Ode to E Pluribus Unum for Sunday June 19 2022

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Eagle Nebula

Image Credit: NASA, ESA, Hubble; Processing & Copyright: Ignacio Diaz Bobillo & Diego Gravinese

Where do stars form? One place, star forming regions known as "EGGs", are being uncovered at the end of this giant pillar of gas and dust in the Eagle Nebula (M16).

Short for evaporating gaseous globules, EGGs are dense regions of mostly molecular hydrogen gas that fragment and gravitationally collapse to form stars. Light from the hottest and brightest of these new stars heats the end of the pillar and causes further evaporation of gas and dust -- revealing yet more EGGs and more young stars.

This featured picture was created from exposures spanning over 30 hours with the Earth-orbiting Hubble Space Telescope in 2014, and digitally processed with modern software by experienced volunteers in Argentina. Newborn stars will gradually destroy their birth pillars over the next 100,000 years or so -- if a supernova doesn't destroy them first.

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The lucrative economics of expert witnesses

https://mail.google.com/mail/u/0/?shva=1#inbox/FMfcgzGpGKgJrZRHpRxSBsnwrPJTpBSJ

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"You here again, Carole?!"

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Bee Balling in Texas

A rare moment captured up close: Diadasia rinconis (Cactus Bees) swarming together in a mating ball, each male eager to become companions with a female.

Native to America, these bees are considered a solitary species, meaning they live without the hierarchy and structure of their European counterparts—though they still work to pollinate cacti and help plants in the American southwest thrive.

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The Jester's Cap

From June 5 2022

Niagra Falls

Last time I was at Niagara Falls was ~7-8 years ago and was watching the inexorable water movement before it went over the edge. It's a whole lot of water. But how much water is a lot of water?

New Orleans made Lake Pontchartrain famous, and the Lake made the causeway famous. LP is generally oval, a tad over 26 miles wide north-south, and about 36 miles wide east-west. The causeway runs from the Big Easy to the north shore and is every bit of 26 miles long, making it a stunningly boring drive, as in "I joined the Navy to see the world. / And what did I see? I saw the sea." While it has a fairly large surface area of ~800 sq. mi., it's not terribly deep.

So, I got to wondering how long it would take the water flow over the much more picturesque Niagara Falls to fill it. By my calculations, at Niagara's maximum flow, filling the lake would take all of about 4 1/2 ... hours. There was no way I could change the variables to make it much closer even to 5 hours. A lot of water falls up yonder.

Copeland

Interesting observation about Copland, but when you think about it, it's not without precedent. Dvořák's New World Symphony is every bit as Americaphilic as Copland's work. Both are Americana at its quintessential best. In fact, I once got to listen to Hans Smetana conduct the Pittsburgh Symphony doing NWS. It was wonderful.

The Mack of Mac

Regarding McDonald's, have you watched the movie, The Founder? It's about Ray Kroc and how Mickie D's came to be what it is today. And, for my money, what an opportunistic ass Kroc was. Michael Keaton plays him. Well.

From June 12 2022

Dots, Lines, and Squibbles

It occurs to me that I didn't explain why people have to see straight lines at an early developmental age in order for them to be able to see them later in life. Nor, for that matter, do I know of anyone having shown this to be correct, but I'm pretty sure it goes something like this....

In the 50s and 60s, two guys at Harvard medical school, Hubel and Wiesel, wanted to map the cat's retina onto its visual cortex. What they did was, using anesthetized cats (that were not going to be awakened), they kept the eyelids open, aimed the eyes at a screen, and projected lantern slides (remember those?) onto it. What they were projecting were dots--either dark ones on a light background or vice versa. And they got bupkiss--nuttin'.

Until one day, they got a big response as they were changing slides. So they went back and looked very carefully across the path that the dot had taken to find out where the dot "receptor" was.

Crickets.

And then, as with Faraday's discovery of his eponymous law, they noticed that it was the moving slide that did the trick. So, was it movement? Or was it something else? turned out to be something else: it was a line, which shape the moving dot traced out. They'd found a line receptor. Then they found that they could rotate the shape and that would trigger progressively deeper (or shallower) levels of the cortex.

What the eye had been sending the brain wasn't dots. It was sending line segments, among other things.

So now take a look at the organization of the retina. All we learned about in medical school was that there are several main neural layers. Beginning farthest back (deepest), there are rods and cones; then bipolar cells, and then ganglion cells. At the rod and cone/ganglion cell junction level, there are horizontal cells called, well, horizontal cells. At the other ends of the bipolar cells, where they synapse with the ganglion cells, there's another horizontal layer of cells, but since horizontal was already taken, they're called amacrine cells. No, I don't know what "amacrine" means.

But when you look at the structure under a microscope, it's clear that the ganglion cells derive inputs from multiple bipolar cells. Each bipolar cell gets a transduced input just from just one photoreceptor, i.e., a rod or a cone. So the ganglion cells are where the encoding happens.

An infant's retina has to start getting programmed to see patterns, and much of what it has to learn to see are straight line segments. If that programming doesn't happen early enough, it can't happen at all. My guess--and it's only a guess--is that the newborn's retina has a lot more synapses between ganglion cells and bipolar cells than it needs. And that, over time--first couple-three years of life--it allows the ones it doesn't use much to wither. And what's left are the detectors that are needed.

Other species have different detectors. Frogs, for example, have cells that are extremely sensitive not so much to light, but to changes in light intensity. They can typically detect light changes roughly 100x *less* rapid than a sunrise or a sunset. This is hardwired: they evidently need to be able to tell when it's getting dark, prolly so they can get out of the way of predators. Mammal eyes are made strangely. The blood supply to the retina is in front of the retina, not behind it, which means that light has to go through the arteries and veins. before it reaches the rods and cones. Not so octopuses: their eyes are made right, with the blood supply where it belongs: behind the retina. That way, there's less interfering with the light, so they can see it lower light conditions than we can.

But wait a minute, you say--if the blood vessels are in front of the retina, I ought to be able to see them-- they should be casting a shadow on my retina. So, as usual, you must be out of your gourd, Joe. Well, yes, I'm out of my gourd, but I'm not wrong about this one. Turns out you cannot see fixed images on your retina--they fade in a second or two at the most. If you take a small penlight, put it on your closed eyelid, and move it back and forth and up and down a bit, you'll see the vessels. That phenomenon is called the Purkinje tree, named, naturally, after professor Tree. Kidding. Anyway, that's a way to visualize it.

As with so many things before they became woke, Scientific American ran an article about this stuff back in the 60s or 70s. The apparatus they used to demonstrate it was a nifty little contact lens that sat on the cornea. It had a tiny projector attached to it and it projected a superimposed square, triangle and circle. As the eye moved, so did the projector, so the image was fixed. And it disappeared moments after they turned it on.

But wait (again), Joe, I'm staring at the period at the end of the last sentence and...there it is! It doesn't disappear to *my* eyes. Yours must be wonky. Not so much, actually. Eyes aren't still objects. They're always making tiny movements--the engineering term is "dithering"--back and forth, up and down. And the reason they do that is to prevent disappearance. Which is also why they made the contact lens as they did.

But wait, Joe--you're still out of your mind. I'm staring at a perfectly evenly and continuously painted wall that's the same color everywhere. I don't see any holes in it. So there's clearly a fixed image of a lot of it-- most of it even--on my retina and I still see it. You do indeed. But the brain gets involved at that level and says (to itself) "I see red over on the left and the right and the top and the bottom of what I can see and I *don't* see anything interrupting it between those boundaries. Ergo, it's all red and that's what I'm reporting to Captain Consciousness."

Vision is pretty tricky stuff. And this only scratches the surface....

Since you asked (or, I'm sure, were about to), when you rotate your head about the front-back axis, your eyes stay upright for some angle before they suddenly start to turn also around that axis. The angle you're looking for is ±17 degrees. Octopuses can do almost a 360.

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The Doobie Brothers

The American rock band from San Jose, California, known for their flexibility in performing across numerous genres and their vocal harmonies. The group's fourteen studio albums include six top-ten appearances on the Billboard 200 album chart,.

The Doobie Brothers were inducted into the Vocal Group Hall of Fame in 2004, and the Rock and Roll Hall of Fame on November 7, 2020. The group has sold more than 40 million albums worldwide.

Takin It To The Streets https://www.youtube.com/watch?v=2rxWPEdYCnI
Listen to the Music https://www.youtube.com/watch?v=DkytJLoxGmQ

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"He will!"

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Rachmaninoff on Piano for Romsai the Elephant

https://youtu.be/SFIT87yPNYk

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How I spent my childhood

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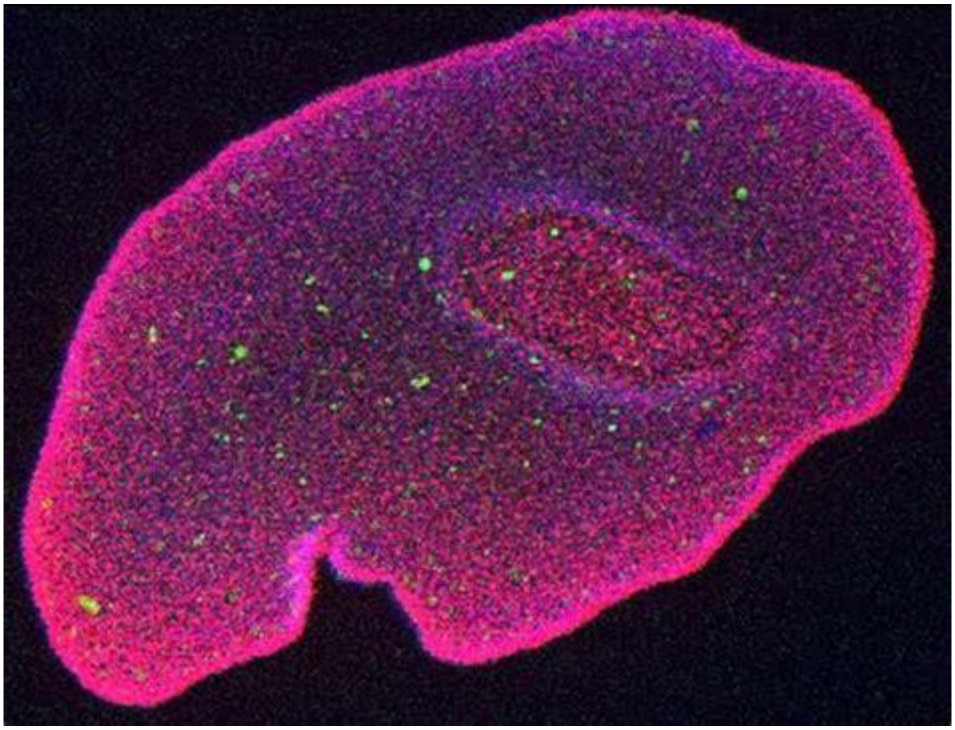
The Mechanical Secrets of a Brainless Animal



https://youtu.be/ImKFUHJdcLE

Trichoplax adhaerens is a species of placozoa, the simplest animals at the base of the tree of life. It doesn't have a nervous system, yet it exhibits complex behaviors. How is this possible?

The answer could illuminate the origins of the nervous system—and the future of robotics. "It's a tour de force of biophysics," said Orit Peleg of the University of Colorado, Boulder.

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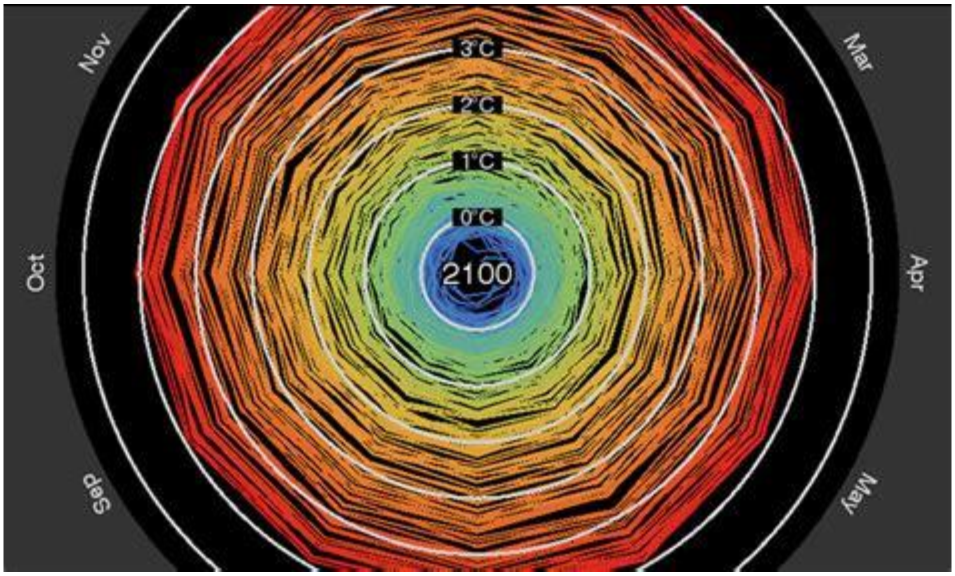
Climate Spiral



This visualization shows monthly global temperature anomalies (changes from an average) between the years 1880 and 2021. Whites and blues indicate cooler temperatures, while oranges and reds show warmer temperatures. As you can see, global temperatures have warmed from mainly human activities as time has progressed.

These temperatures are based on data from NASA's Goddard Institute for Space Studies (GISS). Anomalies are defined relative to a base period of 1951 to 1980. The data file used to create this visualization can be accessed here.

The "climate spiral" is a visualization designed by climate scientist Ed Hawkins from the National Centre for Atmospheric Science, University of Reading. Climate spiral visualizations have been widely distributed; a version was even part of the opening ceremony of the Rio de Janeiro Olympics.

https://youtu.be/jWoCXLuTIkI

Credit: NASA's Scientific Visualization Studio

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My Being Here Belongs

May seed pods
fill my palms
none must promise
to sprout
to fathom green
from roots
locked inside
sizes
shapes
tones
after resting in
cupped aged skin

all within
this on-going
long beginning
time beyond time
of drought
hands holding promises
perhaps now fantasies
but look
sweet alyssum blooming
in dusty earth
at bottom of the berm
thick sumac
its own forest
dressed in blossoms
pale yellow
sumac oiled within
loves the flesh of fire
and quickly burns
in summer's growing heat
two monarchs
dip and waft
following the scent
native milk weed
I planted abounds
one white cabbage moth
hugs small mustard plant's
blossoms
few survived the hoe
does the hawk's call
frighten that agile lizard
small yet claiming one
sandstone rock it's
own Half Dome?
A bee circles my legs
as though confused
I'm not the bottle brush
nor the lavender
nor salvia
but somehow
it seems to sense
even though
beyond rooting,
blooming time
my being here
belongs.

Katherine Holden

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Before Evolving Long Necks, Giraffes Headbutted for Dominance

A major plot twist emerges in the story of how giraffe necks stretched out over time.

By Jocelyn Solis-Moreira

Fossils of a giraffe ancestor with short necks headbutting each other in a grassland in an artist's reimagining

More than 16 million years ago, giraffes had more compact necks and strange keratinized heads, as seen by newly discovered fossils of Discokeryx xiezhi.

A headbutt is not just a move for Pokemon or legendary soccer players: It's a clue to the past life of giraffes. A new study published Thursday in the journal Science details an expedition in Northern China where paleontologists uncovered fossils of short-necked giraffes (or girrafoids, the prehistoric version of the modern-day mammals) that liked to bash each other with their skulls.

The relative is called Discokeryx xiezhi, and they had very short necks. Fully grown individuals today have roughly 6-feet-long necks for swinging around and challenging other giraffes to establish dominance (see video below). But the new findings suggest "necking" may be a more recent evolutionary adaption to fighting.

The international team led by Shi-Qi Wang from the Chinese Academy of Sciences in Beijing analyzed the unique structure of the fossils' headgear and neck joints. They also studied isotope data from preserved tooth enamel that painted a picture of what life was like for the giraffes at the time. The researchers predict the short-necked ancestors lived in the Miocene epoch (a time when grasslands became more abundant) about 16.9 million years ago. The ancient girrafoids spent most of their time roaming open land and likely munched on plant leaves near the ground rather than on top of trees.

As if finding a miniature giraffe species wasn't enough, the researchers discovered a unique bone structure in the male Discokeryx xiezhi's head and neck. The joints showed the creatures had a thickened vertebrae and skullcap with a hard layer of keratin similar to those seen in modern bulls and rams. Their helmet-shaped heads were ready to both give and receive a bump to the noggin.

Ultimately, the team concluded that the reinforced skull was likely a sexual weapon, used to head bash other males in competition for mates.

"It shows that giraffe evolution is not just elongating the neck," study coauthor Jin Meng, a paleontologist at the American Museum of Natural History, told the New York Times. "Discokeryx goes in a totally different direction."

The results also provide an alternative explanation for how present-day giraffes developed their long necks. The prevailing theory is that competition for food was the primary driver behind neck elongation, allowing them to access leaves in the canopy. But sexual competition may have favored head-bashing girrafoids with slightly longer necks. As individuals of the species used more of their necks in fighting, it gave them the opportunity to breed longer-necked offspring with the unintended benefit of being tall enough to reach for food on top of trees.

Present day displays of dominance: Necking https://youtu.be/AhN9aEC4Qak

"At present, it is not easy to distinguish the 'feeding competition' hypothesis from the 'necks for sex' idea," Robert Simmons, an honorary research associate at the University of Cape Town's FitzPatrick Institute of African Ornithology who was not involved in the study, told Live Science. "It is very likely that both have played a role in the evolution of the magnificent animals we see today."

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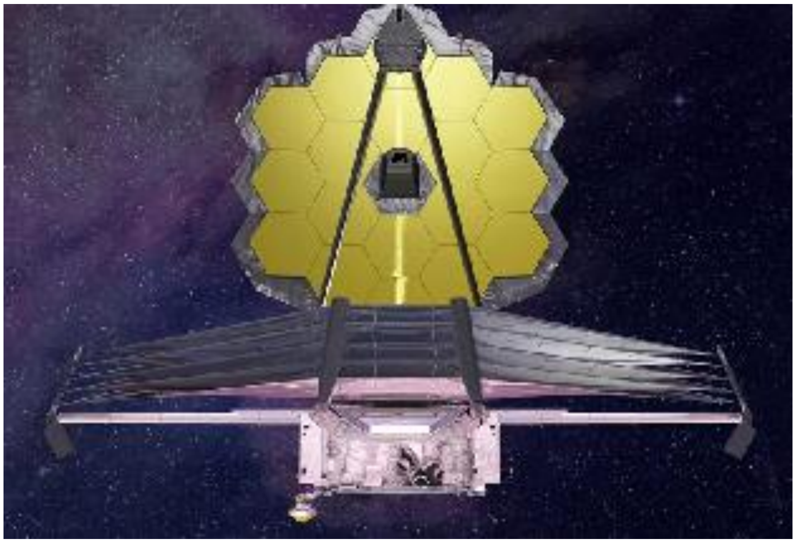
Ever Wonder How Webb Works?



https://www.space.com/james-webb-space-telescope-suffers-micrometeoroid-impacts?utm_source=SmartBrief&utm_medium=email&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_content=54C601BA-14EA-42EE-B84A-15D1EE642205&utm_term=259fcfcb-705f-4282-8a39-1d5a56b9ef08

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Piledriving the Old Fashioned Way

https://youtu.be/om_ldgTix78

Bob Wardlaw, who sent this, pointed out that here in America we would need a 38-page work contract, geotechnical study, engineering report, the scope of works, risk assessment study, project management team, 3 HR consultants, 4 safety officers, 3 site engineers, 2 foremen, 3 leading hands,10 laborers, an oversize pile driver, huge crane, *2 trucks, 6 traffic controllers, site office, 3 politicians making speeches about the project and, of course, an archaeologist…*

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Researchers Achieve 'Absurdly Fast' Algorithm for Network Flow

https://www.quantamagazine.org/researchers-achieve-absurdly-fast-algorithm-for-network-flow-20220608/?mc_cid=ba71006639&mc_eid=636bc88d2e

The new paper handles both maximum flow and a more general version of the problem in which you also want to minimize costs. Over the years, these two problems have inspired many of the biggest advances in algorithmic techniques..

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Samuel Barber: Adagio for Strings

Adagio for Strings is a work by Samuel Barber, arguably his best known, arranged for string orchestra from the second movement of his String Quartet, Op. 11.

Barber finished the arrangement in 1936, the same year that he wrote the quartet. It was performed for the first time on November 5, 1938, by Arturo Toscanini conducting the NBC Symphony Orchestra in a radio broadcast from NBC Studio 8H. Toscanini also conducted the piece on his South American tour with the NBC Symphony in 1940.

Its reception has generally been positive, with Alexander J. Morin writing that Adagio for Strings is "full of pathos and cathartic passion" and that it "rarely leaves a dry eye". The music is the setting for Barber's 1967 choral arrangement of Agnus Dei.

Keisuke Nakagoshi (piano) https://youtu.be/cdAAeCcY9lA
Dover Quartet (Str. Quartet) https://youtu.be/lKrxPTePXEQ?t=19
Leonard Bernstein (Orch) https://youtu.be/q5LODmWn1wA?t=4
Agnus Dei (Choir) https://youtu.be/YVowLNuV4Zk?t=6

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Father of Modern Neuroscience Discovered the Basic Unit of the Nervous System

https://www.scientificamerican.com/article/the-father-of-modern-neuroscience-discovered-the-basic-unit-of-the-nervous-system/?utm_source=promotion&utm_medium=email&utm_campaign=april-sa-alert&utm_content=article&utm_term=SA-20220104_CVP_v1_s1&spMailingID=71358825&spUserID=NTE4NTY0MjU3NTM5S0&spJobID=2236531537&spReportId=MjIzNjUzMTUzNwS2

The wondrous landscape of the brain was finally revealed to Santiago Ramón y Cajal, more real than he could have ever imagined.

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How to Build a P-47 in the Field with Hand Tools and a Few Friends

https://www.reddit.com/r/aviation/comments/v7sotk/how_to_assemble_a_p47_in_the_field_with_only_hand/

Are you ready?

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The Future? Google's Sentient AI

https://cajundiscordian.medium.com/is-lamda-sentient-an-interview-ea64d916d917

Talk about spooky; I think you'll need to read this before you dismiss the idea that machines can think, feel, and innovate.

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Chilling Out on a Dinghy

This super-relaxed seal does not have a care in the world as it appears to have taken a dinghy for a leisurely cruise - complete with a pair of oars.

The large animal, blatantly unbothered by its audience appears completely relaxed.

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Maverick’s Darkstar Mockup in New Behind-the-Scenes Video

https://theaviationist.com/2022/06/14/darkstar-mockup-behind-the-scenes-video/

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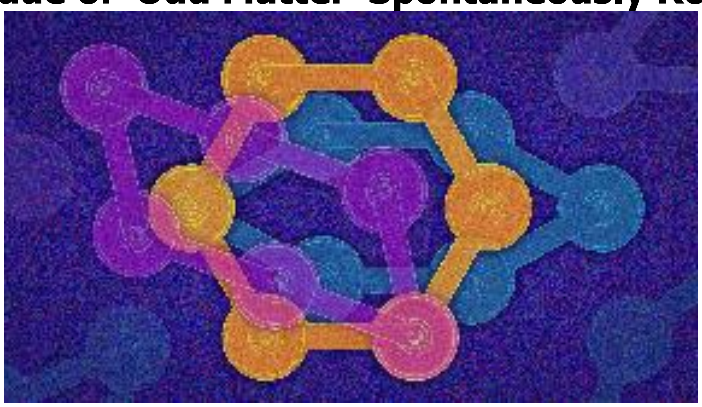
Wheel Made of ‘Odd Matter’ Spontaneously Rolls Uphill



Physicists have solved a key problem of robotic locomotion by revising the usual rules of interaction between simple component parts.

https://www.quantamagazine.org/wheel-made-of-odd-matter-spontaneously-rolls-uphill-20220615/?mc_cid=2b071ebc50&mc_eid=636bc88d2e

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How Migrating Birds Use Quantum Effects to Navigate

New research hints at the biophysical underpinnings of their ability to use Earth’s magnetic field lines to find their way to their breeding and wintering grounds

Credit: Kyle Bean

By Peter J. Hore, Henrik Mouritsen

Imagine you are a young Bar-tailed Godwit, a large, leggy shorebird with a long, probing bill hatched on the tundra of Alaska. As the days become shorter and the icy winter looms, you feel the urge to embark on one of the most impressive migrations on Earth: a nonstop transequatorial flight lasting at least seven days and nights across the Pacific Ocean to New Zealand 12,000 kilometers away. It's do or die. Every year tens of thousands of Bar-tailed Godwits complete this journey successfully. Billions of other young birds, including warblers and flycatchers, terns and sandpipers, set out on similarly spectacular and dangerous migrations every spring, skillfully navigating the night skies without any help from more experienced birds.

People have long puzzled over the seasonal appearances and disappearances of birds. Aristotle thought that some birds such as swallows hibernated in the colder months and that others transformed into different species—redstarts turned into robins for the winter, he proposed. Only in the past century or so, with the advent of bird banding, satellite tracking and more widespread field studies, have researchers been able to connect bird populations that winter in one area and nest in another and show that some travel vast distances between the two locales every year. Remarkably, even juvenile long-haul travelers know where to go, and birds often take the same routes year after year. How do they find their way?

Migrating birds use celestial cues to navigate, much as sailors of yore used the sun and stars to guide them. But unlike humans, birds also detect the magnetic field generated by Earth's molten core and use it to determine their position and direction. Despite more than 50 years of research into magnetoreception in birds, scientists have been unable to work out exactly how they use this information to stay on course. Recently we and others have made inroads into this enduring mystery. Our experimental evidence suggests something extraordinary: a bird's compass relies on subtle, fundamentally quantum effects in short-lived molecular fragments, known as radical pairs, formed photochemically in its eyes. That is, the creatures appear to be able to "see" Earth's magnetic field lines and use that information to chart a course between their breeding and wintering grounds.

A MYSTERIOUS SENSE

Migratory birds have an internal clock with an annual rhythm that tells them, among other things, when to migrate. They also inherit from their parents the directions in which they need to fly in the autumn and spring, and if the parents each have different genetically encoded directions, their offspring will end up with an intermediate direction. For example, if a southwest-migrating bird is crossed with a southeast-migrating bird, their offspring will head south when the time comes. But how do the young birds know which direction is southwest or south or southeast? They have at least three different compasses at their disposal: one allows them to extract information from the position of the sun in the sky, another uses the patterns of the stars at night, and the third is based on Earth's ever present magnetic field.

In their first autumn, young birds follow inherited instructions such as "fly southwest for three weeks and then south-southeast for two weeks." If they make a mistake or are blown off course, they are generally unable to recover because they do not yet have a functioning map that would tell them where they are. This is one of the reasons why only 30 percent of small songbirds survive their first migrations to their wintering grounds and back again. During its first migration a bird builds up a map in its brain that, on subsequent journeys, will enable it to navigate with an ultimate precision of centimeters over thousands of kilometers. Some birds breed in the same nest box and sleep on the same perch in their wintering range year after year. Equipped with this map, about 50 percent of adult songbirds make it back to their nesting site to breed every year.

Migratory birds' navigational input comes from several senses—mainly sight, smell and magnetoreception. By observing the apparent nighttime rotation of the stars around the North Star, the birds learn to locate north before they embark on their first migration, and an internal 24-hour clock allows them to calibrate their sun compass. Characteristic smells can help birds recognize places they have visited before. Scientists know a great deal about the detailed biophysical mechanisms of the birds' senses of sight and smell. But the inner workings of their magnetic compass have proved harder to understand.

The magnetic direction sense in small songbirds that migrate at night is remarkable in several important respects. First, observations of caged birds exposed to carefully controlled magnetic fields show that their compass does not behave like the magnetized needle in a ship's compass. A bird detects the axis of the magnetic field and the angle it makes with Earth's surface, the so-called inclination compass. In laboratory experiments, inverting the magnetic field's direction so that it points in exactly the opposite direction has no effect on the bird's ability to orient correctly. Second, a bird's perception of Earth's magnetic field can be disrupted by extraordinarily weak magnetic fields that reverse their direction several million times per second. Last, even though songbirds fly at night under the dim light of the stars, their magnetic compass is light-dependent, hinting at a link between vision and magnetic sensing.

In 1978, in an attempt to make sense of these features of avian magnetoreception, Klaus Schulten, then at the Max Planck Institute for Biophysical Chemistry in Göttingen, Germany, put forth a remarkable idea: that the compass relies on magnetically sensitive chemical transformations. At first glance, this proposal seems preposterous because the energy available from Earth's magnetic field is millions of times too small to break, or even significantly weaken, the bonds between atoms in molecules. But Schulten was inspired by the discovery 10 years previously that short-lived chemical intermediates known as radical pairs have unique properties that make their chemistry sensitive to feeble magnetic interactions. Over the past 40 years researchers have conducted hundreds of lab studies of radical-pair reactions that are affected by the application of magnetic fields.

To appreciate why radical pairs are so special, we need to talk about a quantum-mechanical property of the electron known as spin angular momentum, or "spin" for short. Spin is a vector with a direction as well as a magnitude, and it is often represented by an arrow, ↑ or ↓, for example. Particles with spin have magnetic moments, which is to say they behave like microscopic magnets. Most molecules have an even number of electrons arranged in pairs with opposed spins (⇅), which therefore cancel each other out. Radicals are molecules that have lost or gained an electron, meaning that they contain an odd, unpaired, electron and hence have a spin and a magnetic moment. When two radicals are created simultaneously by a chemical reaction (this is what we mean by radical pair), the two unpaired electrons, one in each radical, can have either antiparallel spins (⇅) or parallel spins (↑↑), arrangements known as singlet and triplet states, respectively.

Immediately after a radical pair is created in a singlet state, internal magnetic fields cause the two electronic spins to undergo a complex quantum "waltz" in which singlet turns into triplet and triplet turns back into singlet millions of times per second for periods of up to a few microseconds. Crucially, under the right conditions, this dance can be influenced by external magnetic fields. Schulten suggested that this subtle quantum effect could form the basis of a magnetic compass sense that might respond to environmental stimuli a million times weaker than would normally be thought possible. Research that we and others have carried out in recent years has generated fresh support for this hypothesis.

A POSSIBLE MECHANISM

To be useful, hypotheses need to explain known facts and make testable predictions. Two aspects of Schulten's proposed compass mechanism are consistent with what is known about the birds' compass: radical pairs are indifferent to exact external magnetic field reversals, and radical pairs are often formed when molecules absorb light. Given that the birds' magnetic compass is light-dependent, a prediction of Schulten's hypothesis is that their eyes play a part in the magnetic sensory system. About 10 years ago the research group of one of us (Mouritsen) at the University of Oldenburg in Germany found that a brain region called Cluster N, which receives and processes visual information, is by far the most active part of the brain when certain night-migrating birds are using their magnetic compass. If Cluster N is dysfunctional, research in migratory European Robins showed, the birds can still use their sun and star compasses, but they are incapable of orienting using Earth's magnetic field. From experiments such as these, it is clear that the magnetic compass sensors are located in the birds' retinas.

One early objection to the radical-pair hypothesis was that no one had ever shown that magnetic fields as tiny as Earth's, which are 10 to 100 times weaker than a fridge magnet, could affect a chemical reaction. To address this point, Christiane Timmel of the University of Oxford and her colleagues chose a molecule chemically unlike anything one would find inside a bird: one that contained an electron donor molecule linked to an electron acceptor molecule via a molecular bridge. Exposing the molecules to green light caused an electron to jump from the donor to the acceptor over a distance of about four nanometers. The radical pair that formed from this reaction was extremely sensitive to weak magnetic interactions, proving that it is indeed possible for a radical-pair reaction to be influenced by the presence of—and, more important, the direction of—an Earth-strength magnetic field.

Schulten's hypothesis also predicts that there must be sensory molecules (magnetoreceptors) in the retina in which magnetically sensitive radical pairs can be created using the wavelengths birds need for their compass to operate, which another line of research had identified as light centered in the blue region of the spectrum. In 2000 he suggested that the necessary photochemistry could take place in a then recently discovered protein called cryptochrome.

Cryptochromes are found in plants, insects, fish, birds and humans. They have a variety of functions, including light-dependent control of plant growth and regulation of circadian clocks. What makes them attractive as potential compass sensors is that they are the only known naturally occurring photoreceptors in any vertebrate that form radical pairs when they absorb blue light. Six types of cryptochromes have been found in the eyes of migratory birds, and no other type of candidate magnetoreceptor molecule has emerged in the past 20 years.

Like all other proteins, cryptochromes are composed of chains of amino acids folded up into complex three-dimensional structures. Buried deep in the center of many cryptochromes is a yellow molecule called flavin adenine dinucleotide (FAD) that, unlike the rest of the protein, absorbs blue light. Embedded among the 500 or so amino acids that make up a typical cryptochrome is a roughly linear chain of three or four tryptophan amino acids stretching from the FAD out to the surface of the protein. Immediately after the FAD absorbs a blue photon, an electron from the nearest tryptophan hops onto the flavin portion of the FAD. The first tryptophan then attracts an electron from the second tryptophan and so on. In this way, the tryptophan chain behaves like a molecular wire. The net result is a radical pair made of a negatively charged FAD radical in the center of the protein and, two nanometers away, a positively charged tryptophan radical at the surface of the protein.

In 2012 one of us (Hore), working with colleagues at Oxford, carried out experiments to test the suitability of cryptochrome as a magnetic sensor. The study used cryptochrome-1, a protein found in Arabidopsis thaliana, the plant in which cryptochromes had been discovered 20 years earlier. Using short laser pulses to produce radical pairs inside the purified proteins, we found that we could fine-tune their subsequent reactions by applying magnetic fields. This was all very encouraging, but, of course, plants don't migrate.

We had to wait almost a decade before we could make similar measurements on a cryptochrome from a migratory bird. The first challenge was to decide which of the six bird cryptochromes to look at. We chose cryptochrome-4a (Cry4a), partly because it binds FAD much more strongly than do some of its siblings, and if there is no FAD in the protein, there will be no radical pairs and no magnetic sensitivity. Experiments in Oldenburg also showed that the levels of Cry4a in migratory birds are higher during the spring and autumn migratory seasons than they are during winter and summer when the birds do not migrate. Computer simulations performed by Ilia Solov'yov in Oldenburg showed that European Robin Cry4a has a chain of four tryptophans—one more than the Cry1 from Arabidopsis. Naturally, we wondered whether the extended chain had evolved to optimize magnetic sensing in migratory birds.

Our next challenge was to get large amounts of highly pure robin Cry4a. Jingjing Xu, a Ph.D. student in Mouritsen's lab, solved it. After optimizing the experimental conditions, she was able to use bacterial cell cultures to produce samples of the protein with the FAD correctly bound. She also prepared versions of the protein in which each of the four tryptophans was replaced, one at a time, by a different amino acid so as to block electron hopping at each of the four positions along the chain. Working with these alternative versions of the protein would allow us to test whether the electrons are really jumping all the way along the tryptophan chain.

We shipped these samples—the first purified cryptochromes from any migratory animal—to Oxford, where Timmel and her husband, Stuart Mackenzie, studied them using the sensitive laser-based techniques they had developed specifically for that purpose. Their research groups found that both the third and fourth tryptophan radicals at the end of the chain are magnetically sensitive when paired with the FAD radical. We suspect that the tryptophans work cooperatively for efficient magnetic sensing, biochemical signaling and direction finding. We also speculate that the presence of the fourth tryptophan might enhance the initial steps of signal transduction, the process by which nerve impulses encoding the magnetic field direction are generated and ultimately sent along the optic nerve to the brain. We are currently conducting experiments to identify the proteins that interact with Cry4a.

One more cryptochrome finding deserves mention here. We compared robin Cry4a with the extremely similar Cry4a proteins from two nonmigratory birds, pigeons and chickens. The robin protein had the largest magnetic sensitivity, hinting that evolution might have optimized robin Cry4a for navigation.

OPEN QUESTIONS

Although these experiments confirm that Cry4a has some of the properties required of a magnetoreceptor, we are still a long way from proving how migratory birds perceive Earth's magnetic field lines. One crucial next step is to determine whether radical pairs actually form in the eyes of migratory birds.

The most promising way to test for radical pairs inside the birds' eyes was inspired by the work of chemists and physicists who, in the 1980s, showed that fluctuating magnetic fields alter the way radical-pair reactions respond to static magnetic fields. Their work predicted that a weak radio-frequency electromagnetic field, fluctuating with the same frequencies as the "singlet-triplet waltz," might interfere with the birds' ability to use their magnetic compass. Thorsten Ritz of the University of California, Irvine, and his colleagues were the first to confirm this prediction in 2004.

In 2007 Mouritsen began similar behavioral experiments in his lab in Oldenburg—with intriguingly different results. During the spring and fall, birds that travel between nesting and wintering grounds exhibit a behavior called Zugunruhe, or migratory restlessness, as if they are anxious to get on their way. When caged, these birds usually use their magnetic compass to instinctively orient themselves in the direction in which they would fly in the wild. Mouritsen found that European Robins tested in wooden huts on his university's campus were unable to orient using their magnetic compass. He suspected that weak radio-frequency noise (sometimes called electrosmog) generated by electrical equipment in the nearby labs was interfering with the birds' magnetic compass.

To confirm that electrosmog was the source of the problem, Mouritsen and his team lined the huts with aluminum sheets to block the stray radio frequencies. On nights when the shields were grounded and functioned properly, the birds oriented well in Earth's magnetic field. On nights when the grounding was disconnected, the birds jumped in random directions. When tested in an unshielded wooden shelter typically used for horses some kilometers outside the city and well away from electrical equipment, the same birds had no trouble detecting the direction of the magnetic field.

These results are significant on several fronts. If the radio-frequency fields affect the magnetic sensor and not, say, some component of the signaling pathway that carries nerve impulses to the brain, then they provide compelling evidence that a radical-pair mechanism underpins the bird's magnetic compass. The main competing hypothesis, for which there is currently much less support, proposes that magnetic iron–containing minerals are the sensors. Any such particles that were large enough to align like a compass needle in Earth's magnetic field would be far too big to rotate in a much weaker field that reversed its direction millions of times per second. Furthermore, the radio-frequency fields that upset the birds' magnetic orientation are astonishingly weak, and we don't yet understand exactly how they could corrupt the directional information available from the much stronger magnetic field of Earth.

It is also remarkable that the birds in the Oldenburg lab were disoriented much more effectively by broadband radio-frequency noise (randomly fluctuating magnetic fields with a range of frequencies) than by the single-frequency fields mostly used by Ritz and his collaborators. We hope that by subjecting migratory songbirds to bands of radio-frequency noise with different frequencies we will be able to determine whether the sensors really are FAD-tryptophan radical pairs or whether, as some other investigators have suggested, another radical pair might be involved.

Many questions about the birds' magnetic compass remain, including whether the magnetic field effects on robin Cry4a observed in vitro also exist in vivo. We also want to see whether migratory birds with genetically suppressed Cry4a production are prevented from orienting using their magnetic compass. If we can prove that a radical-pair mechanism is behind the magnetic sense in vivo, then we will have shown that a biological sensory system can respond to stimuli several million times weaker than previously thought possible. This insight would enhance our understanding of biological sensing and provide new ideas for artificial sensors.

Working to gain a full understanding of the inner navigation systems of migratory birds is not merely an intellectual pursuit. One consequence of the enormous distances migratory birds travel is that they face more acute threats to their survival than most species that breed and overwinter in the same place. It is more difficult to protect them from the harmful effects of human activity, habitat destruction and climate change. Relocating migratory individuals away from damaged habitats is rarely successful because the birds tend to instinctively return to those unlivable locales. We hope that by providing new and more mechanistic insights into the ways in which these extraordinary navigators find their way, conservationists will have a better chance of "tricking" migrants into believing that a safer location really is their new home.

When you next see a small songbird, pause for a moment to consider that it might recently have flown thousands of kilometers, navigating with great skill using a brain weighing no more than a gram. The fact that quantum spin dynamics may have played a crucial part in its journey only compounds the awe and wonder with which we should regard these extraordinary creatures.

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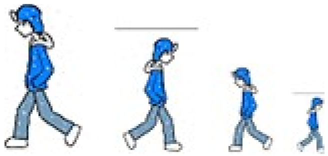
My Walking Thoughts



For June 19 2022

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Beware Electric Bikes?   Sometimes.

Let me start by saying I have no problem with the e-bikes themselves nor for the most part those who operate them…especially those who own them. But…

Once a week or so--more often as the temperature in the Ojai Valley moves into the 'Red' range—I take to the Ventura Beach shoreline with its moderating breezes. There the pathways are filled with packs of pedestrians, dogs, skaters, bicyclists, and Moto GP wannabees on their rented electric stuff…Segways, skateboards, bicycles, and unicycles. On weekends this makes for a madhouse as half of Los Angeles arrives to take part in the fun—who can blame them—and the result can and sometimes does turn a bit ugly.

The the half-mile long central area pathway is generally 20- or more yards wide, enough room to accommodate a dozen interlaced lines of traffic. Tthe pathways on either side of this are narrower…sometimes constricted to five to six feet in width, requiring paradors to pay attention to their surroundings. But not all of them are so inclined.

My 4-mph amble lies about mid-range of the pedestrian parade progress, pedal-powered vehicles about twice that, and the motorized mob can travel three-, four times faster…some as fast as 30 mph, and therein lies a problem.

Like Sunday before last when a woman pushing a baby carriage chose the wrong moment to stop and step into the median to check on her cargo.

“Look …” Smack…”out!”

The silent marauder who at full throttle had whizzed by me 15 seconds or so before nailed the mother, pitching her and the pram into the brush on one side then caromed into an older couple head-on, knocking them both onto the opposite verge.

For a short while the only sounds were those of the traffic on nearby Highway 101. Then screams, the mother and baby on one side, the man and woman on the other…but the e-cyclist? His angst was limited to expletives aimed at pedestrians in general and his victims in particular.

A park ranger was there within minutes, two fire trucks not much later with paramedics to treat the older couple. The mother was shaken but unhurt and by then the baby was giggling.

But the guy on the e-bike? Long gone, perhaps looking for more adventure on a sunny Sunday afternoon among us yokels.

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Another outtake from Phantoms from Vietnam.

When I wrote this snippet I was laying the groundwork on Gordon’s character, but shortly afterward I realized that while it might interest me—perhaps help me with the character development, the effort got in the way of the story itself, so I shelved it.

I wrote quite a bit more on the Nakanos, who in the wake of the Pearl Harbor attack were bundled off to internment camps such as the one at Manzanar near Lone Pine, CA. I’ll share more on this in future Phantoms from Vietnam outtakes.

George Nakano.

One week it was Gordon’s turn to walk to the Nakano’s farm to await the school bus, where he and George would throw rocks at the crows who joined them in their daily ritual. The next it would be George’s turn to make the trek, and their feathered playmates, anticipating the altered venue shifting to the fence rails a mile to the west.

Gordon and George had been doing this for the four years since they started Kindergarten. Now three months into the third grade where they struggled mightily with reading and cursive exercises, their rock-throwing range line had moved from the road verge to the south side of the drainage ditch to “give the birds a chance,” they agreed. If the crows were aware of this sporting concern, they didn’t show it, choosing instead to keep up a steady taunting racket as their part of the event.

Mr. Keller, who drove the school bus was as much a participant as the boys and birds, knowing where they would be when he arrived to transport them to PS 645, the county school system's primary school—grades one through eight. This was important because George's farm was a mile closer to the North-South county road than Gordon's, nominally a minute and a half difference in their boarding time. Mr. Keller's internal clock allowed him to time his arrival to allow the boys a full five minutes of rock-throwing time. If he had a choice in the matter, Mr. Keller would have parked the bus and joined in the fun, but the school board would have looked with disfavor on such behavior.

While the boys might not have known the particulars, they were aware that farming practices in Southern San Joaquin Valley were on the cusp of change—the shift to irrigation—though many, including Uncle Joe and George's father, Ralph, were in no rush to go more deeply in debt than they already were in the face of rising costs.

In defense of increased interest charges, Sam Taylor, branch manager at the Farmers & Cattlemen's Bank in Bakersfield, explained that the culprit was the nation's emergence from the Great Depression.

"More projects chasing scarce dollars," he explained. "It'll settle down before long. By this time next year, the economy should be cooking."

"Hogwash," disagreed Frank Sedge, whose feed store felt the money crunch every bit as much as did his customers. "It's all the stuff we're sending to Europe. They can call it Lend-Lease all they want, but it's paid for by us.

"Besides," he continued, his voice tinged with bitterness at the irony," the more stuff we send to the Brits and Russians, the more the bankers will force us to join the fight so they can recover their money."

"We've got no business getting involved in another European War," Ralph Nakano said, voicing the thoughts of his fellow Deacons of the Calvary Baptist Church at their weekly meeting at Scotty's Corner Restaurant. "Ralph Jr., turns 16 in two months, and he's set to go Cal-Poly over in San Luis Obispo. Let the Brits and Germans kill each other all they want. Just leave us out of it."

"Can't you guys cut out your bitching," Pastor Jacobs pleaded, waving his arms the same way he did from the pulpit every Sunday morning. "Our Thanksgiving celebration was the best I can remember," he reminded the group, "and if Jud Bailey at the Sears store up in Bakersfield is telling the truth, Santa's going to be really busy this year."

Uncle Joe had raised Gordon's weekly allowance from a nickel to a dime at the beginning of the past summer, but the real windfall came at harvest time when his labors added $27.50 to his account at the F&C Bank, bringing his total wealth to $32.76, six cents of which came from interest, Mr. Taylor told him as he handed over the latest deposit slip.

"The more you have in your account, the more interest you earn," he advised with great solemnity. Then shaking Gordon's hand as he would his largest depositor, Taylor added, "The bank thanks you for your trust and support."

Their financial duties completed, Uncle Joe led Gordon and George to the Rexall Drug Store where Mr. Symonds, the proprietor, pharmacist, and sometime soda jerk performed his magic on two scoops of vanilla ice cream bathed in chocolate syrup, a smidgen of what he called his special potion, three squirts of soda water, a ferocious stirring in his blender, the resulting elixir slavered with a generous helping of whipped cream, all topped by a cherry.

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