Our body is governed by

Reporting by: Sylvia Stylianidou, Laura Baker, Charlotte Bates, Holly Gedling, William Howe & Rosanna Shaw

Main Image Credit: The Guardian

The body clock is a key component in the regulation of our sleep cycle. This 'clock' is formally known as our bodies circadian rhythm and it is responsible for the fluctuating levels of sleepiness and alertness experienced throughout the day. This natural internal system operates over a slightly longer than 24-hour cycle, which is why in the absence of exposure to the solar day it drifts out of synchrony.

Our internal clock is controlled by an area of the brain called the Suprachiasmatic Nucleus (SCN), located in the hypothalamus. The SCN is sensitive to varying levels of light, which is why we feel sleepy in the dark and alert in the light. The circadian rhythm varies from person to person, and affects many biological processes alongside the sleep-wake cycle such as body temperature, hormone release and eating habits.

Circadian rhythm sleep disorders (CRSDs) arise when our desired time of sleep doesn't match up with our underlying inclination to sleep that is controlled by the circadian rhythm. Shift work disorder is a CRSD found in people that work early morning shifts, night shifts, over-night shifts or rotating shifts. It is caused by a conflict between the body's circadian rhythm and the individual's work shifts.

The symptoms of shift work disorder include mental and physical deterioration which often leads to education, hobbies and relationships being compromised. On average, shift workers may sleep up to four hours less than a regular worker and because of this excessive tiredness they can suffer from 'micro sleeps', whereby they fall asleep for a few seconds at a time.

This is dangerous for workers who are driving or operating heavy machinery, and reduces the quality of their work. Sufferers can ease their symptoms by taking sleeping pills to help them sleep in the day, or by using bright light therapy periodically. Additionally, it is believed that a gradual change into shifts would be useful as it is easier for the body clock to adjust by an hour or two each day.

Jet lag is another CRSD experienced by many people after travelling to a new time zone. This occurs due to a mismatch between the sleep-wake cycle that we are used to, generated by our internal circadian clock, and external cues. Since the body clock adjusts more easily to a forward shift of the sleep-wake pattern, eastward travel is linked to more severe jetlag than westward.

Since the internal clock is slow to adjust, it re-mains on its original schedule for a few days. This causes various symptoms ranging from fatigue with inability to sleep during the new night time; to headaches, loss of concentration and gastrointestinal problems. Additionally, it has been shown that chronic jet lag may lead to deficits in spatial learning and memory, even after the circadian rhythm has reset. Therefore, there may be long lasting implications on cognition and productivity for people who travel abroad frequently. Not everyone is affected in the same way but generally, as the number of time zones crossed or age of the person increases, symptoms worsen.

Even though there is no treatment developed for jet lag yet, there are indications that melatonin might be a key part in developing one. For the time being, dividing the total time-zone transitions into more than one part can help minimise the effects of jet lag. Another tip would be taking naps when needed, but when aiming to adapt to the new time zone avoid naps exceeding four hours during night time of the departure time zone, otherwise the body clock will anchor itself to its original rhythm. Δ

New York: The Next Atlantis

With climate change unchecked: a look at how rising seas levels could affect one of the world's biggest mega-cities

R porting by: Katherine Barrow, Martha
B wles, Imogen Brawn,, Kendelle
Bl ownlee, Lawrence Pearse & Emily White

Main Image Credit: Architectural Digest

Simulation of New York Flooding by 2100 Image Credit: Rolling Stone

Sea level rise, a direct impact of human-induced temperature increase, is set to have devastating implications for over 270 million people by 2100. Thermal expansion, an increase in the volume of water due to rising temperatures, and the melting of global ice stores are the two primary reasons contributing to the 3.2mm annual sea level rise.

Although the current increase can be attributed human-induced climate change, sea level rise is not a new phenomenon and has been seen throughout history. For example the gradual submergence of Doggerland, the area of land that existed between mainland Europe and the east of Great Britain, which fully submerged at approx. 6000 BC. The Mesolithic hunter-gatherers that populated this rich landscape were forced to relocate as the melting of glaciers and ice sheets resulted in sea level rise.

Access to oceans and the draw of fertile land near river deltas, are major reasons urban settlements arise near rivers and coasts, but these benefits do not come without risks. The ancient Egyptian city of Thonis, positioned on the Canopic mouth of the Nile, was submerged in the 3rd-century due to the rising sea levels of the Mediterranean and liquefaction of land. The underwater city was rediscovered in 1999 and resembles that of the fictional ruins of Atlantis.

New York, a major contemporary city positioned at the mouth of the Hudson River and home to over 8 million people, is seemingly unfit to deal with future sea level rise. Sitting at just 10m above sea level this low-lying city houses some of the World's most expensive architecture and the outdated Manhattan seawall is now 20 times more likely to be overwhelmed than it was 170 years ago.

Rapid urban expansion compounds the problem, by increasing impermeable surfaces and providing fewer opportunities for water to be intercepted. With 33,000 buildings (valued at $18.3 billion) built on a floodplain which is currently susceptible to extreme flooding events every 100 years the costs of managing this problem is increasing. Projections show that by 2050, extreme flooding events are likely to occur more frequently at a rate of every 3-20 years.

In 2010, during the building of the new World Trade Centre, archaeologists discovered that it was being built upon a 18th century dock – indicating that this land was historically under water. It is evident that population growth and unsustainable planning, in conjunction with sea level rise, makes New York City increasingly vulnerable to one day becoming a myth akin to that of Atlantis unless action is taken. Δ

Flood Map 2020

Flood Map 2100

Image Credit: New York City Department of City Planning

Resistance is Futile

Reporting by: Amy Tilbury, Ellie Gomes-Callus, Sarah Jardine, Rachel Jenkins, Elliot McGregor

Main Image Credit: Shutterstock

Penicillin antibiotics were introduced in the 1940s and changed the course of medicine, but their overuse led to the development of resistance in many strains of bacteria, including *Staphylococci Aureaus*. This in turn led to the emergence of today's superbug MRSA (Methicillin-resistant *S. Aureaus*).

MRSA bacteria lives on the skin of 1 in 30 people in the UK, mostly without harm. But if it gets into the blood stream it can spread to the body's main organs and give rise to life-threatening sepsis. According to Public Health England incidence of MRSA infections peaked in 2003 with 7,700 cases. This declined over the next decade as a result of improved hygiene and testing measures but a change in approach resulted in a resurgence and a 2.4% rise in reported cases in 2016.

A number of mechanisms allow bacteria to evade antibiotic treatment. For any of these to occur a bacteria must first gain genes for resistance, either from random mutation in its own DNA or from other cells in its environment. Genes code for proteins which confer resistance by interacting directly with the antibiotic molecule or by causing physical changes in the cell which reduce antibiotic efficiency.

After antibiotic resistance to penicillin was first observed further strains of antibiotic, such as Methicillin, were created forming a family known as beta-lactams. Beta-lactams prevent normal cell wall synthesis in bacteria by binding to Penicillin-binding proteins (Pbps). This leaves the bacterial cell unstable and vulnerable to destruction.

Some resistance to antibiotics comes from an enzyme called beta lactamase which breaks a part of the beta-lactam molecule that is critical to its function. This can be overcome by combining antibiotics with beta lactamase inhibitors but because MRSA uses a mutated Pbp, it is unresponsive to this treatment.

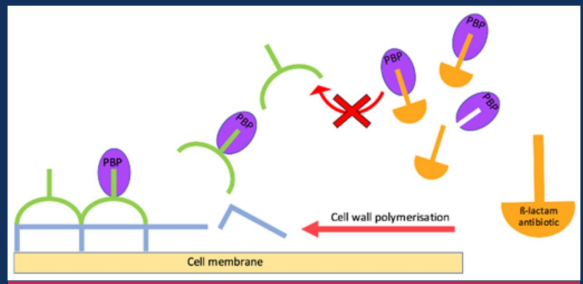
Research has found that interfering with the synthesis of a molecule called Wall Techoic Acid (WTA) can make MRSA more vulnerable to beta-lactam antibiotics. WTA is found in the cell walls of gram-positive bacteria such as *S. Aureaus* and is important for cell growth and division. Research by a team at Merck Laboratories in New Jersey has identified two synthetic compounds, Tarocin A and Tarocin B which can prevent the production of WTA.

These compounds act by inhibiting an early stage of WTA synthesis, leaving the bacterial cell without an essential part of its wall structure. Not only does techoic acid make up around half of the wall mass, it also has a role in holding other components in place. The absence caused by Tarocin A and B leaves the wall weak and more susceptible to binding by beta-lactam antibiotics.

Alternative antimicrobial treatments being developed use machinery from bacteriophages: viruses which infect bacterial cells. These viruses produce endolysins, molecules which break down the cell wall of the host bacterium to allow the virus to spread. By modifying endolysin, scientists are able to target and kill only MRSA bacteria in a way that is unlikely to stimulate resistance.

When diagnosed early MRSA infections have a death rate of around 15% but if not discovered until later this increases to 50%. Data predicts that by 2050 the death toll from resistant-bacteria infections will be higher than that of cancer in the UK. With cases of MRSA on the rise and new resistant-bacteria emerging a novel response is required.

Fortunately, the use of combination therapies, which have already proven successful in cases such as Hepatitis C, are starting to be seen in antibiotic treatment. Making use of innovative approaches is a vital part of the puzzle and must be implemented alongside improved used of antibiotics to tackle antibiotic-resistance Δ



The traditional approach: beta-lactams (orange) bind bacterial PBP (purple) preventing cell-wall assembly. PBPs in MRSA bacteria are shaped differently so beta-lactams cannot bind

Timeline of Antibiotic Discovery	Before 1930	1930-1939	1949-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000 onwards
	Penicillin (D)	Sulfonamides (D) Gramidin (D)	Penicillin (I) Streptomycin (D) Bactracin (D) Cephalosporins (D) Chloramphenicol (D) Chlortetracycline (D) Neomycin (D)	Oxtetracycline (D) Erythromycin (D) Vancomycin (D) Kanamycin (D)	Methicillin (I) Ampicillin (I) Spectinomycin (R) Gentimicin (D) Cephalosporins (I) Vancomycin (I) Doxycycline (I) Clindamycin (R)	Rifampicin (I) Tobramycin (D) Cephamycins (D) Minocycline (I) Cotrimoxazole (I) Amikacin (I)	Amoxicillin-clavulanale (I) Imipinem/Cilastin (I) Ciprofloxacin (I)	Azithromycin (I) Quinupristin/Dalfopristin (I)	Linezolid (I) Cefditoren (I) Daptomycin (I) Telithromycin (I) Tigecycline (I)

D-Discovered | R-Reported | I-Introduced

Image Credit: Antimicrobial Resistance Learning Site

A Waste of Time and Space

Hundreds of billions of dollars have been spent on spa e exploration since the 1950s is this money well spent or money down the drain, our team investigates.

Reporting by Thomas Ruler, Hannah Burne, Sophie McCluskey, Daniel O'Connor & Gregory Purnell

Main Image Credit: Pezels

Space, the intangible expanse that created life on Earth, has fascinated humanity since our inception. Early civilizations associated celestial objects with gods and spirits, but powerful nations are now competing for the prestige of exploring the unknown, something that has inspired great advances in technology.

Investment trends in space travel have recently seen an escalation. In America alone, there has been significant expenditure in the National Aeronautics and Space Administration (NASA). In 2015, $17.5 billion - 35% of total scientific and academic research spending - was invested in space exploration. The International Space Station has cost over $120 billion globally, but with poverty still a troubling issue around the world, it's hard to justify the expense associated with space exploration.

The current generation is the most advanced to date, and this is in part as a result of the funding and research that has gone into exploring space. A vast amount of technology, across every area of life, has NASA and the Space Race to thank for its inception. Heart pumps, based on the technology of space shuttle fuel pumps, have improved countless people's lives. Artificial limbs which improve the quality of life for amputees have developed alongside advances in shock absorbers for rockets. Technological advances such as silicon chips, developed for the Hubble Telescope, are now used to help make breast cancer screening less invasive.

Lightweight composite materials created for the space industry are used across a range industries. Virtual reality simulators, initially designed for practicing missions can now be used to replicate environments for medical operations, flight conditions, and truck driving. The list of technology which we owe to the space race includes: smoke detectors, lightning protection, wind shear detection, warning systems for aircraft, golf balls, the Dustbuster, enriched baby food, and don't forget that pen. What's more, this list is growing as further development are spun out into the healthcare and commercial sectors.

Although there have been many significant scientific advances which have come about as a result of this investment, this has to be weighed against the adverse effects of space travel on human health. There are some obvious negative side-effects to travelling to space, humans were not designed to live and work in an environment with unprotected radiation, microgravity, and a lack of accessible resources. This puts an unprecedented strain on the body in ways that would not be experienced on Earth.

In addition, research suggests that in their efforts to explore humans are contaminating the vast expanse of space. There are approximately 500,000 pieces of debris of varying sizes orbiting the Earth., all have been put their by humans. Any piece of space debris, even something as seemingly harmless as a fleck of paint, can be a hazard so it is important to be aware of them. Debris can travel at speeds up to 17,500mph, so has the potential to cause massive amounts of damage to satellites and spacecraft.

We have sent more crafts into space than we have to the Mariana Trench, the deepest part of the ocean. Exploration of areas such as the Mariana Trench could lead to technological advances as scientists find ways to explore an area of exceedingly high pressure (8 tons per square inch at the bottom) and low temperature. Also as some species do live in these environments it provides an opportunity to investigate how carbon-based lifeforms can adapt to that environment which could be useful to advances in healthcare. There is definitely an argument that if we really want to examine the unknown, we should fully explore Earth before we try to find out more about other planets.

One cannot deny the clear positive impact space has had on both our day-to-day lives, and the level of science we are able to conduct. With over $10 billion in contracts currently being rolled out by SpaceX - a privately-funded space programme which aims to put a man on Mars, and the US Vice President laying out his intention for man to return to the Moon, space exploration seems unlikely to slow down any time soon. Δ

Nature's Light Show

Norse mythology considered the ethereal dancing lights in the sky at higher latitudes to be a fire bridge built by Gods but what actually causes the auroras

Reporting by George Hunter-Brown, Joseph Amphlett, Evie Clephan, Emma Kucewicz & Madhumitha Kumaravel

Main Image Credit: KinYu-Z.Net

The Northern Lights (Aurora Borealis), one of the seven wonders of the natural world, is a spectacular display of shimmering and dancing multi-coloured lights filling the whole night sky. Through history different groups have believed different things about the cause of this light show considering them anything from divine warnings of war or famine, to horse drawn carriages carrying heavenly guests to a magical wedding. Some even believed them capable of relieving the pain of childbirth.

The actual explanation begins with large explosions at the surface of the Sun called coronal mass ejections. Most of the ejections come from sunspots which are areas of high activity on the Sun's surface. These events release masses of charged particles out of the Sun, usually electrons or protons, producing what we call the solar wind. These solar winds bombard Earth's magnetic field and while most of the particles are repelled, some make it into our atmosphere through cusps of the magnetic field. These weaker regions occur at the poles of Earth's magnetic field hence why we see auroras towards the North and South Pole.

The particles that make it through the cusps are accelerated by the distortion of Earth's magnetic field and end up in a region of the upper atmosphere called the ionosphere. Here they collide with atoms and molecules in our own atmosphere transferring energy to them and moving them into excited states. The de-excitation of these atoms and molecules causes the emission of energy, in the form of photons of light. It is this emission of visible light on a large scale which produces the display of lights in our sky.

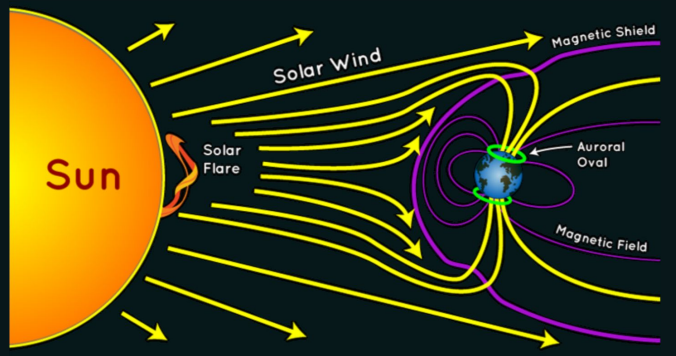
The aurora's display of different colours is due to different atoms producing light of different wavelengths when returning to their original lower-energy state. The most common colours observed are blues, greens and reds corresponding to the de-excitation of oxygen and nitrogen, the most abundant gases in our atmosphere.

Earth isn't the only planet to display auroral activity, the four gas giants (Jupiter, Saturn, Uranus, and Neptune) all have strong magnetic fields and dense atmospheres giving rise to the conditions for auroras. Comparing auroral behaviour across planets allows Earth to be placed in a solar system context.

Due to the difference in composition of each planet's atmospheres, the colours of their auroras are different. Using images and measurements from the Hubble Space Telescope, scientists can study the electromagnetic radiation received from these planets.

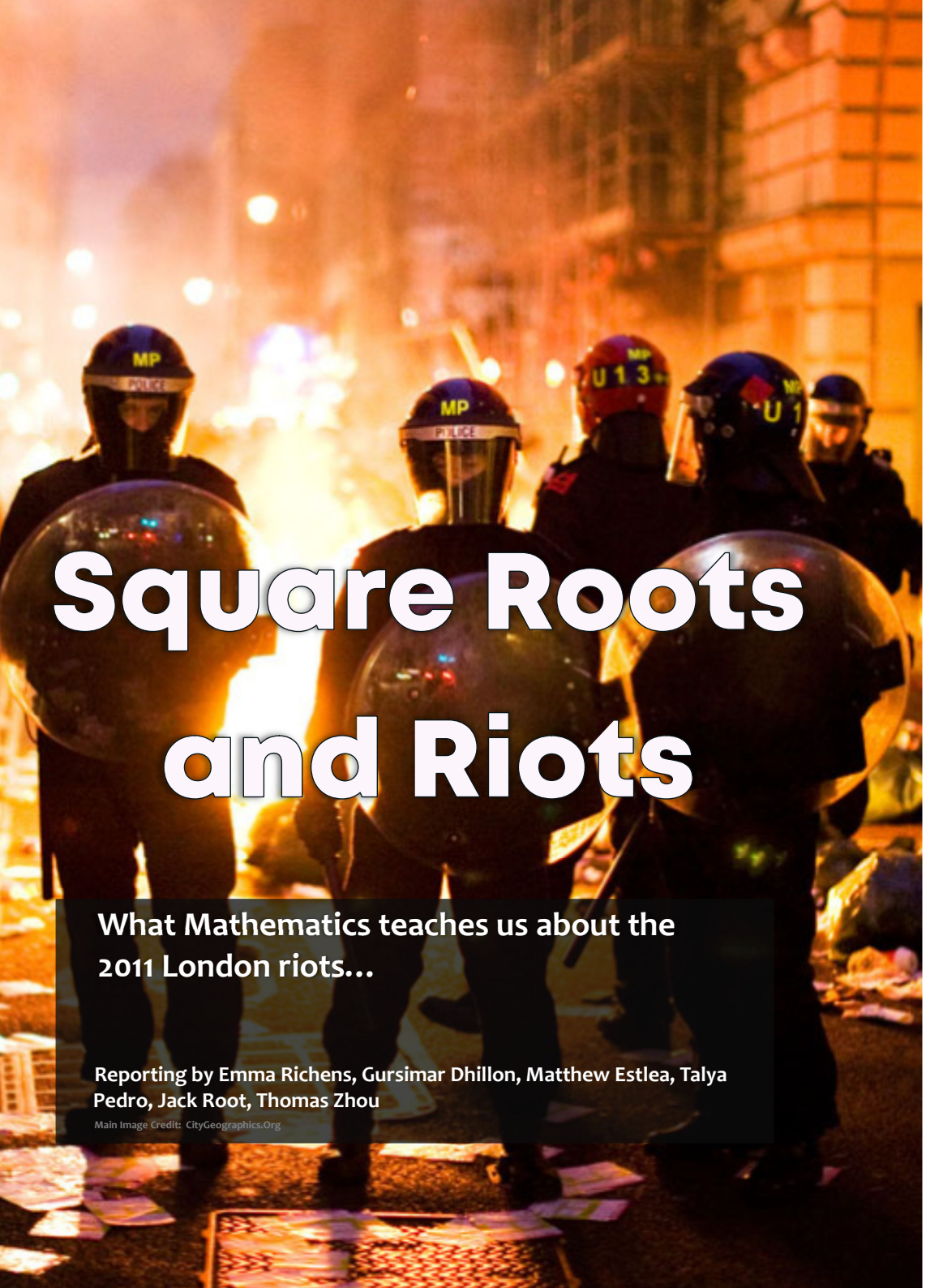
On Saturn, whose atmosphere is predominantly composed of hydrogen, the strongest auroras are found in the UV and infrared regions of the colour spectrum, invisible to the human eye, but weaker pink and purple auroras have also been spotted. Jupiter's fast rotation creates a complex and energetic environment in which charged particles move and interact which creates supercharged, glowing auroras.

As we approach the solar minimum, which is predicted to occur in 2019, there have been reports that the Northern lights will fade away. A solar minimum is the phase in the 11 year solar cycle when the number of sunspots is at its lowest, resulting in a decline in coronal mass ejections. However, sunspots are not the only phenomena responsible for auroras; magnetic activity can lead to coronal holes in the surface of the Sun which can also blast fast solar winds towards the Earth. So aurora watchers (and the local polar bear population) don't have to worry, as it is this source which is likely to continue nature's mesmerising light show during the solar minimum. Δ



Particles from solar ejections interacting with the Earth's magnetic field

Image Credit: University of Alaska Geophysical Institute



Square Roots and Riots

What Mathematics teaches us about the 2011 London riots...

Reporting by Emma Richens, Gursimar Dhillon, Matthew Estlea, Talya Pedro, Jack Root, Thomas Zhou

Main Image Credit: CityGeographics.Org

Much of the physical world we live in can be mathematically modelled with relative simplicity. The orbits of large objects, like planets around a star, can be represented by a surprisingly basic equation. By contrast, millions of minute water molecules in a whirlpool can be modelled due to the predictability of the system as a whole. But what about everything in between? Mathematician Warren Weaver summarised the problem by saying, "scientific methodology went from one extreme to another - from two variables to an astronomical number - and left untouched a great middle region".

The major issue for scientists is that the majority of human interaction falls within this 'great middle region', making it challenging to model effectively. But an emerging field of mathematics is attempting to change this. We have begun to extrapolate ideas – allowing us to write mathematical equations which can accurately predict human behaviour. A crucial implication of this field is being able to find ways to reduce violence, such as creating a more efficient police response.

In 2011, London saw its worst prolonged period of rioting for over 20 years - the data gathered on the event allowed mathematicians, such as Hannah Fry and her colleagues, to find analogous, pre-existing models in the physical world to simulate the riots, which we may be able to use to anticipate future events.

This model initially shows how the decision to riot spreads within a population; it has been likened to an epidemic. Nowadays, it is easy to communicate with friends almost instantly, meaning one person may encourage multiple friends to join the riot with them. Exposure like this does not mean an individual will join but it will lead to a cascade of that information. Similarly, with an infection not everyone who is exposed to the vector will become ill, as it is dependent on factors such as pre-existing antibodies, but exposure can spread quickly if population density is high and transmittance is easy.

The accuracy of this model led Gary Slutkin – a public health epidemiologist from the University of Illinois – to create an organisation "Cure Violence" in the year 2000, which aims to reduce the spread of violence within communities using strategies typically associated with disease control.

Once an individual has made the decision to riot, they are faced with a second decision: where is the best place to go? Data suggests that the majority of looters stayed close to their homes – with 80% remaining within 3km of where they live. Before we are quick to condemn these people as lazy, we should bear in mind that this is almost identical to people's normal shopping habits. People may be willing to trek farther afield for a large retail park, but for everyday trips they don't go further than necessary. Using statistical data like this, as well as trends in consumer habits, it has become easier to create mathematical models to predict the next major site. Understanding how people decide on the location for rioting can help police effectively allocate resources to areas where they are most needed and determine whether costly road closures will be efficient in reducing violence.

In the final stage of the model, the looter aims to avoid interaction with the police at all costs. The police, on the contrary, will be doing their best to arrest actual rioters whilst acting as a deterrent to potential rioters. Interestingly, the mechanism behind this relationship has been found to be remarkably similar to the interactions of predator and their prey in the wild. Studying current models of animal predation may provide insights as to how a rioting 'population' can be effectively reduced and policed.

These examples show how analogous systems in the world around us can help advance our understanding of human behaviour, and the practical implications of accurate models are innumerable. There are still huge challenges ahead when modelling such complex systems, but perhaps we can make Weaver's 'great middle region' just a little less great. Δ

Destruction of the Underwater Pharmacy

Reporting by Ellie Webb, Orie Amadi, Harry Boddington, Benjamin Caplan, Benjamin McGonigle, Evie Ward

Main Image Credit: Faharizetu

Coral reefs are some of the most biodiverse ecosystems on Earth, rivalling that of the Amazon rainforest. They create unique and complex habitats for marine organisms to thrive. Despite covering less than 0.1% of the planet, they are home to one quarter of marine species, and their skeletal structures act as a substrate enabling marine organisms to thrive in places they otherwise couldn't. The high density of life at the reefs creates competition for resources which drives the evolution of unique chemicals used in defence and attack for survival.

Due to the potential use of these chemicals in medicine, some people consider coral reefs to be an 'underwater pharmacy'. More than 25 marine-based drugs are currently at the human trial stage, many with anticancer and antiviral properties.

Coral Reef ecologist, Andrew W. Bruckner says that, 'The prospect of finding a new drug in the sea, especially among coral reef species, may be 300 to 400 times more likely than isolating one from a terrestrial ecosystem'.

The importance of coral reef ecosystems to the future of pharmaceutical breakthroughs is undeniable and yet the stability of these environments is under threat due to anthropogenic-induced stresses. Many of these are linked to global warming which will require a long-term approach to resolve but others would be easy to do something about now and prevent further damage occurring. If we can't do more to protect these environments and stress their importance to the global community then we will lose many opportunities before we even know they are there. Δ

Threats to Coral Reef Ecosystems

Increasing temperature – Warming waters due to climate change are one of the major threats to reefs. Coral has a unique symbiotic relationship with organisms known as zooxanthellae, which photosynthesise and provide the coral with energy in the form of organic compounds. When the temperature gets too high, the coral expels the zooxanthellae and its bright colour is lost. This is known as bleaching, and results in fatal starvation of the coral.

Ocean acidification - Absorption of atmospheric CO2 by the oceans has caused a drop in the water's pH from 8.2 to 8.1 since the Industrial Revolution, due to increased burning of fossil fuels. Coral polyps and other calcifying organisms rely on CO32- ions in order to form their calcium carbonate skeletons through calcification. Reduction in carbonate ions is not only decreasing the growth rates of many coral species, but the skeletal structures made are also weaker and more prone to wave damage and dissolution.

Other factors - Overfishing, Pollution, Invasive Species, Agricultural Run-off, Destructive Fishing Techniques (such as using cyanide and dynamite)

Drug Discovery from the Underwater Pharmacy

Bryostatin 1 is sourced from the species *Bugula neritina*, and was originally thought to be an anti-cancer compound due to its action on protein Kinase C. Recent;y this drug has recently been in Phase II development for Alzheimer's disease, with particular success in moderate to severe cases. Some patients even re-gain control of swallowing and word recognition.

Ziconotide is a novel drug used for pain relief. It was derived from the cone snail species *Conus magus* which is found in sandy coral reefs and shallow bays. This pain reliever is 1000 times stronger than morphine, without the addictive nature, and has been used for relief from severe and chronic pain, for example in amputees. It works as a selective blocker of calcium channels which control neurotransmission in nerves and synapses.

Sinularin, a molecule isolated from a Sinularia coral, can reduce the severity of neuroinflammation and sensitivity to pain. It has also been shown to have anticancer properties. This recent discovery indicates its potential as a medicine to treat a wide range of conditions. For example, the ability of sinularin to initiate programmed cell death in leukaemia cells could be developed as a potential cure for the disease.

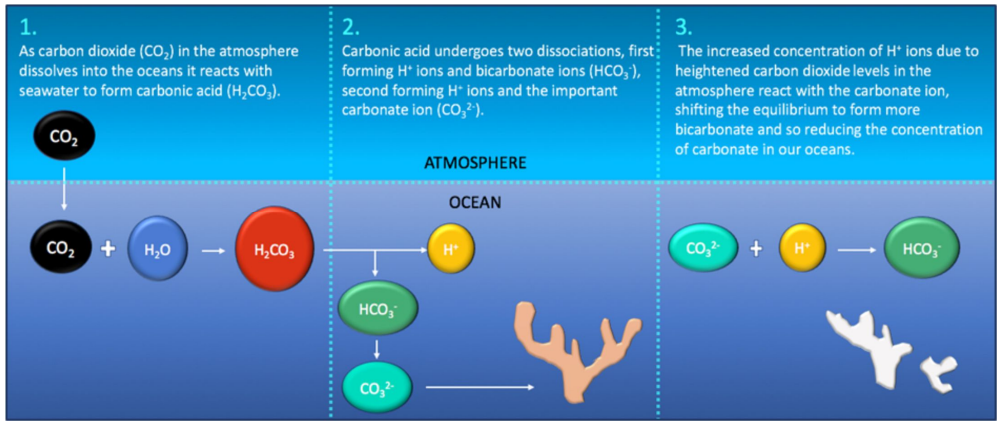


Illustration showing the process and effect of ocean acidification

Rethinking Schizophrenia

Reporting by Miguel Barrulas, Jaimee Broadley, Jonathan Ding, Cameron Florence, Benedict Greenwood, William Richards

Main Image Credit: Greg Dunn & Brian Edwards

The beauty of the brain is often overlooked and its complexity taken for granted. Nevertheless, at some point in our lives we are all confronted with facing its fragility. Schizophrenia is one of the most common mental disorders, usually diagnosed during early adulthood. A diverse set of symptoms distort an individual's thoughts, feelings and behaviours; often leading to an erratic and isolated lifestyle.

Despite being first classified as a disorder in 1887 and evidence of schizophrenic symptoms dating back to Pharaonic Egypt, psychologists are uncertain of its cause. One of the most widely accepted theories defines schizophrenia as a neurodevelopmental disorder, meaning genetic factors make individuals susceptible to developing the disorder, while the onset is triggered by environmental factors. Previously the focus of research was on neuronal cells, but this is shifting as new evidence suggests genetic factors that cause defects in non-neuronal cells play a primary role.

The Central Nervous System (CNS) is comprised of two major cell types – neurons and glial cells. Neurons form pathways for electrical signals to travel to and from the CNS, while glial cells support the function of the neurons by maintaining a suitable chemical environment for transmission.

A subset of glial cells, oligodendrocytes, are responsible for wrapping neurons in a fatty layer called the myelin sheath. This enables electrical impulses to travel faster along the neurons. Several studies highlight abnormal myelin distribution and composition in the brains of schizophrenics, which some scientists believe is due to alterations in the genes responsible for the function of oligodendrocytes.

Dr. Steven Goldman of the University of Rochester holds this opinion stating that: "The inability of these cells to do their job…to help nerve cells build and maintain healthy and effective communication networks, appears to be a primary contributor to the disease". As the brain is such a complex organ comprised of an enormous web of interlinking pathways, defects in one cell type can result in impaired function in others. These studies present a difficult conundrum for scientists. Do abnormal glial cells cause the development of schizophrenia or does schizophrenia result in abnormal glial cells?

To attempt to answer this question Windrem et al conducted an experiment allowing human glial physiology, gene expression and the effects of neurophysiological function to be assessed in mice. Using stem cell technology, Windrem's team transformed cells from schizophrenic patients and transplanted them into the CNS of new-born mice, to create mice with brains containing human glial cells from schizophrenic patients. As mice cannot give verbal accounts of their symptoms, it is difficult to determine whether they have schizophrenia. But since disease-associated changes in learning and behaviour are observed in human schizophrenics completing tasks measuring anxiety, short term memory, perception of pleasure and sleep patterns. Windrem's team adapted these tasks for the mice to see whether disruption in normal glial development induced the symptoms of schizophrenia.

> "The inability of these cells to do their job …to help nerve cells build and maintain healthy and effective communication networks, appears to be a primary contributor to the disease"

Across all tests, the performance of the mice reflected the typical behaviour seen in patients with schizophrenia. Which suggests that impaired glial cell development is sufficient to yield some of the symptoms of schizophrenia seen in humans. This research has interesting consequences for future studies, paving the way for scientists to analyse the genes responsible for glial cell development and investigate how environmental factors may influence their expression. This study represents another step towards fully understanding schizophrenia and developing more effective treatments.Δ

Life on Mars?

Reporting by Ciaron Bennett, Edward Bowman, Maire Gilmartin, Michaela Kompauerova, Sophie Poole, Hannah Terry

Main Image Credit: Caldiptera Wordpress

True Facts about the Tardigrade

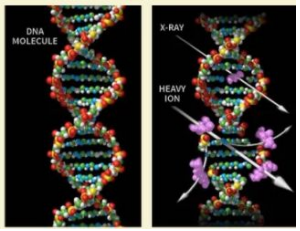
- They are 0.5-1mm micro animals with segmented bodies
- They have been around for around 530 million years
- They have 4 pairs of legs and 4-8 claws per leg
- They are also known as Water Bears or Moss Piglets
- They were first discovered in 1773 by a German pastor
- There are more than 1,150 species
- They are found in a myriad of inhospitable environments
- They are found in Antarctic Ice, deep ocean trenches and the heights of the Himalayas
- Tardigrade babies are born with a full range of adult cells, instead of growing by cell division, their cells simply become bigger
- They are able to survive extremes of temperature, pressure, prolonged dehydration, toxicity and radiation.

Illustration of a tardigrade Image Credit: BBC Nature

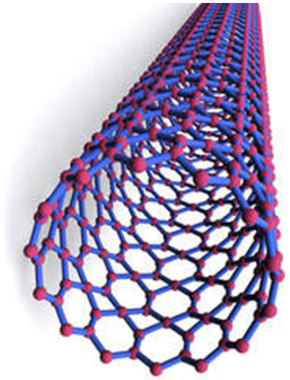
Humans have been exploring the possibility of colonising Mars for many years, but for human life to exist on Mars there are many challenges. The absence of a magnetic field strong enough to deflect cosmic rays and an atmosphere 100 times thinner than Earth's contribute to high radiation levels. Techniques used on Earth to limit exposure, like lead lining, are ineffective on Mars. This is because heavier elements, like lead, produce secondary radiation in space when bombarded by primary radiation from galactic cosmic rays, solar particle events and particle radiation.

NASA Space Radiation Element Scientist Lisa Simonsen says: "This ionizing radiation travels through living tissues, depositing energy that causes structural damage to DNA and alters many cellular processes". This structural damage includes genetic mutations, faulty DNA repair, and large DNA deletions which all have the potential to lead to cancer as well as evidence of cataracts and damage to the cardiovascular and central nervous system.

NASA has been exploring potential physical, biological and operational countermeasures which could be taken to allow space exploration to continue and in particular to facilitate a manned mission to Mars. Radiation shielding could come in the form of spacesuits made of hydrogenated Boron Nitride Nanotubes (BNNTs). The properties of these nanotubes make them an ideal material as it has high mechanical strength, is electrically insulating and, most importantly, is an excellent absorber of neutron radiation. However, high cost and slow rate of production prevent this being implemented into current spacesuits.



How radiation damages DNA
Image Credit: Space.com



Boron Nitride Nanotubes
Image Credit: NewAtlas.com

Other avenues of research into safeguarding astronauts have come from studying the only animal known to have survived in space: tardigrades. These eight-legged aquatic animals, known as 'water bears', can endure extreme temperatures and pressures, more than a century without water, and high levels of x-ray and UV radiation. They are one of the few animals known to have survived Earth's five mass extinctions.

The European Space Agency's Fotor-M3 mission in 2007 studied the impact of harsh environmental effects on tardigrades. Dehydrated tardigrades were exposed to the vacuum of outer-space and high solar UV radiation. After rehydration back on Earth, 68% of specimens survived. This dehydrated state is known as a 'tun' state and involves the tardigrade curling up into a ball and synthesising special molecules which fill their cells forming a matrix. This matrix locks DNA, membranes and proteins in position and protects them.

This allows them to survive many years without any metabolism and, once rehydrated, they can repair their damaged DNA. Scientists are trying to understand and learn from this 'tun' state in order to apply the tardigrades' unique biochemistry to try to protect humans from the extreme conditions on Mars as well as to understand more about the environmental limits of life.

While the problem of exposure to radiation for humans on Mars has not yet been solved, there are many avenues of research being explored from a biochemical and physical point of view. Which will hopefully mean that one day Mars is an option to support human life. Δ