PULSE Science magazine

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ANEMIA IN SPACE

Health difficulties of long-term space travel

DEPRESSION

A possible vaccine for trauma





Image source: National Geographic, 2017

ANEMIAINSPACE

Anemia in astronauts has been observed since the earliest space flights, however the reasons behind anemia in space flight were unknown. New research has shown that space flight is related to consistently elevated levels of the products of hemoglobin breakdown, by around 50%, in 14 astronauts during the course of their 6-month missions on the International Space Station. On Earth, around 2 million red blood cells are being destroyed every second but scientists estimate that this is increased to around 3 million every second for astronauts in space. One year after landing, erythrocytic effects such as increased hemolysis, reticulocytosis, and hemoglobin levels persisted. These findings suggest that the destruction of red blood cells, known as hemolysis, is a primary effect of microgravity in space flight, and they support the hypothesis that "space anemia" is a hemolytic condition that should be taken into account in the screening and monitoring of both astronauts and passengers. In a study conducted, of the 13 astronauts shows the red blood cell mass levels return to normal 3 to 4 months after return. However, their bodies were destroying up to 30% more red blood cells up to a year after re-entry hinting that there were more severe, long-term effects of "space anemia".

As humans look to the stars, it is vital for us to consider the implications of space travel and the toll it takes on our bodies when traveling through space. Due to the weightless nature of space, astronauts often don't notice the effects of anemia until they land again and gravity takes effect once more. There is evidence that the length of time you spend in space affects the severity of your anemia but this is still in the research phase and requires the collection of much more data. This means that long distance travel and long stays in space on the Moon or Mars or even space tourism requires a greater understanding of the physiological impacts of outer space on our bodies, including anemia. Red blood cell management will be essential for manned missions due to the impact of anemia on a person's overall fatigue and physical capabilities and is another element to consider in the recruitment of astronauts. Fortunately, none of these examined astronauts suffered the typical anemic symptoms such as fatigue or hunger. This suggests that their red blood cell production values were also increased for the duration of the space. However, for this increase in red blood cell production to take place, the astronaut's diet needs to be sufficiently nutritious. Space anemia is just a challenge in a long line of struggles that we need to overcome if we wish to someday become an interplanetary species; as testament to how much work we still have ahead of ourselves.

AUTHOR: Rohan Janaki

SOURCE: Trudel, G. et al. (2022) "Hemolysis contributes to anemia during long-duration space flight," Nature medicine, 28(1), pp. 59–62. doi: 10.1038/s41591-021-01637-7.



WHY ARE ALL SNOWFLAKES UNIQUE?

Wilson Bentley, an American meteorologist, captured over 5,000 photographs of snowflakes, all of which had their own unique pattern and shape. Snowflakes are single ice crystals that form through a process called nucleation, where water molecules join together around a small particle. The supercooled cloud water droplets form the crystal form when frozen. The humidity of the atmosphere and temperature are major factors that contribute to a snowflakes pattern and shape. Since every snowflake will be formed at a slightly different condition, the probability of 2 snowflakes having the exact same shape is extremely low, to a point where most considered impossible.

Snowflakes owe their hexagonal shape to the way in which they formed. Water molecules in the solid state are able to form hydrogen bonds with other water molecules. Water is made from an oxygen atom and 2 hydrogen atoms, which will form a polar covalent bond, in which the electrons are shared unevenly between the molecules. Since oxygen is much more electronegative than hydrogen, the electrons will be more attracted to the oxygen atom than to the hydrogen atoms, hence forming a partial positive and partial negative charge around the hydrogen and oxygen atoms respectively. The oxygen with a partial negative charge on one molecule will attract the hydrogen with a partial negative charge on another molecule, and the molecules will slowly begin to pivot so that the opposite charges pair up. The shape that tends to form from this process is a hexagonal shape as water molecules arrange themselves in a lattice structure.



AUTHOR: Janaine Ho

SOURCE: earthsky.org/earth/how-do-snowflakes-get-their-shape/ www.loc.gov/everyday-mysteries/meteorology-climatology/item/i s-it-true-that-no-two-snow-crystals-are-alike/ www.sciencenewsforstudents.org/article/how-snowflake-made

INOCULATION AGAINST DEPRESSION

When studying disease and illnesses, doctors and scientists usually look for two things: how to cure the disease, and how to prevent it. However, with mental illnesses, we have neither: while medication for mental conditions certainly exists, these merely suppress symptoms and do not cure the illness. Selective serotonin reuptake inhibitors (SSRIs), for example, are a common class of antidepressants that increase serotonin levels in the brain. While these can make an individual more responsive to other forms of treatment, (for example Cognitive Behavioural Therapy), they are not a cure to depression and other related mental health conditions, as the root cause of these conditions cannot be solely attributed to a low level of serotonin. Nevertheless, the pharmaceutical industry has concentrated greatly on perfecting these types of drugs, instead of seeking to prevent the illnesses from occuring in the first place.

Eight years ago, Rebecca Brachman stumbled upon a drug that appeared to protect against the detrimental effects of acute or chronic stress – a potentially paradigm-shifting discovery opening up a new field of preventative psychopharmacology, aptly named for its exploration of pharmaceutical drugs that aim to prevent psychological conditions. Brachman named her new class of drugs "alexigents" – from the Greek alexo, meaning "to protect.", and while scientists still are unaware of the biochemical causes of depression and trauma, they have found a strong relationship between developing both depression and PTSD and the body's capacity to handle stress: its stress resilience. Brachman defines stress resilience as 'the ability to recover from a stressful experience, for the body to bounce back to homeostasis'. Stress resilience encompasses more than just an absence of risk factors (for example a genetic predisposition or environmental exposure in childhood), but rather involves a separate, active biological process – which also means we might be able to enhance it."

However, a lot of misconception still surrounds the idea of depression and other mental illnesses, and possible treatment. Stress hormones, such as cortisol are commonly thought as purely negative; as a hindrance to both mental and physical health. Yet stress hormones are an integral part of the body's self-protective response. Brachman explains that cortisol makes resources, like sugar and oxygen available to the body and increases blood pressure. Stress hormones like cortisol also keep the immune system in check. Cortisol and other compounds have a multitude of applications in the healthcare and pharmaceutical industry, and are commonly used in over-the-counter anti-inflammatory creams and asthma inhalers, and even to treat severe COVID-19.

Thus, alexigents do not aim to prevent the stress response from taking place: they don't stop an individual from experiencing stress. Alexigents boost the body's stress resilience in order to limit any long-term effects from stress, like conditions such as depression and PTSD. Stress is still a necessary biochemical process in the body – alexigents

"Take the pandemic, for example," says Brachman, "the effects of chronic traumatic stress have been devastating, especially in healthcare workers and vulnerable populations. Imagine the impact if we could prevent even a fraction of these cases." Alexigents could save public services millions in subsequent medical costs, as well as save families the grief and emotional costs that comes from mental illness and suicide.

AUTHOR: Danica Ling G9

SOURCES: Eng, K., 2022. A scientist explores: What if we could inoculate people against depression and trauma?. [online]ideas.ted.com. Available at: [Accessed 29 March 2022">https://ideas.ted.com/what-if-we-could-inoculate-people-against-depression-and-trauma/> [Accessed 29 March 2022] ns.uk. 2022. Overview - SSRI antidepressants. [online] Available at:

²⁰type.cognitive%20behavioural%20therapy%20(CBT)> [Accessed 29 March 2022]. Brachman, R., n.d. Rebecca Brachman, PhD, fonline] Rebecca Brachman, PhD, Available at: https://rebecca.brachman.org/> [Accessed 29 March 2022].]



<https://www.nhs.uk/mental-health/talking-therapies-medicine-treatments/medicines-and-psychiatry/ssri-antidepressants/overview/#:--text=Selective%20serotonin%20reuptake%20inhibitors%20(SSRIs)%20are%20a%20widely%20used%</pre>

CRISPR AND THE PROSPECT OF DESIGNER BABIES

'The ability to have perfect physical and mental characteristics of every unborn child' - this is one of the most common sci-fi film scenarios. Specifically, its use of designer babies conjures up scenes from the well-known film 'Gattaca,' released in 1997 by Andrew Niccol. In the film, a problematic investigation starts with a purchasing of a gene that has been laboratory engineered that further leads the protagonist on the edge. Here, Andrew Niccol connotes that its situation has been triggered by a simple desire for perfection toward creating a spotless human being. To prevent the status of being 'genetically inferior,' designer babies are created from an embryo selected by preimplantation genetic diagnosis or genetically modified to influence the traits of the resulting children. However, is this a wild imagination of Hollywood films or is it a reflection of reality? Today, the majority of designer babies are created to prevent inheriting genetic defects through the selection of "disease-free" embryos bv preimplantation genetic diagnosis. To process gene editing, clustered, regularly interspaced, short palindromic repeats (CRISPR) are used as an editing tool for genes. CRISPR-Cas9 was originally adapted from a naturally occurring genome editing system in bacteria where the bacteria produce RNA segments from the CRISPR arrays to target the viruses' DNA.



Specifically, Cas9 works together in a complex with the guide RNA to be directed to the complementary sequence of a gene that is being targeted where a break will be generated.

In the case of humans, our body undergoes an active Mitochondrial DNA replacement therapy. Considering that thousands of copies of mtDNA are present in the cytoplasm of the cells, most DNAs are prone to mutations that can lead to the development of mitochondrial diseases. To prevent its mutation, replacement therapy involves using an egg from an egg donor who does not have mutations. After the removal of the egg's nucleus, it is replaced with the nuclear DNA from the woman who has mitochondrial DNA mutations, fertilizing with the father's sperm in the embryology lab.

Using its theory, the world's first designer babies were reportedly born in China in 2018 claimed to the scientist Jiankui. This was the first attempt to create an 'ultimate human.' Gene-edited twin babies 'Lulu' and 'Nana' were born through the process of editing their part of DNA passed on from the HIV-positive father, which showed the possibility of interpreting applications to potentially cure genetic conditions such as sickle cell anemia and cystic fibrosis.



AUTHOR: Maeji Son SOURCE: https://www.mdpi.com/1467-3045/28/1/47/pdf



This was a significant production for the field of biotechnology as it has not just undermined the ethical considerations, but has created doubt about the safety of inheritable genome editing. As this therapy has been considered illegal in countries -except for France, Switzerland, Italy, and the United Kingdom- due to its hidden risks, some question the reliability of the biotechnology that has been prohibited permitted under very stringent and conditions for decades. Severe side effects and off-target cleavage includes the following, but are not limited to: the creating new possibility of toxic substances, the probability of causing allergies, changes in essential nutrients, and causing antibiotic resistance issues that may arise within the trial of the gene-editing therapy. Furthermore, critics urge the prospect of CRISPR being for genetic enhancement and not just for the treatment of genetic diseases, reinforcing the idea of heiahtenina parental expectations toward the next generations. Within the overwhelming usage of gene editing, will Genetic Engineering change everything forever or will it remain a realm of science fiction?



MENSTRUAL Synchrony

Why do best friends have their period at the same time?

When women live together , they will begin their menstruation at the same time, we call this period syncing. Period syncing is also known as "Menstrual Synchrony" and "McClintock effect." This is based on the theory that when you're in physical contact with someone who menstruates, your pheromones influence each other, causing your monthly cycles to align.

Until now, researchers are not quite sure because there is not very much clinical data to support whether it is true or not. However, there is no research to back up the idea of friends synchronizing, anecdotal and empirical data suggests the potential possibility. According to Alyssa Dweck, the obgyn at the Mount Kisco Medical Group, notes not only having a few common pheromones will lead to Period Syncing. People who live close to each other, for example, may have comparable diets, exercise routines, sleep/wake cycles, and shared stressors, all of which might affect menstrual habits.

Nevertheless, there are still people that believe friends having menstruation at the same time is only a coincidence. According to Oxford University and a period tracking app company Clue was the biggest blow yet to the theory of period syncing. They had collected data from over 1,500 people demonstrating that it's unlikely that women can disrupt each other's menstrual cycles by being in close proximity to one another which had proved that there is no pattern or reason behind Menstrual Synchrony.



AUTHOR: Nancy Zhao

SOURCE: McDonald, C., 2022. Is it true that periods synchronize when women live together?. [online] BBC

News. Available at: <https://www.bbc.com/news/magazine-37256161> [Accessed 28 March 2022].

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SHORTSLEEVE, C., 2022. Why You and Your Best Friend Share the Same Menstrual Cycle. [online] Women's Health. Available at:

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When we are making formula milk or mixing any powders and water together, it always forms milk beans which are some common clusters. If we observe the milk clusters, the surface is a wet layer of milk slurry, and the inner parts are formed by dry powder unaffected by water. From this we could see that milk beans are formed when water surrounds a pound of powder, but cannot penetrate to the interior. If we take a close look at the process of mixing powdered milk, it could be separated into four stages according to Forny et al. published a paper on Powder Technology in 2011. First, water moistens the surface of powders, next water permeates into the gaps between powders, then the water dissolves the solid bridge between particles of the powders and disperses big



POWDERED MILK BEAN

powder clusters into particles, and last the small particles dissolve in water. From this we could see that the main cause of milk beans depends on the first two stages, wetting and penetration. During these two stages, it relates to the concept of hydrophilic. For example if we apply a drop of water on a piece of glass, the water extends into a liquid layer where the contact angle is < 90, it means the glass is hydrophilic. But if it doesn't spread, it is called hydrophobic. Rounder the water drops are on the surface of a material, the more hydrophobic the material is. In this case, powdered milk is hydrophobic. Hydrophobic surfaces show a high affinity to air, and even if the material is immersed in water it does not guarantee air could be removed. Hansen et al. found that powdered milk contains 10-15% of air which prevents the water from getting in. However the powdered milk even is hydrophobic, but water will still try to get into it because of the capillary process. The nature of the capillary effect is when water moistens the internal surface of the tube and spreads upwards on the edge to form meniscus. Water in narrow tubes can

rise by itself and form meniscus liquid surfaces. The air gaps inside the milk powder could also be viewed as some capillaries, and the process of water penetrating in could also be viewed as the capillary phenomenon. In these tubes, the water can penetrate 2 to 4mm into powdered milk in natural condition. This could be done by using the Young-Laplace Equation and Jurin's Law and Lucas-Washburn Equation and Cassie-Baxter Equation. In conclusion, because of the high hydrophobicity of powdered milk where too much air is inside which causes water to penetrate in forming the milk beans.

SOURCE:

AUTHOR: Manlin Wu

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WHY DO SO MANY COUPLES LOOK ALIKE OVER TIME?



Lookalike couples have had a high profile for many years. Back in 1987, scientists from the University of Michigan set out to study the phenomenon of married couples who grow to look more alike over time. According to the researchers' hypothesis back in 1987, couples tend to begin looking alike because they typically "occupy the same environments, engage in the same activities, eat the same food, and mimic each other's emotional expressions," all of which can influence facial features.

How could these things be physically possible? The social psychologist Robert Zajonc, suggested "convergence in the physical appearance of spouses". The meaning of this could be attributed to the fact that long time lovers become so in sync with one another, they end up unconsciously imitating each others' expressions, which in time changes the appearance of their faces. Also the another reason for eventually starting to look like your partner is because you have the similar experiences with them. Throughout their life together, a couple experiences a great deal of exciting and depressing memories. Everything they go through together as a couple will influence their emotional state and body language. Their past stories were "written" on their faces, even a couple's wrinkles form in the same places. Another reason for this is because our immune system reflects our lifestyle, including our diets and physical exercise. A group of scientists concluded that couples who had been married for a long time have very similar immune systems. Maybe that's why the partners often share their habits and lifestyle in general. Couples who are in tune with each other often mirror each other's habits and body language. It shows that there's emotional comfort and trust in their relationship. Scientists state that partners tend to change their own habits throughout their married life. For example, if one of them was trying to guit smoking and started eating healthy food, the other one often did the same.

Rather than the faces changing, it was found that couples are inclined towards picking partners who have similar facial features as them. Lookalike partners may also be drawn to each other, subliminally, because of their genes. Plenty of studies have found that spouses tend to be more genetically similar than strangers, sharing predictors of everything from height to educational attainment. There is also some preliminary evidence that people may be attracted to potential mates who come from similar ancestry – at least for white couples, since they've been the focus of most early research. Both of these tendencies could feasibly translate to physical similarities within a couple.

Nevertheless, spouses' appearances are similar but do not converge with time. This brings facial appearance in line with other traits – such as interests, personality, intelligence, attitudes, values, and well-being – which show initial similarity but do not converge over time.

SOURCE:

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AUTHOR: Xilan Yao



MY FAVORITE (SCIENTIST - MS JAHAN, CHEMISTRY

"My favourite scientist is one who isn't very well-known nowadays, but his contributions towards Science from ancient times has been amazing and set the early stage for the Sciences that we study today. His name is Ibn Sina, but he is popularly known as Avicenna.

His contributions were not only limited to natural Sciences such as physics, chemistry, medicine and pharmacology, but he has also made vast advancements in the fields of psychology, philosophy, maths and astronomy, along with works in poetry, Islamic scholarship and theology. Originally from present-day Uzbekistan, Ibn Sina's book "The Canon of Medicine" was used as the standard medical text in European universities up until the 1700s, well after his death.



What I like about him that makes him my favourite is that his knowledge and scholarship wasn't limited to one track and specialisation, and he made huge and remarkable strides in multiple fields from a very young age. We are used to society's expectations in conformity and we are raised thinking that we can only do one thing and be really good at it, but Scientists like Ibn Sina exemplify the very ability to stretch yourself well and far beyond what you may think you are capable of, in many areas in life – something that we can connect to the NLCS ethos of scholarship even today!"

PULSE

PHANTOM LIMBS -The presence of an absence

A phantom limb refers to a persistent sensation in a limb that no longer exists (6). The great American neurologist Sir Weir Mitchell popularized this phenomena with the publication of "The Case of George Dedlow' in 1866, a first-hand account from a fictional army physician who eventually had all his limbs amputated (2). This tale was based on Mitchell's experience with several amputee soldiers who described the same mysterious sensation (1) – the 'usual consciousness that they still had the lost limb' (4).

'[I was] suddenly aware of a sharp cramp in my left leg. I tried to get at it... with my single arm, but, finding myself too weak, hailed an attendant. Just rub my left calf,... if you please. Calf?... You ain't got none, pardner. It's took off...'(3)

The thing that is truly remarkable about phantoms is their life-like quality - their inherent realness to the patient experiencing it. A phantom limb feels like a normal limb, moving in perfect coordination with the rest of the patient's body. And this locational coherence is further accompanied by the vivid sensory qualities of an existent limb, making it capable of possessing the full spectrum of human sensation - whether benign feelings of pressure and warmth, milder and irritable inklings of an itch, or more agonising experiences of burning and shooting pain. (3)

This sense of reality reinforces the belief that the phantom is not only real, but an integral part of embodied experience. As such, the struggles of patients go beyond dealing with the loss of a limb, for on top of trying to find treatment for a non-objectifiable sensation, they have to cope with a disruption of their sense of self (1). This is noted when Dedlow stated that losing his limbs made him feel 'less conscious of myself, of my own existence' (4). Mitchell's tale could be interpreted in some sense as an admission of a doctor's helplessness. Whilst unable to find a 'cure', they also could not address an emotional need of many of the amputees - the need to feel whole. (1)



Phantom limbs are not uncommon, occurring in up to 80% of amputees (5), yet it remains poorly understood to this day, both in terms of underlying mechanisms and effective treatment options.

Phantom limb pain was originally considered a psychiatric illness (7). The possibility of 'pain without lesion' challenged the basic premises of scientific medicine at the time (1), and many doctors then were quick to dismiss pain without an objective, physical cause. However, the mounting evidence has shifted the paradigm from a psychogenic theory to ones involving peripheral and central neural mechanisms (7). Experts have proposed a couple potential sources for PLP - neuromas, the spinal cord, and the brain - though most recent research points to the brain as a prevailing explanation for this phenomenon.

There are 2 proposed mechanisms that originate in the brain, one of which is termed cortical reorganisation. The 'cortical map' in our cerebral cortex reflects the arrangement of brain regions according to their specific function. Neuroplasticity - the ability of neurons to modify their connections and behaviours (6), enables local brain regions to 'take over' the cortical areas that originally represented the amputated region. This serves a potential explanation for why afferent nociceptive stimulation of neurons within the stump or in neighbouring areas can cause certain sensations to arise in the phantom limb itself (7).

The other mechanism is called the neuromatrix theory, and was proposed by Ronald Melzack in 1989 (7). He suggested the concept of a 'neurosignature' – a built in matrix of neurons for the whole body, which integrates new information from the environment to generate a characteristic output of nerve impulses (9). This pattern of activity is constantly updated based on one's conscious experience (7), with every new input being compared to what the brain expects to receive. Based on this theory, pain is the result of an unexpected change in input (9). An amputation results in a deprivation of various inputs from the limbs to the neuromatrix, thereby creating an abnormal neurosignature which the amputee experiences as phantom limb pain (7).

There is an extensive array of potential treatment options for those suffering from phantom limb pain, all of which are based on specific proposed mechanisms. Though the contributions of these various theories are undeniably helpful, they serve to illuminate only parts of the picture. A theory that unifies all these mechanisms has yet to be discovered, and further research seeks to unravel more of the mystery that remains.

AUTHOR: Jieun

SOURCE:

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First, to be clear, snake milker is a real job! But yes, you are probably right - snakes don't produce milk. So what exactly does a snake milker do?

Essentially, a snake milker is a specialist zoologist who extracts venom from snakes or other massive reptiles in order to create antivenom or conduct further medical research. Snake venom is a highly toxic saliva containing zootoxins that leads to the immobilisation and digestion of prey. Usually, when humans are bitten by a snake, snake venoms can induce harmful inflammatory and neurotoxic effects including severe pain or even paralysis. In the more extreme cases, it can even be fatal! Therefore, it's very important that a snake milker is specially trained to handle these snakes and is capable of carrying out the process safely. Due to its relatively high risks, this career requires many years of education.

But you may ask, why would we want to extract the venom if it's so dangerous? The answer is that venom can be very useful in the medical field and has a lot of research potential. Specifically, venoms have been used to treat blood clots, combat blood pressure and reduce heart attack risks.

Besides the potential research breakthroughs of new medical treatments, venom is also studied and experimented to create anti-venom used by hospitals and laboratories to treat people who were bitten by a snake. New studies have also suggested that snake venom can possibly be used to help in strokes and malignant tumours in the future.

The benefits that snake venom brings to the society either by saving lives or treating illnesses are so broad, but without the hard-work of the snake milkers, who put their lives at risk, the possibilities of it would never be explored.

AUTHOR: Inez SOURCE: <u>https://www.environmentalscience.org/career/snake-milker</u>



DID YOUKNOW?

Giant kelp (*Macrocystis pyrifera*) is the largest algae on Earth. It is mostly found in the Pacific Ocean, lining the coast of California all the way up to Alaska.

They are one of the fastest growing organisms and can grow 60 cm a day and up to 50m in one season.

Algae are able to photosynthesis but lack most characteristics of a typical plant, so are classified as protista. This kingdom includes all the other 'misfits' of the natural world that do not follow the rules of the other, more well know and defined kingdoms; plants, fungi, animal and prokaryote.

Scientists estimate that 50-80% of the atmospheric oxygen we depend on, is produced by algae. Thank you algae!





SCIENCE RIDDLES

- 1. What four periodic elements, when combined, make up something that terrifies criminals?
- 2. What do chemists call a benzene ring with iron atoms replacing the carbon atoms
- 3. What is a Priest's favorite part about Physics?
- 4. I am needed for flight but cannot fly on my own. What am I?
- 5. I can burn your mouth and sting your eye, but i am consumed everyday. What am i?
- 6. **What is the most uninteresting of all the periodic** element?

(answers are on the back page)

NEW LOGO Thank UPDATE

Thank you to all students that submitted their entry to the Science Week competition. The Pulse team are still reviewing the entries, the winner will be announced next edition.

PULSE

"Imagination is more important than knowledge."

ALBERT EINSTEN



Pulse CCA meets every Monday 3:45-4:45 in E620. Presently only Grades 9, 10 and 11 can attend in person. However, we welcome guest articles from all members of our community. If you would like to learn more or submit an article please email cparker@nlcssingapore.sg

LINK TEACHER: Chanelle Parker

