Ode to E Pluribus Unum for Sunday July 2 2023

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Independence Day 2023

July 4th is an important date in the United States, as it marks the celebration of Independence Day. Here are some facts surrounding July 4th:

July 4th commemorates the adoption of the Declaration of Independence by the Continental Congress in 1776. This document declared the thirteen American colonies as a new nation separate from British rule, forming the United States of America.

Declaration of Independence: The Declaration of Independence was primarily drafted by Thomas Jefferson, with input from other committee members including John Adams and Benjamin Franklin. It outlined the colonies' grievances against British rule and asserted their right to self-governance.

Founding Fathers: The leaders and visionaries who played key roles in the American Revolution and the establishment of the United States are often referred to as the Founding Fathers. Figures such as George Washington, Thomas Jefferson, John Adams, and Benjamin Franklin are remembered and honored on Independence Day.

The Liberty Bell: The Liberty Bell is an iconic symbol of American independence. It is located in Philadelphia, Pennsylvania, and traditionally associated with the ringing of the bell to announce the reading of the Declaration of Independence.

Reflections on Freedom: Independence Day provides an opportunity for Americans to reflect on the principles of freedom, liberty, and democracy that the nation was built upon. It is a time to appreciate the sacrifices made by previous generations and celebrate the values that define the United States.

Historical Events: While July 4th is primarily associated with the Declaration of Independence, other significant historical events have occurred on this date. For example, both John Adams and Thomas Jefferson, who were instrumental in drafting the Declaration, passed away on July 4, 1826, exactly 50 years after its adoption.

American Flags: The American flag, also known as the Stars and Stripes, is prominently displayed on July 4th. Many people decorate their homes, buildings, and public spaces with flags to show their patriotic spirit.

National Anthem: "The Star-Spangled Banner" is the national anthem of the United States. It is often sung or played during July 4th events, symbolizing national unity and pride.

Fireworks: Fireworks displays are a significant part of the July 4th celebrations. Spectacular firework shows light up the night skies in many cities and towns across the United States, accompanied by patriotic music.

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These are just a few facts surrounding July 4th and the significance of Independence Day in the United States. The holiday holds great importance in American history and is a time of national pride and celebration.

Celebrate the Fourth with all your heart. It is the placeholder of our legacy.

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Updated Human Genome Makes it More Equitable and Inclusive

The new pangenome reference is an amalgamation of different genomes from 47 people with ancestry from around the world.

https://bit.ly/3MjJqbG

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World's Fastest Supercomputer Chugs Along in Tennessee

How long before your smartphone will hit 2.0 exaflops?

The US continues to be home to the world's top supercomputer for the second consecutive year, with Oak Ridge National Laboratory's Frontier facility ranking No. 1 in the semiannual list of the world's 500 most powerful systems. Japan's Fugaku system, which held the top spot in the past, remains at No. 2.

Beyond leading the list, the Frontier system, powered by Intel-rival chipmaker AMD, continues to qualify as the first and only true exascale computing platform, capable of performing a billion billion operations per second. The computing power of the system is also believed to be comparable to that of the human brain.

https://youtu.be/dzS6e6Nyvak

The Frontier system has improved by 17% in performance since first entering the list, now reaching 1.194 exaflops, up from 1.02 exaflops—a measure of performance for supercomputers. AMD currently powers four of the top 10 supercomputers, while Intel and IBM power two apiece.

Intel has been working on a two-exaflop Aurora supercomputer, designed for the Argonne National Laboratory, which it aims to be on par with the Frontier system.

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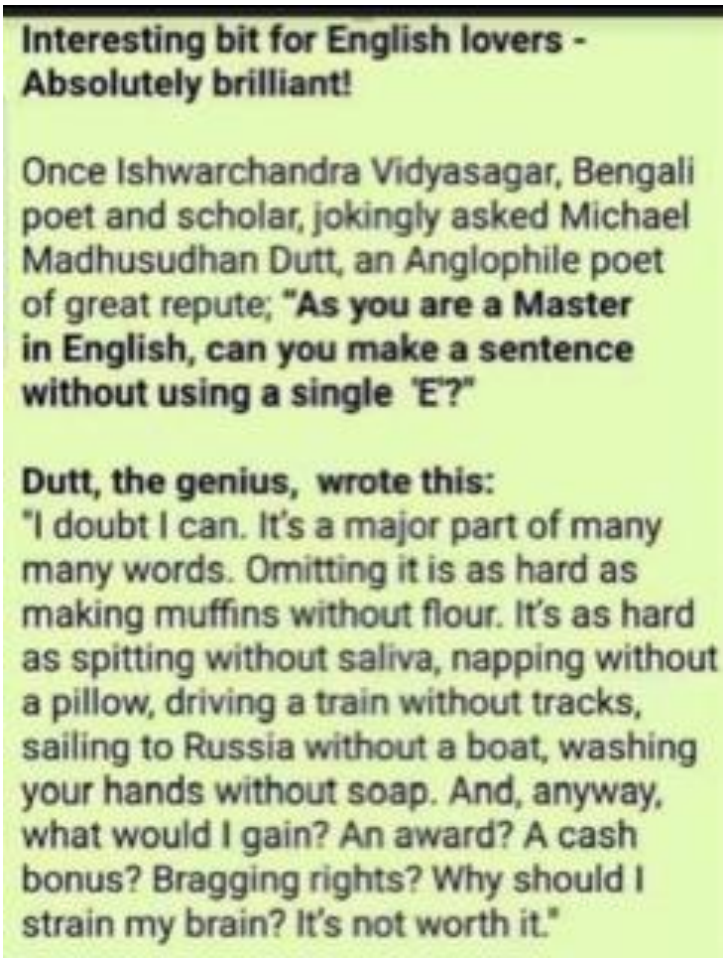

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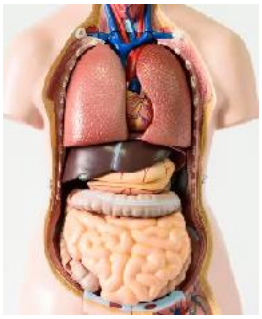
Seven Body Organs You Can Live Without



You can lose large chunks of vital organs and live. For example, people can live relatively normal lives with just half a brain. Other organs can be removed in their entirety without having too much impact on your life. Here are some of the "non-vital organs."

https://bit.ly/43fntkS

I lost my spleen when I was 14 and there's evidence I was born with no brain at all

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Jupiter's Swirls from Juno

NASA/JPL-Caltech/SwRI/MSSS; Processing & License: Kevin M. Gill

Big storms are different on Jupiter. On Earth, huge hurricanes and colossal cyclones are centered on regions of low pressure, but on Jupiter, it is the high-pressure, anti-cyclone storms that are the largest.

On Earth, large storms can last weeks, but on Jupiter they can last years. On Earth, large storms can be as large as a country, but on Jupiter, large storms can be as large as planet Earth.

Both types of storms are known to exhibit lightning. The featured image of Jupiter's clouds was composed from images and data captured by the robotic Juno spacecraft as it swooped close to the massive planet in August 2020. A swirling white oval is visible nearby, while numerous smaller cloud swirls extend into the distance.

On Jupiter, light-colored clouds are usually higher up than dark clouds. Despite their differences, studying storm clouds on distant Jupiter provides insights into storms and other weather patterns on familiar Earth.

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All Butterflies Evolved from Moths in North America

Scientists have revealed how butterflies evolved 100 million years ago and took over the world in a new tree of life.

By Soumya Sagar for Live Science

https://bit.ly/3OFEuk2

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Simulation: A Disk Galaxy Forms

Youtube

How did we get here? We know that we live on a planet orbiting a star orbiting a galaxy, but how did all of this form?

Since our universe moves too slowly to watch, faster-moving computer simulations are created to help find out. Specifically, this featured video from the IllustrisTNG collaboration tracks gas from the early universe (redshift 12) until today (redshift 0).

As the simulation begins, ambient gas falls into and accumulates in a region of relatively high gravity. After a few billion years, a well-defined center materializes from a strange and fascinating cosmic dance. Gas blobs -- some representing small satellite galaxies -- continue to fall into and become absorbed by the rotating galaxy as the present epoch is reached and the video ends.

For the Milky Way Galaxy, however, big mergers may not be over -- recent evidence indicates that our large spiral disk Galaxy will collide and coalesce with the slightly larger Andromeda spiral disk galaxy in the next few billion years.

https://youtu.be/X4UF9Akman0

Video Credit: TNG Collaboration, MPCDF, FAS Harvard U.; Music: World's Sunrise
(YouTube: Jimena Contreras)

Make sure and have your smartphone ready to capture the coalescence.

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Neptunia and the World of Seagrass

Today, we're on a work call talking about Blue Carbon, the term for carbon captured by the world's ocean and coastal ecosystems. We're discussing how to best communicate the nuances of seagrass science to the world. How to communicate the importance of these seagrass meadows, and their variety, without oversimplifying the story. A constant challenge for any science communicator.

Dr Richard J. Lilley, and photographs by Dr Dimitris Poursanidis for Oceanographic

https://bit.ly/42ZfdEX

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Cargo Carrier Gets Drone Delivery Approval

Cargo airline Ameriflight has been given the go-ahead by the FAA to integrate drones into its operations and says it will soon be offering drone deliveries throughout the U.S. "Moving forward with the future of our newly operative UAS division allows us to expand into a largely untapped delivery market with a lot of room for speed and safety logistic improvements," said company owner Jim Martell. The drones will be used to drop off high-priority shipments of small packages in urban and suburban areas. The first shipments will be medical samples and pharmaceuticals.

The company says the drone operation is an expansion and will not affect the crewed side of the business, which uses about 100 aircraft. The drones are made by Matternet and will be controlled from a central facility. The drones were type certified by the FAA in September of 2022 after a four-year review. The quadcopter can carry 4.4 pounds about 12 miles and is in constant contact with the central control facility and cloud-based software system that creates all the routing and flight profiles. It's not a beta test. "This partnership enables us to offer our customers turnkey access to fast and reliable on-demand delivery capabilities today. This is not a test program or a future deployment concept—this is the real, scalable, and safe drone-based solution that customers are looking for."

By Russ Niles for AVweb

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Flash Mob - Wayzata Symphony Orchestra and Edina Chorale

The Wayzata Symphony Orchestra and the Edina Chorale performed a flash mob performance of Beethoven's Ode To Joy on November 16, 2015 at the IDS Crystal Court in downtown Minneapolis, Minnesota, USA.

https://youtu.be/cIiTdsvCjYo

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Homo Naledi Buried Their Dead at Least 100,000 Years Before Homo Sapiens

Exploration team members navigate the narrow chutes leading to the Dinaledi Chamber of the Rising Star cave in South Africa, where fossil elements belonging to Homo naledi were discovered.

https://bit.ly/3qsl7kl

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The 2023 Milky Way Photographer of the Year Competition

The scenery I wanted to see--Mitsuhiro Okabe

Modern cameras can capture vibrant details and colors in the night sky beyond what our eyes can see. However, what really matters in any great image is the photographer behind the camera, who provides the idea, plan, and creativity to bring the image to life.

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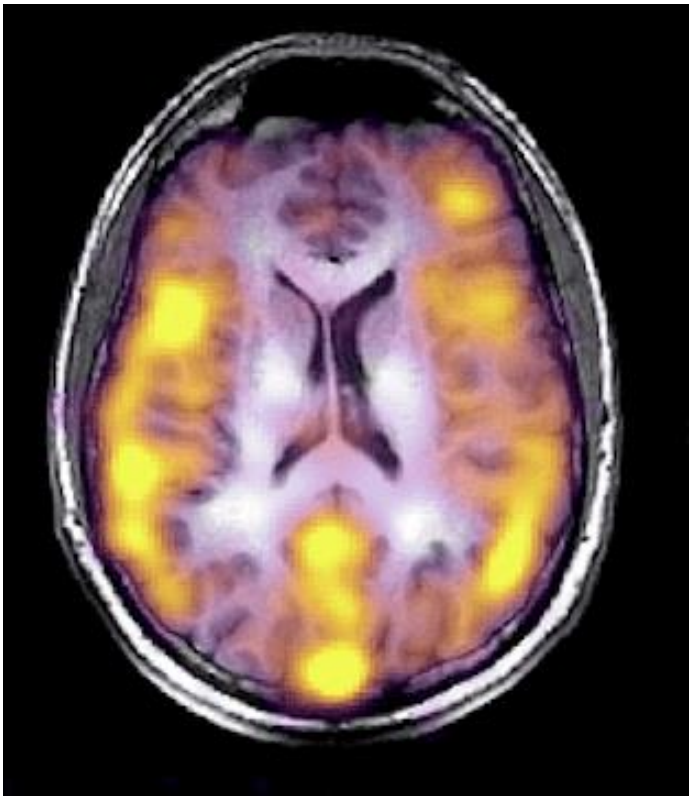
Dynamic Nuclear Polarization Is Transforming Medical Imaging



A brain scan using an experimental technique known as "dissolution dynamic nuclear polarization" (d-DNP). This process can greatly improve the images produced using magnetic-resonance imaging (MRI).
(Courtesy: James Grist et al 10.1016/j.neuroimage.2019.01.027)

An experimental technique that started life in nuclear and particle physics is now being used to measure chemical reactions inside the human body and to help diagnose cancer and heart disease in almost 50 clinical trials. Jack Miller charts the unexpected rise of dynamic nuclear polarization, which is vastly improving the quality of magnetic resonance imaging

https://bit.ly/45RUbuy

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Beautiful Castles

Prague Castle, Czech Republic

https://bit.ly/3o4b5Fy

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Hyperion XP-1 Is a 221-MPH Hydrogen-Powered Hypercar

The XP-1 is claimed to go from zero to 60 mph in 2.2 seconds, but it's really a hook for a much bigger story: hydrogen infrastructure.

Hyperion plans to address the infrastructure problem first, building its own fueling stations in something akin to Tesla's Supercharger network. Except Hyperion won't need as many stations, because Hyperion says the XP-1 offers more than 1000 miles of range (1016 miles, at a mix of 55 percent city and 45 percent highway driving). Squeezing more range out of batteries is an incremental process; to double the range of a fuel-cell car, you just use a bigger tank. That's just one of the advantages that Kafantaris hopes will help convince the general public that hydrogen is the best battery out there.

https://bit.ly/3WdqhN9

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Photographic Project Documenting Ecologically Unique Areas

Words and photographs by Samantha Schwann

Cocos is a hive for an abundant and diverse array of marine life, both endemic and migratory. Occasionally referred to as "Shark Island", it contains the highest density of apex predators within the Eastern Tropical Pacific. More than 4,700 marines species have been recorded in its waters to date, including tuna, marlin, manta, dolphin, whales, and 30 varieties of coral.

https://oceanographicmagazine.com/features/cocos-island-ocean-corridors/

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U.S. Navy Selects Students For 2023 Summer Flight Academy

Photo: Vulcanair

The U.S. Navy has chosen 28 high school students from across the country to attend its eight-week 2023 Summer Flight Academy aviation program. The program includes approximately 40 hours of flight training in either a Vulcanair V.10 or Piper Warrior as well as aviation-oriented classroom work. Students selected for the academy, which was established in 2021 by Commander, Naval Air Forces (CNAF), attend for free with no obligations to the military.

"The primary goal of the CNAF Flight Academy is to expose diverse, young talent to Naval Aviation, and inspire them to join the profession," said CNAF Operations Officer for Diversity, Equity, and Inclusion, and CNAF Flight Academy Program Manager Lt. Olivia Barrau. "For these motivated students, flying a plane and completing this program can empower them to consider Naval Aviation as a viable career choice. While we hope all our Cadets join Naval Aviation, we proudly contribute to their dreams of becoming aviators in any capacity."

Academy students finish the program with a private pilot certificate and college credit from Delaware State University (DSU), Elizabeth City State University (ECSU) or D2 Aviation School. According to the Navy, around 70 percent of the Summer Flight Academy's alumni are now directly affiliated with the U. S. military. The program is estimated to cost approximately $26,000 per student.

By Kate O'Connor for AVweb

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NASA Simulated Flight Through Jupiter's Great Red Spot

NASA

The most famous storm in the solar system is also one of the largest: Jupiter's Great Red Spot. The storm is just a blemish on Jupiter, but if you compare it to the size of Earth — this storm could swallow our entire planet whole. In July, NASA Juno spacecraft flew over the spot and NASA then used that data to produce a simulated flight through the Great Red Spot. Following is a transcript of the video.

NASA's Juno spacecraft is orbiting Jupiter. Recently, it flew over Jupiter's famous Great Red Spot. The Great Red Spot is a giant storm 1.3X the size of Earth that's been raging for hundreds of years. As Juno flew over the swirling vortex, it measured the storm's temperature and depth.

NASA then used Juno's data to produce this simulation of what it would be like to fly into this massive storm. The storm is 50 to 100X deeper than Earth's oceans. As you dive deeper into the atmosphere the temperature increases.

"The warmth of the spot's base explains the ferocious winds we see at the top of the atmosphere," said Andy Ingersoll, Juno co-investigator in a NASA statement.

Wind speeds are greater than Earth's most powerful hurricanes. So, it's best that Juno keep its distance and simply enjoy the view from afar.

https://youtu.be/U_nBW2eJFfE

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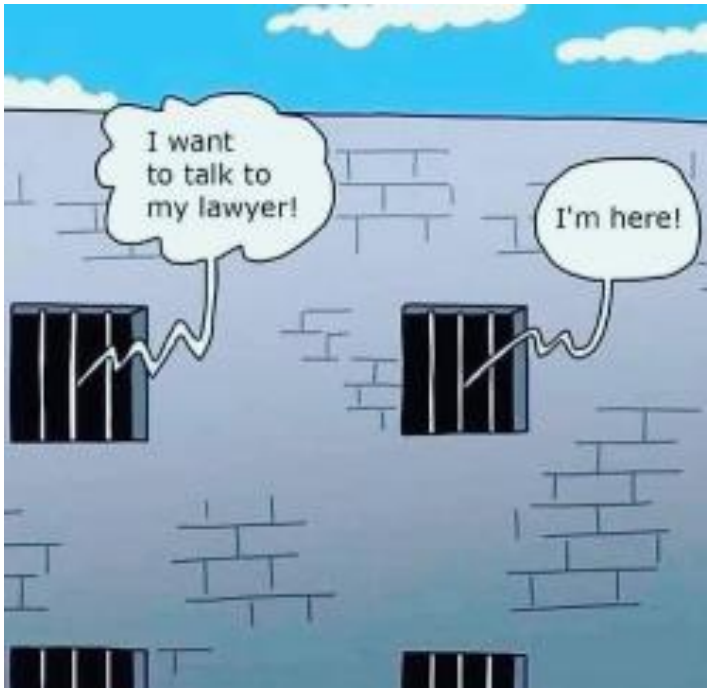

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Octopuses Rewire Their Brains to Cope with Drops in Temperature

A new study adds temperature-induced RNA editing to the list of things you didn't know these clever creatures could do.

Octopus bimaculoides can edit its RNA in response to changing temperature.
Image credit: charlotteseid via iNaturalist (CC BY-NC 4.0)

Everyone’s favorite smart, sentient "aliens" just got a whole lot weirder: Octopuses are able to recode proteins in their nerve cells to protect their brains from changes in temperature, new research has revealed. When things get chilly, the canny cephalopods tinker with their RNA – the messenger molecule between DNA and protein production – ensuring neurological activity can be maintained.

"We generally think that our genetic information is fixed, but the environment can influence how you encode proteins, and in cephalopods this happens on a massive scale," senior author Joshua Rosenthal of The University of Chicago's Marine Biological Laboratory said in a statement.

"RNA recoding gives organisms the option to express a diverse quiver of proteins when and where they choose. In cephalopods, most of the recoding is for proteins that are really important for nervous system function, so the natural question is, are they using this to acclimate to changes in their physical environment?"

Unlike mammals, which can generate their own body heat in response to temperature changes, octopuses don’t thermoregulate. This means that fluctuations in temperature, such as when they're diving or with changes in season, pose a threat to their survival, rendering the ability to adapt essential. RNA editing offers octopuses a temporary and flexible way of achieving this, allowing them to produce different neural proteins in warm and cool environments.

The discovery of RNA editing in cephalopods is not new – it was first documented in squid in 2015 and, later, octopuses – but the purpose of it has remained a mystery.

“A big question for us was, ‘What are they using it for?’” Rosenthal said in another statement.

To investigate, the team acclimated wild-caught California two-spot octopuses (Octopus bimaculoides) to warm or cool temperatures. Two to three weeks later, they examined their RNA, finding that editing had occurred at over 20,000 sites.

“This is not something that happens here or there; this is a global phenomenon,” said co-senior author Eli Eisenberg of Tel-Aviv University. “But that being said, it does not happen equally: proteins that are edited tend to be neural proteins, and almost all sites that are temperature sensitive are more highly edited in the cold.”

Follow-up experiments revealed that RNA editing occurs surprisingly quickly: cold-induced editing was seen within hours, significant changes in less than a day, and a steady state was reached within four days.

The team also looked into the effect of all this on the function of two proteins, kinesin-1 and synaptotagmin, both of which play an important part in nervous system function.

RNA editing, they found, altered the rate of kinesin-1 movement, and disrupted the responsiveness of synaptotagmin.

A fourth and final experiment demonstrated that RNA editing in response to temperature occurs in wild octopuses too, following seasonal temperature changes. This was reported in the California two-spot octopus, as well as Verrill's two-spot octopus (Octopus bimaculatus), and the researchers believe it to be widespread among other octopus species and squid.

RNA editing in response to temperature change joins a long list of things you didn't know these clever creatures could do, from having nightmares to creating incredible sites known as "Octopolis" and "Octlantis". It could also help explain other facets of their behavior, including their ability to camouflage and solve puzzles.

"I think it's the tip of the iceberg," Rosenthal added.

Author Maddy Chapman published in the journal Cell.

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Boeing's Starliner, Snarled by Snafus, Delays Launch (Again)

A brief history of the aviation giant's attempts to enter orbit.

NASA/Getty Images

Aviation giant Boeing might be king of the skies, but when it comes to space, it's struggling to get off the ground.

Boeing announced at a NASA press conference on June 1 that it hit another snag in the development of its Starliner spacecraft that threatens to significantly impair its operational timeline.

Boeing said that the Starliner capsule was hit with a double whammy of issues. The first is related to the safety of its parachute system, which a subcontractor informed Boeing could fail at limits much lower than originally tested.

The second problem is with tape that is used throughout Starliner, which Boeing discovered to be flammable.

The snafus are a major setback for Starliner, which had its first crewed flight test scheduled for July 21, when it would take two NASA astronauts to the International Space Station.

These two issues delayed Starliner's crewed flight test past its planned July launch (which was already delayed from April).

Boeing won nearly $5 billion in contracts to develop Starliner under NASA's Commercial Crew Program, but hasn't successfully launched any of its contracted missions. (Competitor SpaceX, meanwhile, is on target to launch all six of its contracted NASA missions.)

And this isn't the first time that Boeing's Starliner program has encountered roadblocks.

Software malfunctions in 2019 affected its first uncrewed flight test and earlier this year, the company was looking to potentially redesign Starliner's propulsion valves, which were identified as a problem last summer, and, when faulty, could affect the spacecraft's movement.

So far, Starliner's development has been marred by cost overruns, with Boeing stating in its Q2 2022 earnings that the program had cost nearly $700 million more than originally expected. That number has since increased to over $833 million.

Mark Nappi, Starliner manager and Boeing VP, said that Boeing is "still committed" to completing the work on Starliner, CNBC reported. But Boeing is running out of time to complete the missions before the ISS is decommissioned in 2030.

Nappi said it is "feasible" that Boeing could have a crewed flight test for Starliner in 2023 but didn't commit to a timeline.

By Jordan McDonald for Tech Brew

I try to avoid contentious commentary, but both Boeing's and NASA's performance in the Starliner fiasco has gone far beyond even the sublime, leading me to wonder how much longer Congress should put up with the continuing failures and cost overruns that read more like black humor than serious attempts to move forward with manned space flight.

This article from Tech Brew talks about Boeing's space failures but one has but to look at the company's record of military and commercial disasters in order to question the company's and NASA's ability to manage such complex and expensive programs.

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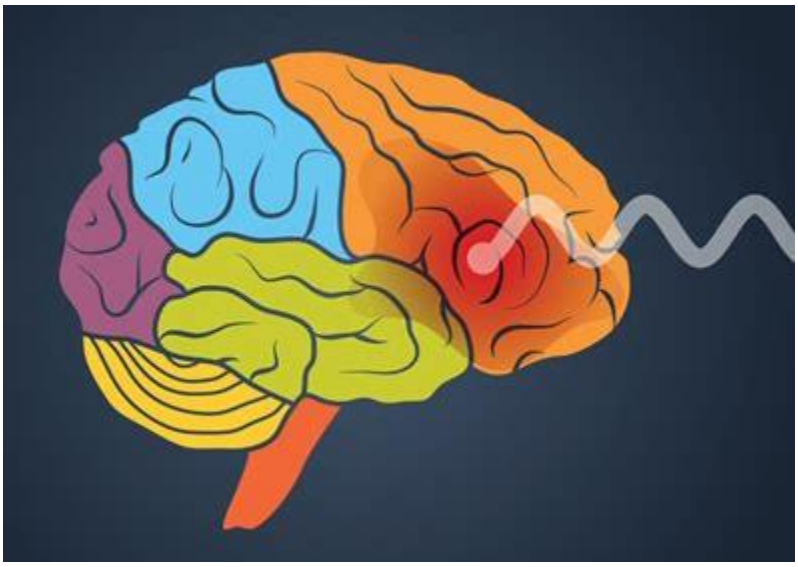
Why the Human Brain Loves Opioids



Pain and pleasure rank among nature's strongest motivators, but when mixed, the two can become irresistible. Here is the science behind how opioids brew a perfect addiction in the brain.

https://youtu.be/fVdXlB89QOA

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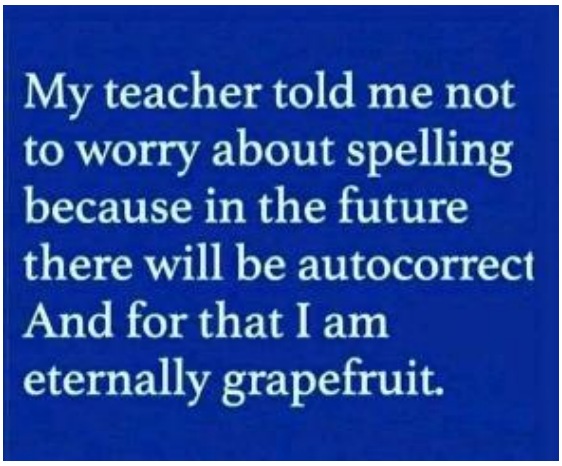

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How Psychedelic Drugs Achieve Their Potent Health Benefits

Mouse studies suggest that drugs from LSD to ecstasy renew the brain's flexibility — but some scientists are skeptical.

Crystals of the psychedelic drug MDMA, also called ecstasy, which restores the ability of mice to learn from certain aspects of their environment.
Credit: Police Scotland/Contraband Collection/Alamy

Psychedelic drugs are promising treatments for many mental-health conditions, but researchers don't fully understand why they have such powerful therapeutic effects. Now, a study in mice suggests that psychedelics all work in the same way: they reset the brain to a youthful state in which it can easily absorb new information and form crucial connections between neurons1.

The findings raise the prospect that psychedelic drugs could allow long-term changes in many types of behavioural, learning and sensory system that are disrupted in mental-health conditions. But scientists caution that more research needs to be done to establish how the drugs remodel brain connections.

The study was published on 14 June in Nature.

Short trip, long benefits

Psychedelics such as MDMA (also known as ecstasy), ketamine and psilocybin — the active ingredient in magic mushrooms — are known for producing mind-altering effects, including hallucinations in some cases. But each compound affects a different biochemical pathway in the brain during the short-term 'trip', leaving scientists to wonder why so many of these drugs share the ability to relieve depression2, addiction and other difficult-to-treat conditions in the long term.

Gül Dölen, a neuroscientist at Johns Hopkins University in Baltimore, Maryland, and her colleagues sought answers by studying how psychedelics affect social behaviour in mice. Mice can learn to associate socializing with positive feelings, but only during an adolescent 'critical period', which closes as they become adults.

The scientists trained mice to associate one 'bedroom' in their enclosure with mousy friends and another room with solitude. They could then examine how psychedelics affected the rodents' room choices — a proxy for whether the drug affects the critical period.

Sociable mice

Dölen's team had previously found3 that giving MDMA to adult mice in the company of other mice reopened the critical period, making the MDMA-treated animals more likely to sleep in the social room than were untreated mice. This was not surprising: MDMA is well known for promoting bonding in some animals and in humans.

For their new paper, the researchers gave adult mice either MDMA or one of four psychedelic drugs not known to promote sociability: ibogaine, LSD, ketamine and psilocybin. Mice that received any of the psychedelic drugs were more likely to choose the social room than untreated mice, suggesting that each of the drugs could reopen the critical period.

But mice did not prefer the social room if given enough ketamine to make them unconscious and therefore unaware of their companions. This suggests that the drugs only open the social critical period if they are taken in a social context. Each drug opened the critical period for a different length of time, ranging from one week for ketamine to more than four weeks for ibogaine.

Next, the team looked at the animals' brains. They found that in certain brain regions, neurons had become more sensitive to the 'love hormone' oxytocin. Dölen suspects that the drugs confer a state called metaplasticity on the neurons, making the cells more responsive to a stimulus such as oxytocin. This state makes them more likely to rewire and form new connections that would indicate the neurons were responding. The neurons also started expressing genes involved in regulating a protein matrix on their surface. Modifying this matrix, Dölen says, could free the neurons' branches to grow and find new connections.

Drugs that hold the key?

Dölen argues that psychedelics function as a master key that can unlock many kinds of critical period — not just one for sociability — by bestowing metaplasticity on neurons. The end result depends on the context in which the drugs were taken: the level of social engagement, in this case. The results indicate, she says, "that there's some mechanistic relationship between critical period opening and that altered state of consciousness that's shared by all psychedelics".

Takao Hensch, a neurologist at Harvard University in Cambridge, Massachusetts, says the paper is "pioneering" in finding biological mechanisms for how psychedelic drugs work. "It gives hope that [critical periods] are not irreversible and a very careful cellular understanding of psychedelic drugs might hold the key to reopening brain plasticity," he says. He adds that social behaviour is very complex and that the drugs' effects should be studied in other brain regions.

David Olson, a biochemist at the University of California, Davis, is sceptical. The drugs, he says, could be changing physical connections between neurons in certain parts of the brain, rather than inducing metaplasticity that makes the neurons more open to influence by environmental stimuli.

Dölen is now testing whether the psychedelic drugs can reopen other types of critical period, including those for the motor system. Reopening it, she says, could lengthen the amount of time that people who have had strokes can benefit from physical therapy, which currently works only in the first few months after a stroke.

I too am skeptical.

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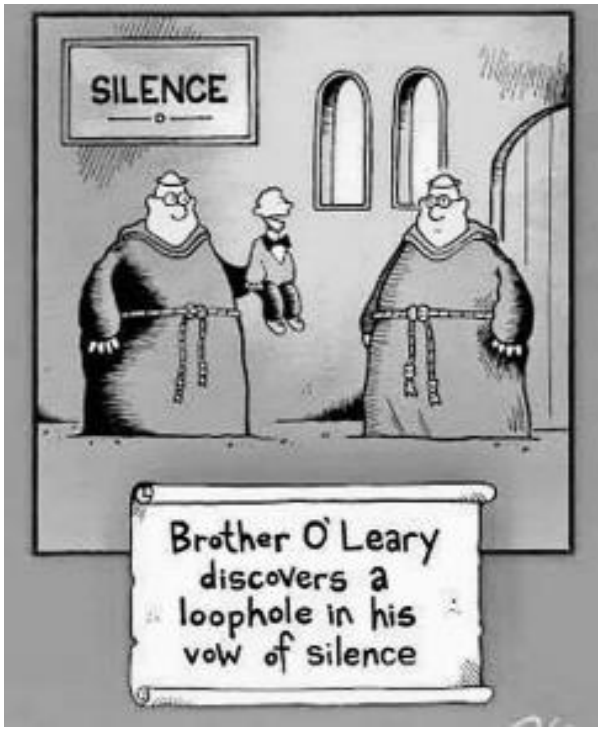

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The Evolutionary History of the Brain

Despite advances in neuroscience and genetics, the question of why the brain evolved remains elusive. But Feldman Barrett's fascinating exploration of the brain's evolution offers insights into the most important functions of this complex organ, and invites us to think more deeply about the origins of our own intelligence.

https://bit.ly/43VYFP4

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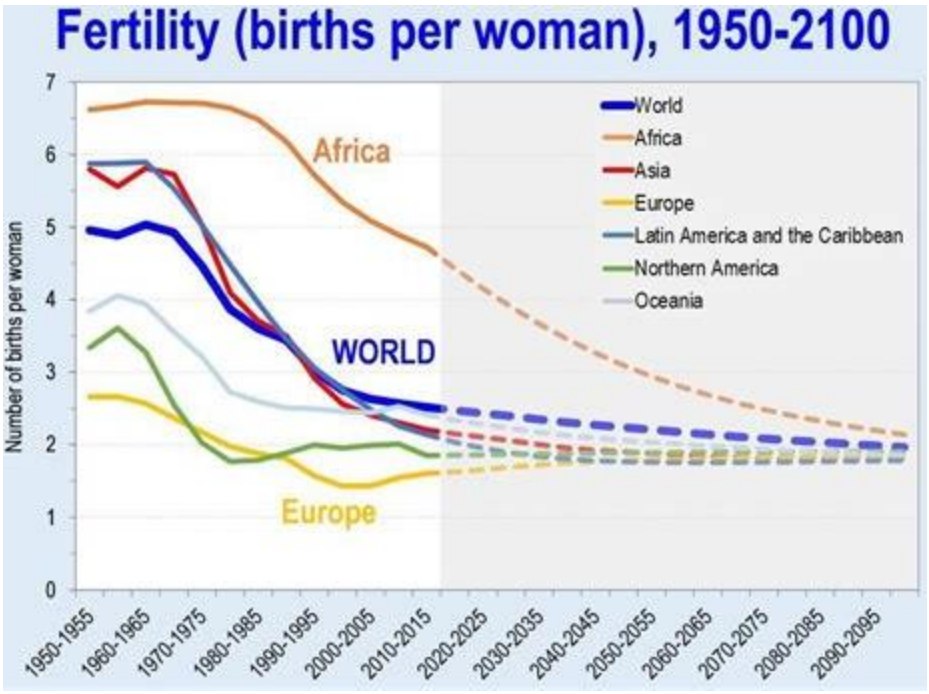
The Rapid Decline of Global Birth Rates



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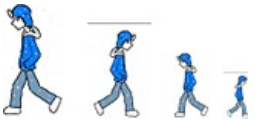
My Walking Thoughts



For Sunday July 2 2023

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Chaos in the Classroom: Sooner and More (Cont.)

This is the Third of the Walking Thoughts series on Chaos Theory, looking at what it is, its emerging impact on how you and I see the world, and eventually why it's important to incorporate its lexicon and visions into our educational DNA quickly and at the lowest possible level.

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Before I start, I need to ask for your thoughts.

I began this series on Chaos Theory (CT) on June 13th stating that we need to look for ways to find ways to incorporate its features and lexicon into primary and secondary curricula as soon as possible.

Last week's edition embarked on the exploration of CT's history and major themes beginning with the Lorenz Attractor representing the behavior of a simplified model of atmospheric convection that became the lodestone in the development of chaos theory. I've become used to receiving differing levels of response ranging from several to 'a bunch,' but this time nothing…nada, and I'd like to know why.

Do you find the topic too remote? Too esoteric? Not worth your time? Since I intend to pursue it for several more weeks, it would help me to know your thoughts. Anyway, onward and upward into the realm of the irrational.

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Nonlinear dynamical systems: Opening up new fields of study

In the 1960s and 1970s, mathematicians and physicists continued the exploration of nonlinear systems leading to the concept of "strange attractors," geometric structures that are the hallmark of chaotic systems.

Dutch mathematician, Floris Takens, determined that under certain conditions, a dynamical system's attractor can be reconstructed from a single observed variable or time series data. This technique known as time delay embedding, helped establish the fundamental link between chaos theory and the existence of strange attractors.

The American mathematician and physicist. Mitchell Feigenbaum, best known for his discovery of universal scaling laws, found that as a system undergoes successive period doublings, the bifurcation points approach fixed ratios known as the Feigenbaum constants ($\alpha \approx 2.5029$ and $\delta \approx 4.6692$). Rather than trying to explain this myself, I'll turn you over to an interesting and informative video: *The logistic map connects fluid convection, neuron firing, the Mandelbrot set and so much more.* https://youtu.be/ovJcsL7vyrk

Feigenbaum's research on universality, scaling laws, and bifurcations not only advanced the understanding of chaotic systems, but established connections between seemingly unrelated phenomena, highlighting the presence of universal features in chaos.

Nonlinear dynamical systems exhibit several distinctive features that differentiate them from linear systems. These features contribute to the complex and often unpredictable behavior observed in nonlinear systems. Here are some key features of nonlinear dynamical systems:

Sensitivity to Initial Conditions: (We covered this last week, here we put into into perspectiive) Nonlinear systems are highly sensitive to initial conditions. Even tiny variations in the starting conditions can lead to significant differences in the system's behavior over time. This phenomenon, known as the butterfly effect, implies that small uncertainties or errors in measurements or inputs can result in divergent outcomes.

Complex Trajectories: Nonlinear systems can produce complex trajectories in their state space. The trajectories may exhibit irregular patterns, oscillations, bifurcations, and other non-repetitive behaviors. The system's behavior may be highly intricate and difficult to predict, even with precise knowledge of the system's equations.

Attractors: (Today's focus) Nonlinear systems often have attractors, which are stable states or patterns that the system tends to converge to over time. Attractors can be fixed points, limit cycles, or strange attractors characterized by intricate, fractal-like structures. Strange attractors represent long-term, non-periodic behavior associated with chaotic systems.

Bifurcations: Nonlinear systems can undergo bifurcations, which are qualitative changes in their behavior as system parameters are varied. Bifurcations can lead to the creation or destruction of attractors, the emergence of new periodic or chaotic behaviors, or the transition between different dynamic regimes.

Nonlinearity and Feedback: Nonlinear systems involve nonlinear relationships between the system's variables and their rates of change. Nonlinearity can arise from interactions, feedback loops, threshold effects, or other nonlinear mechanisms. Feedback, in particular, can give rise to rich and complex dynamics in nonlinear systems.

Self-Organization: Nonlinear systems can exhibit self-organization, where complex patterns or structures emerge spontaneously from the interactions among the system's components. Self-organization often leads to the formation of coherent structures, such as waves, patterns, or spatial organization, without explicit external control or design.

Emergence of Chaos: Nonlinear systems can exhibit chaotic behavior, characterized by extreme sensitivity to initial conditions, aperiodic trajectories, and unpredictability. Chaotic systems exhibit long-term irregular behavior, even though they are deterministic and governed by precise equations.

Understanding and analyzing nonlinear dynamical systems require specialized mathematical and computational tools, such as differential equations, numerical simulations, bifurcation analysis, and chaos theory. These features make nonlinear dynamical systems a fascinating and challenging area of study with applications across various scientific disciplines.

So, what does this do for us?

Here are some ways in which an understanding of nonlinear dynamical systems is meaningful:

1. Prediction and Control: By studying the underlying dynamics and patterns, we can gain insights into their behavior and make predictions about their future states.

This knowledge can then be applied to control systems, weather forecasting, financial markets, and other domains where accurate predictions and control are crucial.

2. Explaining Natural Phenomena: Nonlinear dynamical systems help us comprehend phenomena such as population dynamics, climate patterns, biological rhythms, and the behavior of physical systems. *By studying nonlinear dynamics, we can gain a deeper understanding of the underlying mechanisms driving these phenomena.*

3. Design and Optimization: By considering the nonlinear behavior of a system, engineers and designers can anticipate and account for potential instabilities, bifurcations, or chaotic behavior. *This understanding can lead to improved system performance, robustness, and efficiency.*

4. Resilience and Adaptability: Understanding the dynamics of complex systems allows us to identify critical thresholds, tipping points, or vulnerabilities. *This knowledge can inform strategies for building resilient systems, managing ecosystems, and addressing socio-economic challenges.*

5. Emergent Properties and Self-Organization: Nonlinear systems give rise to emergent properties and self-organization. *Understanding these phenomena can inspire innovative approaches in fields such as artificial intelligence, robotics, and optimization algorithms.*

6. Interdisciplinary Insights: Nonlinear dynamics provides a common framework for studying complex phenomena across various scientific fields. *It fosters collaboration and cross-pollination of ideas between different disciplines, leading to new insights, discoveries, and technological advancements.*

Overall, an understanding of nonlinear dynamical systems enhances our ability to comprehend and navigate the complexity and uncertainty present in many aspects of the natural world and human-made systems. It empowers us to make better predictions, design more efficient systems, manage resources more effectively, and tackle complex challenges across diverse domains.