What of clouds and storms, when land and sky becomes obscured? There are an infinite number of variables working against these sorts of visual cues, and likewise there are an infinite number of things that can go wrong.

To successfully complete a journey of this magnitude, a more reliable plan of action must be put into place. For these swans, as is the case with all species of migratory birds, one of the secrets to their success lies within their beaks. As the old saying goes, "follow your nose," these birds do just that. Collected inside of the beaks of migrants lies an almost alien like iron ore known as magnetite. When found inside of animals, this mineral is more appropriately termed biogenic magnetite, and the deposits of this stuff are permanently magnetized bars that align themselves with magnetic north. Deep within these birds lies a natural compass rotating continuously to keep track of the magnetic poles.

All said and done, our planet is really just one big magnet, and the magnetic field that radiates out of the poles can be perceived in the air, on land, and deep beneath the surface of the vastness of our oceans. This field is a constant. It is there day and night, in stormy weather and blue skies. The ability to tune into this geomagnetic field therefore, offers an unsurpassed ability to navigate the world abroad.

Birds as it turns out, are not the only creatures to possess this biogenic magnetite. Whales have it; sea turtles have it, many different species of mammals, amphibians, lobsters, and even humans all contain deposits of this magnetic mineral in crystal like form. For most species, like humans and sea turtles, magnetite is found within the brain. The neurobiological reaction that occurs here to create the perception of direction however is still for the most part sparsely understood. Really though that's all aspects of the mechanics of migration. It's like a rabbit hole. The closer you look the deeper it goes. The answer to one question, only elicits more questions.

Case in point, the loggerhead sea turtle undergoes one of the most dramatic of migrations on Earth. Upon hatching, the baby turtles orient themselves straight towards the Gulf Stream many miles off the coast. From here, it will spend roughly the next ten years of its life being swept around the Atlantic ocean in the clockwise rotation of currents we call the North Atlantic Gyre, for which the famed Gulf Stream is only the western boundary. Tens of thousands of miles of travel and nearly a decade later, these turtles begin to reappear off the coast of the US. When it finally comes time for the females to lay their eggs, they will most often return back to the same beaches they themselves once hatched from some thirty years before.

Ospreys, one of the most successful birds of prey on Earth, also show this incredible behavior of returning to their natal homes. Upon migrating south in the fall, the ospreys that call the Outer Banks home will undertake their journey to Central America at break neck speeds. Once arriving in places like Venezuela, that year's fledglings will then spend the next two years of their life in the tropics where they mature and find their mate that they will stick with for life. After their two year foray in tropical bliss, these birds will then once again find their way back to this very sandbar where they were born. Each year following, they will undergo this same monumental journey south once again, only to return in the spring, not just to these islands, but to the very nest from which they left the previous fall.

To be able to pinpoint a location such as the osprey, loggerhead sea turtles, and tundra swans do, these creatures need more than just a compass. The knowledge of which direction is north and south will only point you in the general direction. Like trying to give directions to my house on the Outer Banks, you need more information than just simply knowing that I live north of Mexico.

As it turns out, the Earth's magnetic field is quite complex and every place on this planet has its own unique magnetic signature or address if you will. Cape Hatteras National Seashore will therefore have a completely different magnetic address than say, Bermuda or even Lake Mattamuskeet. Thus many species are not only able to perceive this geomagnetic field, they are also able to discern the subtle variations in its pulse and intensity. These variations are the signatures that locations can then be mentally mapped by.

Sea turtles' unique behavior of returning to their natal beaches or birthplace after so many years absent, much like salmon, has given these oceanic reptiles top priority in terms of studying magnetic orientation. Dr. Kenneth Lohmann of UNC Chapel Hill, a researcher whose name is almost inextricable from the literature on geomagnetism in sea turtles, has done extensive research on loggerhead turtles in the coastal waters of North Carolina and the rest of the Southeast.

Dr. Lohmann has shown repeatedly that loggerhead turtles are not only able to align themselves with the magnetic poles, but to also read the variations in the geomagnetic field so as to orient themselves throughout the oceans. In one of his more renowned experiments, Lohmann placed loggerhead hatchlings into an artificial pool that allowed him to replicate the magnetic field. As loggerhead hatchlings orient themselves toward the Gulf Stream for which they live out the first decade of their lives floating around the Sargasso Sea, Lohmann's experiments were designed to discern whether or not hatchlings would orient themselves towards this gyre despite his manipulation of the geomagnetic signature replicating various locations on the eastern seaboard. By controlling the magnetic field in the pool, Lohmann was able to emulate the magnetic signature of areas south, north, and east of the North Atlantic Gyre. With each change in the magnetic field, the hatchlings responded in fashion by swimming towards where the Gyre would be in relation to their current magnetic address. The implications

of these findings cannot be overstressed. GPS has been around for a very long time.

With life beginning in the primordial soup that was the oceans of our planet nearly four billion years ago, it would only make since that such use of the geomagnetic field would first evolve beneath the ocean blue. Thus may be why magnetoreception is so wide spread amongst pelagic (open ocean) species. With little in the form of visual cues to utilize for migrating vast distances through seas, the ability for animals to tap into the one global constant could be the difference between finding seasonally available food sources, and wandering aimlessly in the vast abyss towards starvation.

Upon land though, magnetoreception begins to take on unique twists. As terrestrial life is the evolutionary offspring of this aquatic world, many air breathers have inherited such abilities and then some. The problem with our ability to single out exactly how creatures are tapping into this magnetic field has been that the literature is confounded by the fact that many researchers find distinct and unexplainable links to vision in migration. As noted above, there are always the stars and major geographic landmarks to guide the observant migrant across the land, but what of those that cannot see such landmarks? What of those who have never had the opportunity to see such landmarks, why is light and vision seemingly still playing a role?

Nearly forty years ago, Klaus Schulten of the University of Illinois made a radical proposal that migratory birds may actually see the lines of the Earth's magnetic field. For such claims, Schulten was laughed at by some and ignored by others. For those that did think that he might be onto something though, they could never prove such a link. The problem was that researchers just couldn't find a chemical present in the optical system of birds, or any other animals for that matter, sensitive enough to actually be influenced by the subtle geomagnetic field. That is, until researcher Peter Hore of Oxford University discovered that chryptochromes, a light sensitive protein in the retinal neurons of bird's eyes, was in fact sensitive to weak magnetism.

Research on robins has now shown that not only are these birds visually responding to the Earth's magnetic field but that they are able to actually see the magnetic lines of this field in living color. Experiments have shown time and time again that this ability to "see" the magnetic field is specifically related only to the right eye of birds, for when they are covered or a frosted lens is placed over top of that eye, the birds distinctly lose their orientation ability. The right eye therefore functions as something of a gateway for these birds' magnetoreception.

One aspect of these findings that has sparked curiosities all over the world, is the fact that chryptochromes are present in the eyes of humans as well. This naturally leads us to question why we do not see the lines of the geomagnetic field? Chryptochromes it turns out rely upon free radicals – those pesky things that speed up aging, cause cancer, and fuel multi-million dollar marketing campaigns to advertise antioxidants on cereal boxes. And for magnetoreception, chryptochromes specifically require the free radical known as superoxide. Humans

however, naturally produce an enzyme known as superoxide dismutase for searching out and destroying this stuff. So it would seem that over the course of human evolution we traded our own magnetoreception and ability to perceive the Earth's field for a longer life span.

This revelation of the function of chryptochromes has simply blown the roof off of the study of migration. Thousands of species of birds across the globe are considered migratory. Do chryptochromes function similarly in all of these species? What of the biogenic magnetite that is known to be present in these species and how does it play a role if birds can simply see the magnetic field? Those species that never left the ocean have of course inherited the ability of orientation from their ancestors, but what of those species that left the terrestrial lifestyle for one in the ocean blue? Whales, sea turtles, seals . . . what allows for these creatures to locate themselves at all times across some sort of geomagnetic map? Like I said - rabbit hole.

Since the days when the famed naturalist Aristotle theorized migration was nothing more than birds hibernating underground like some sort of winged member of the tribe of bears, humans have groped for understanding of the phenomena that is migration. Today however, our desire to understand the mechanics behind migration goes far beyond simple fascination. Researchers are now realizing that the understanding of the movement of animals is going to play one of the most critical roles for protecting and insuring the continuation of these species in the future. It no longer suffices to simply know where animals are coming from and where they are going. How they manage these feats and what our civilization has put into place that interferes with these mechanics is quickly becoming a major concern for conservation biology and a driving force behind environmental policy making.

Regardless of where we live in North Carolina, we all play witness to the grand spectacle of migration each and every year. Whether it is warblers and dragonflies in the piedmont, hawks and monarch butterflies in the Appalachians, or whales and shorebirds along the coast, our state sits squarely in the middle of one of the great migration corridors on Earth. Next fall and spring, as species you have not seen for nearly 6 months begin to flood back into your area, consider the epic journey that they are in the midst of and how their built in GPS technology is light years ahead of your Garmin.